

DevOps Workshop Lab Guide

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Introduction: Labs Setup

Welcome to the lab! Here you will find a collection of exercises and accompanying source-code.

Overview

This workshop contains a number of lab folders meant to be worked through in numerical order - as each exercise builds upon the last. There is also a *samples* directory, containing completed applications.

Your workspace is the **my_work** folder. If you get stuck implementing any of the labs, **solutions** are available for your perusal.

PCF Environment Access

This workshop assumes participants will be interacting with PCF One. Depending on the client and environment, ask the instructor for an alternate CF API endpoint and/or url for the Apps Manager UI.

Account set up

1. If you do not have an account yet, please ask the instructor for one.

installations

The following tools are needed for the labs:

cf cli: <https://github.com/cloudfoundry/cli/releases> Docker: <https://docs.docker.com/docker-for-mac/install/> kubectl: <https://network.pivotal.io/products/pivotal-container-service> pks cli: <https://network.pivotal.io/products/pivotal-container-service> OpenJDK 11: `brew cask install adoptopenjdk11` IntelliJ Community Edition: <https://www.jetbrains.com/idea/download> Lombok plugin for IntelliJ: <https://plugins.jetbrains.com/plugin/6317-lombok>

Target the Environment

1. Set the API target for the CLI (set appropriate end point for your environment) and login:

```
$ cf api https://api.run.pcfone.io
$ cf login
```

Enter your account username and password, then select an org and space.

Apps Manager UI

1. An alternative to installing the CF CLI is via your PCF Apps Manager interface.

2. Navigate in a web browser to (depending on environment):

```
https://apps.run.pcfone.io
```

3. Login to the interface with your email and password
 - The password will be supplied to you by the instructor
4. Click the 'Tools' link, and download the CLI matching your operating system

01. Building a Spring Boot Application

In this lab we'll build a simple [Spring Boot](#) application whose sole purpose is to reply with a standard greeting.

Getting started

Although we will use a pre-created initial skeleton, it's important you'll learn how to use the [Spring Initializr](#). Head over to the URL and enter the following details:

1. Select a Gradle Project (projects are usually built using gradle or maven)
2. Select Java and the target language.
3. Latest stable version
4. **group**: io.pivotal
5. **artifact**: cloud-native-spring
6. Search for the following dependencies:
 - a. Web
 - b. Hateoas
 - c. Rest Repositories
 - d. JPA
 - e. Actuator
 - f. Lombok
7. Click "Generate"
8. Observe the contents of the downloaded ZIP file. This is the structure of a standard Spring Boot application. Code goes into `src/main/java`, properties or static content goes into `src/main/resources`, tests go into `src/test/java`.

Now let's continue with the pre-made skeleton.

1. Open a Terminal (e.g., `cmd` or `bash` shell)
2. Clone the pre-existing git repository:

```
git clone https://github.com/odedia/devops-workshop.git
```

3. Change the working directory to be `devops-workshop/labs/my_work/cloud-native-spring`

```
cd devops-workshop/labs/my_work/cloud-native-spring
```

4. Open this project in your editor/IDE of choice (IntelliJ is recommended).

idea .

Add an Endpoint

Within your editor/IDE complete the following steps:

1. Create a new package `io.pivotal.controller` underneath `src/main/java`.
2. Create a new class named `GreetingController` in the aforementioned package.
3. Add an `@RestController` annotation to the class `io.pivotal.controller.GreetingController` (i.e., `/cloud-native-spring/src/main/java/io/pivotal/controller/GreetingController.java`).

```
package io.pivotal.controller;

import org.springframework.web.bind.annotation.RestController;

@RestController
public class GreetingController {

}
```

4. Add the following request handler to the class `io.pivotal.controller.GreetingController` (i.e., `/cloud-native-spring/src/main/java/io/pivotal/controller/GreetingController.java`).

```
@GetMapping("/hello")
public String hello() {
    return "Hello World!";
}
```

Completed:

```
package io.pivotal.controller;

import org.springframework.web.bind.annotation.RestController;
import org.springframework.web.bind.annotation.GetMapping;

@RestController
public class GreetingController {

    @GetMapping("/hello")
    public String hello() {
        return "Hello World!";
    }

}
```

Build the *cloud-native-spring* application

Return to the Terminal session you opened previously and make sure your working directory is set to be `devops-workshop/labs/my_work/cloud-native-spring`

We're going to use [Gradle](#) to build and package artifacts. If you don't already have gradle installed, don't worry, we have you covered. You can use the embedded gradlew Wrapper.

1. Find out what tasks are available to you with

```
./gradlew tasks
```

2. First we'll run tests

```
./gradlew test
```

3. Next we'll package the application as a library artifact (it cannot be run on its own)

```
./gradlew jar
```

4. Next we'll package the application as an executable artifact (that can be run on its own because it will include all transitive dependencies along with embedding a web server and a servlet container)

```
./gradlew build
```

5. Examine the contents of the `build/libs` directory. You should see the final Spring Boot *jar* file. This jar file is completely portable - it contains everything that app needs, including an embedded Web server. This is why it is so big.

Run the *cloud-native-spring* application

Now we're ready to run the application

1. Run the application with

```
./gradlew bootRun
```

2. You should see the application start up an embedded Apache Tomcat server on port 8080 (review terminal output):

```
2018-08-22 17:40:18.193 INFO 92704 --- [          main]
o.s.b.w.embedded.tomcat.TomcatWebServer : Tomcat started on port(s): 8080 (http)
with context path ''
2018-08-22 17:40:18.199 INFO 92704 --- [          main]
i.p.CloudNativeSpringUiApplication      : Started CloudNativeSpringUiApplication
in 7.014 seconds (JVM running for 7.814)
```

3. Browse to <http://localhost:8080/hello>
4. Stop the *cloud-native-spring* application. In the terminal window type **Ctrl + C**

02. Enhancing Boot Application with Metrics

Set up the Actuator

Spring Boot includes a number of additional features to help you monitor and manage your application when it's pushed to production. These features are added by adding *spring-boot-starter-actuator* to the classpath. Our initial project setup already included it as a dependency.

1. Verify the Spring Boot Actuator dependency is in following file: **cloud-native-spring/build.gradle** You should see the following dependency in the list:

```
dependencies {  
    implementation('org.springframework.boot:spring-boot-starter-actuator')  
    // other dependencies omitted  
}
```

2. Run the application again using `./gradlew bootRun` and then check the application's metrics at <http://localhost:8080/actuator>.
3. Stop the application by typing **Ctrl+C**.

By default Spring Boot does not expose all the management endpoints (which is a good thing!). Though you wouldn't want to expose all of them in production, we'll do so in this sample app to make demonstration a bit easier and simpler.

4. Add the following properties to **cloud-native-spring/src/main/resources/application.yml**.

```
management:  
  endpoints:  
    web:  
      exposure:  
        include: "*"
```

5. Run the updated application

```
gradle clean bootRun
```

Try out the following endpoints. The output is omitted here because it can be quite large:

curl <http://localhost:8080/actuator/health>

→ Displays Application and Datasource health information. This can be customized based on application functionality, which we'll do later.

curl <http://localhost:8080/actuator/beans>

→ Displays all of the beans in the Spring context.

curl <http://localhost:8080/actuator/configprops>

→ Displays a collated list of all @ConfigurationProperties.

curl <http://localhost:8080/actuator/env>

→ Displays the application's shell environment as well as all Java system properties.

curl <http://localhost:8080/actuator/mappings>

→ Displays all URI request mappings and the controller methods to which they are mapped.

curl <http://localhost:8080/actuator/threaddump>

→ Displays a thread dump of the currently running application in JSON format.

curl <http://localhost:8080/actuator/heapdump>

→ Downloads a heap dump that you can import into a JVM profiler such as JProfiler.

curl <http://localhost:8080/actuator/httptrace>

→ Displays trace information (by default the last few HTTP requests).

6. Stop the *cloud-native-spring* application.

Include Version Control Info

Spring Boot provides an endpoint (<http://localhost:8080/actuator/info>) that allows the exposure of arbitrary metadata. By default, it is empty.

One thing that *actuator* does well is expose information about the specific build and version control coordinates for a given deployment.

1. Edit the following file: **cloud-native-spring/build.gradle** Add the [gradle-git-properties](#) plugin to your Gradle build.

First, you'll need to be able to resolve the plugin so add the following to the *plugins{}* section

```
plugins {  
    id 'com.gorylenko.gradle-git-properties' version '2.2.0'  
}
```

You'll also configure the plugin by adding a *gitProperties{}* block.

+

```
gitProperties {
    dateFormat = "yyyy-MM-dd'T'HH:mmZ"
    dateFormatTimeZone = "UTC"
    dotGitDirectory = "${project.rootDir}/../../.."
}
```

→ Note too that we are updating the path to the `.git` directory.

+ The effect of all this configuration is that the `gradle-git-properties` plugin adds Git branch and commit coordinates to the `/actuator/info` endpoint.

1. Run the `cloud-native-spring` application:

```
./gradle clean bootRun
```

2. Let's verify that Git commit information is now included

```
curl http://localhost:8080/actuator/info
```

```
{
  "git": {
    "commit": {
      "time": "2017-09-07T13:52+0000",
      "id": "3393f74"
    },
    "branch": "master"
  }
}
```

3. Stop the `cloud-native-spring` application

What Just Happened?

We have mapped Gradle properties into the `/actuator/info` endpoint.

Read more about exposing data in the `/actuator/info` endpoint [here](#)

Health Indicators

Spring Boot provides an endpoint <http://localhost:8080/actuator/health> that exposes various health indicators that describe the health of the given application.

Normally, the `/actuator/health` endpoint will only expose an UP or DOWN value.

```
{  
  "status": "UP"  
}
```

We want to expose more detail about the health and well-being of the application, so we're going to need a bit more configuration to `cloud-native-spring/src/main/resources/application.yml`, underneath the `management` prefix, add:

```
endpoint:  
  health:  
    show-details: always
```

1. Run the cloud-native-spring application:

```
gradle bootRun
```

2. Use curl to verify the output of the health endpoint

```
curl http://localhost:8080/actuator/health
```

Out of the box is a *DiskSpaceHealthIndicator* that monitors health in terms of available disk space. Would your Ops team like to know if the app is close to running out of disk space? *DiskSpaceHealthIndicator* can be customized via *DiskSpaceHealthIndicatorProperties*. For instance, setting a different threshold for when to report the status as DOWN.

```
{
  "status": "UP",
  "details": {
    "diskSpace": {
      "status": "UP",
      "details": {
        "total": 499963170816,
        "free": 375287070720,
        "threshold": 10485760
      }
    },
    "db": {
      "status": "UP",
      "details": {
        "database": "H2",
        "hello": 1
      }
    }
  }
}
```

3. Stop the cloud-native-spring application.

Metrics

Spring Boot provides an endpoint <http://localhost:8080/actuator/metrics> that exposes several automatically collected metrics for your application. It also allows for the creation of custom metrics.

1. Browse to <http://localhost:8080/actuator/metrics>. Review the metrics exposed.

```
{
  "names": [
    "jvm.memory.max",
    "http.server.requests",
    "jdbc.connections.active",
    "process.files.max",
    "jvm.gc.memory.promoted",
    "tomcat.cache.hit",
    "system.load.average.1m",
    "tomcat.cache.access",
    "jvm.memory.used",
    "jvm.gc.max.data.size",
    "jdbc.connections.max",
    "jdbc.connections.min",
    "jvm.gc.pause",
    "jvm.memory.committed",
    "system.cpu.count",
```

```

    "logback.events",
    "tomcat.global.sent",
    "jvm.buffer.memory.used",
    "tomcat.sessions.created",
    "jvm.threads.daemon",
    "system.cpu.usage",
    "jvm.gc.memory.allocated",
    "tomcat.global.request.max",
    "hikaricp.connections.idle",
    "hikaricp.connections.pending",
    "tomcat.global.request",
    "tomcat.sessions.expired",
    "hikaricp.connections",
    "jvm.threads.live",
    "jvm.threads.peak",
    "tomcat.global.received",
    "hikaricp.connections.active",
    "hikaricp.connections.creation",
    "process.uptime",
    "tomcat.sessions.rejected",
    "process.cpu.usage",
    "tomcat.threads.config.max",
    "jvm.classes.loaded",
    "hikaricp.connections.max",
    "hikaricp.connections.min",
    "jvm.classes.unloaded",
    "tomcat.global.error",
    "tomcat.sessions.active.current",
    "tomcat.sessions.alive.max",
    "jvm.gc.live.data.size",
    "tomcat.servlet.request.max",
    "hikaricp.connections.usage",
    "tomcat.threads.current",
    "tomcat.servlet.request",
    "hikaricp.connections.timeout",
    "process.files.open",
    "jvm.buffer.count",
    "jvm.buffer.total.capacity",
    "tomcat.sessions.active.max",
    "hikaricp.connections.acquire",
    "tomcat.threads.busy",
    "process.start.time",
    "tomcat.servlet.error"
  ]
}

```

2. Browse to <http://localhost:8080/actuator/metrics/jvm.memory.used> to see how much memory is currently being used.
3. Stop the cloud-native-spring application.

03. Creating a Dockerfile

Now that we have a running application, we want to run it in Kubernetes. But before we can do it, we'll need to create a docker file (or, to be more precise: an [OCI-compliant](#) image).

For a simple demo application in this workshop, any choice is probably fine. However, when you go to production things get a big more complicated:

1. What should be our base operating system? There are many choices. Ubuntu, RedHat, Suse, CentOS.
2. Who will be in charge of patching the OS?
3. What version of Java should we use? There are *many* choices. Search [Docker hub](#) for Java and see the various options. Who performs CVE Patching on these images? (Hint: if you don't know the answer, it's probably you).

Write a Dockerfile for this app. Select one of the options from [Docker hub](#) for now.

1. The jar file containing the application is under *build/libs/cloud-native-spring-1.0-SNAPSHOT.jar*.
2. The command to run the java application is

```
java -jar <file-name>.jar
```

→ Hint: Use the **ENTRYPOINT** command at the end of your Dockerfile to run the app.

Here's a base Dockerfile you can use with missing parameters:

```
FROM <??>
COPY build/libs/cloud-native-spring-solution-1.0-SNAPSHOT.jar /app.jar
EXPOSE 8080
ENTRYPOINT ["<??>", "<??>", "<??>"]
```

Let's build the docker image:

```
docker build -t cloud-native-spring .
```

Now let's run this container locally to make sure things still work.

```
docker run -p 8080:8080 cloud-native-spring
```

Go to <http://localhost:8080/hello> and check the results.

Tag the image and push it to docker.io.

```
docker tag cloud-native-spring <your-username>/cloud-native-spring  
docker push <your-username>/cloud-native-spring
```


04. Deploying to Kubernetes

In this lab we'll deploy our very simple application to Kubernetes, and try to make it production ready.

Login to PKS cluster shared by the instructor.

Creating a namespace

Create a new namespace for your team:

```
kubectl create namespace <my-team>
```

Creating a deployment

Create a deployment manifest to run the image we just deployed. Here's a skeleton you can use (or write your own):

```

apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  annotations:
    deployment.kubernetes.io/revision: "1"
  labels:
    run:
  name:
  namespace: default
spec:
  replicas:
  selector:
    matchLabels:
      run:
  strategy:
    rollingUpdate:
      maxSurge:
      maxUnavailable:
    type:
  template:
    metadata:
      labels:
        run:
    spec:
      containers:
        - image:
          imagePullPolicy:
          name:
          ports:
            - containerPort:
              protocol:
          dnsPolicy:
          restartPolicy:

```

Creating a service

Since we're using PKS, we're lucky - we can use a **LoadBalancer**. If we were to use another solution we might have to revert to a **NodePort** or to implement other solutions. Complete the skeleton yaml below, or write your own:

```
apiVersion: v1
kind: Service
metadata:
  labels:
    run:
name:
namespace:
spec:
  ports:
  - nodePort:
    port:
    protocol:
    targetPort:
  selector:
    run:
  sessionAffinity: None
  type:
```

Exposing a DNS Record

There are several ways to expose the service as a routable URL:

1. You can create an A record pointing to the load balancer. You will have to make sure the IP doesn't change.

→ Problem: Developers rarely have access to DNS, which means waiting for tickets between development and IT.
2. You can create an ingress gateway that routes to the deployment, which requires installing an additional ingress service to the cluster such as nginx.
3. You can leverage Istio/KNative

For now, let's just use the External IP we got.

Scaling

Edit the deployment yaml so that there are 3 pods instead of 1.

Testing our results

Check your external IP by running:

```
kubectl get svc -n <my-team-namespace>
```

Open <http://<my-external-ip>/hello> and make sure you got a response.

Making changes

One of the main advantages of going cloud-native is to have a fast feedback loop. What would happen if you were to make a single change in the code right now?

1. Change the greeting message from "Hello World!" to "Hello VMware!".
2. Get your new code to a running state in Kubernetes.

Logging

Check the logs of one of the pods by running `kubectl logs <pod-name> -n <my-team-namespace>`.

Logs from one pod is nice, but your application is being served from multiple pods. How can you get the logs from all pods of your app?

1. You can use sidecar containers to manually handle logging to a central solution
2. You can install Fluentd daemon sets (requires privilege access to `kube_system` namespace)
3. You can use commercial solutions such as Splunk, Datadog, SumoLogic, Log Insight etc. (at an added cost)
4. You can use open source solutions such as ELK, Graylog (but it is now your responsibility to maintain and upgrade this solution)

Monitoring

Our container provides basic metric information. We can get some of the data by running:

```
kubectl describe pod <my-pod> -n <my-team-namespace>
```

But this will only give us information on a specific pod. What about connections between pods or deployments? How can we find our own metrics that we expose via actuator? We can query the `/actuator` URL but this will only give a response from *one* of the pods.

1. You can use commercial solutions such as SysDig, Dynatrace, NewRelic, Wavefront (at an added cost)
2. You can use open source solutions such as Kibana, Prometheus, Grafana (but it is your responsibility to maintain and upgrade them)

The bottom line: If you got all of the requirements above working well, congratulations - you built your own platform on top of Kubernetes!



Kelsey Hightower ✓

@kelseyhightower

Following



Kubernetes is a platform for building platforms. It's a better place to start; not the endgame.

1:04 PM - 27 Nov 2017

219 Retweets 628 Likes



9



219



628



Kelsey Hightower ✓

@kelseyhightower

Following



Perception: I'm using pure Kubernetes; I don't need a platform.

Reality: Everything you do above kubectl is proof you need a platform and you're actually building one.

9:43 AM - 24 Feb 2019

365 Retweets 1,193 Likes





Joe Beda  @jbeda · Mar 4

Heh. Craig and I are the first to say that k8s is only part of the puzzle and it isn't the solution to all problems. No snake oil.



4



7



44



Craig McLuckie

@cmcluck

Follow

Replying to @jbeda @RwandaRob @kelseyhightower

If we do our job right, people will stop talking about k8s in the next 5 years. Not because it goes away, but because it becomes a normalized and boring substrate supporting waves of new innovation above it.

1:35 PM - 4 Mar 2019

30 Retweets 162 Likes



05. Adding Persistence to our Boot Application

In this lab we'll utilize Spring Boot, Spring Data, and Spring Data REST to create a fully-functional hypermedia-driven RESTful web service. Along the way we'll take a brief look at [Flyway](#) which can help us manage updates to database schema and data.

Create a Hypermedia-Driven RESTful Web Service with Spring Data REST (using JPA)

This application will allow us to create, read update and delete records in an [in-memory](#) relational repository. We'll continue building upon the Spring Boot application we built out in Lab 1. The first stereotype we will need is the domain model itself, which is [City](#).

Add the domain object - City

1. Create the package [io.pivotal.domain](#) and in that package create the class [City](#). Into that file you can paste the following source code, which represents cities based on postal codes, global coordinates, etc:

```

package io.pivotal.domain;

@Data
@Entity
@Table(name="city")
public class City implements Serializable {
    private static final long serialVersionUID = 1L;

    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private long id;

    @Column(nullable = false)
    private String name;

    @Column(nullable = false)
    private String county;

    @Column(nullable = false)
    private String stateCode;

    @Column(nullable = false)
    private String postalCode;

    @Column
    private String latitude;

    @Column
    private String longitude;
}

```

Notice that we're using [JPA](#) annotations on the class and its fields. We're also employing [Lombok](#), so we don't have to write a bunch of boilerplate code (e.g., getter and setter methods). You'll need to use your IDE's features to add the appropriate import statements.

→ Hint: imports should start with `javax.persistence` and `lombok`

2. Create the package `io.pivotal.repositories` and in that package create the interface `CityRepository`. Paste the following code and add appropriate imports:

```

package io.pivotal.repositories;

@RepositoryRestResource(collectionResourceRel = "cities", path = "cities")
public interface CityRepository extends PagingAndSortingRepository<City, Long> {
}

```

You'll need to use your IDE's features to add the appropriate import statements.

→ Hint: imports should start with `org.springframework.data.rest.core.annotation` and `org.springframework.data.repository`

Use Flyway to manage schema

1. Edit *build.gradle* and add the following dependencies within the *dependencies {}* block

```
implementation('org.flywaydb:flyway-core:5.2.4')
implementation('com.zaxxer:HikariCP:3.3.0')
```

2. Create a new file named `V1_0__init_database.sql` underneath *devops-workshop/labs/my_work/cloud-native-spring/src/main/resources/db/migration*, add the following lines and save.

```
CREATE TABLE city (
  ID INTEGER PRIMARY KEY AUTO_INCREMENT,
  NAME VARCHAR(100) NOT NULL,
  COUNTY VARCHAR(100) NOT NULL,
  STATE_CODE VARCHAR(10) NOT NULL,
  POSTAL_CODE VARCHAR(10) NOT NULL,
  LATITUDE VARCHAR(15) NOT NULL,
  LONGITUDE VARCHAR(15) NOT NULL
);
```

Spring Boot comes with out-of-the-box [integration](#) support for [Flyway](#). When we start the application it will execute a versioned [SQL migration](#) that will create a new table in the database.

3. Add the following lines to *devops-workshop/labs/my_work/cloud-native-spring/src/main/resources/application.yml*

```
spring:
  datasource:
    hikari:
      connection-timeout: 60000
      maximum-pool-size: 5
```

[Hikari](#) is a database connection pool implementation. We are limiting the number of database connections an individual application instance may consume.

Run the *cloud-native-spring* Application

1. Return to the Terminal session you opened previously
2. Run the application

```
./gradlew clean bootRun
```

3. Access the application using `curl` or your web browser using the newly added REST repository endpoint at <http://localhost:8080/cities>. You'll see that the primary endpoint automatically exposes the ability to page, size, and sort the response JSON.

```
curl http://localhost:8080/cities

HTTP/1.1 200 OK
Server: Apache-Coyote/1.1
Content-Type: application/hal+json;charset=UTF-8
Transfer-Encoding: chunked
Date: Thu, 28 Apr 2016 14:44:06 GMT

{
  "_embedded" : {
    "cities" : [ ]
  },
  "_links" : {
    "self" : {
      "href" : "http://localhost:8080/cities"
    },
    "profile" : {
      "href" : "http://localhost:8080/profile/cities"
    }
  },
  "page" : {
    "size" : 20,
    "totalElements" : 0,
    "totalPages" : 0,
    "number" : 0
  }
}
```

4. To exit the application, type **Ctrl-C**.

So what have you done? Created four small classes, modified a build file, added some configuration and SQL migration scripts, resulting in a fully-functional REST microservice. The application's `DataSource` is created automatically by Spring Boot using the in-memory database because **no other DataSource was detected in the project**.

Next we'll import some data.

Importing Data

1. Copy the `import.sql` file found in `devops-workshop/labs/` to `devops-workshop/labs/my_work/cloud-native-spring/src/main/resources/db/migration`. Rename the file to be `V1_1__seed_data.sql`. (This is a small subset of a larger dataset containing all of the postal codes in the United States and its

territories).

2. Restart the application.

```
./gradlew clean bootRun
```

3. Access the application again. Notice the appropriate hypermedia is included for `next`, `previous`, and `self`. You can also select pages and page size by utilizing `?size=n&page=n` on the URL string. Finally, you can sort the data utilizing `?sort=fieldName` (replace `fieldName` with a `cities` attribute).

```
curl http://localhost:8080/cities

HTTP/1.1 200 OK
Server: Apache-Coyote/1.1
X-Application-Context: application
Content-Type: application/hal+json
Transfer-Encoding: chunked
Date: Tue, 27 May 2014 19:59:58 GMT

{
  "_links" : {
    "next" : {
      "href" : "http://localhost:8080/cities?page=1&size=20"
    },
    "self" : {
      "href" : "http://localhost:8080/cities{?page,size,sort}",
      "templated" : true
    }
  },
  "_embedded" : {
    "cities" : [ {
      "name" : "HOLTSVILLE",
      "county" : "SUFFOLK",
      "stateCode" : "NY",
      "postalCode" : "00501",
      "latitude" : "+40.922326",
      "longitude" : "-072.637078",
      "_links" : {
        "self" : {
          "href" : "http://localhost:8080/cities/1"
        }
      }
    },
    // ...

    {
      "name" : "CASTANER",
      "county" : "LARES",
```

```
    "stateCode" : "PR",
    "postalCode" : "00631",
    "latitude" : "+18.269187",
    "longitude" : "-066.864993",
    "_links" : {
      "self" : {
        "href" : "http://localhost:8080/cities/20"
      }
    }
  } ]
},
"page" : {
  "size" : 20,
  "totalElements" : 42741,
  "totalPages" : 2138,
  "number" : 0
}
}
```

4. Try the following URL Paths with `curl` to see how the application behaves:

<http://localhost:8080/cities?size=5>

<http://localhost:8080/cities?size=5&page=3>

<http://localhost:8080/cities?sort=postalCode,desc>

Next we'll add searching capabilities.

Adding Search

1. Let's add some additional finder methods to `CityRepository`:

```

@RestResource(path = "name", rel = "name")
Page<City> findByNameIgnoreCase(@Param("q") String name, Pageable pageable);

@RestResource(path = "nameContains", rel = "nameContains")
Page<City> findByNameContainsIgnoreCase(@Param("q") String name, Pageable
pageable);

@RestResource(path = "state", rel = "state")
Page<City> findByStateCodeIgnoreCase(@Param("q") String stateCode, Pageable
pageable);

@RestResource(path = "postalCode", rel = "postalCode")
Page<City> findByPostalCode(@Param("q") String postalCode, Pageable pageable);

@Query(value = "select c from City c where c.stateCode = :stateCode")
Page<City> findByStateCode(@Param("stateCode") String stateCode, Pageable
pageable);

```

→ Hint: imports should start with `org.springframework.data.domain`, `org.springframework.data.rest.core.annotation`, `org.springframework.data.repository.query`, and `org.springframework.data.jpa.repository`

2. Run the application

```
./gradlew clean bootRun
```

3. Access the application again. Notice that hypermedia for a new `search` endpoint has appeared.

```
curl http://localhost:8080/cities
```

```
HTTP/1.1 200 OK
Server: Apache-Coyote/1.1
X-Application-Context: application
Content-Type: application/hal+json
Transfer-Encoding: chunked
Date: Tue, 27 May 2014 20:33:52 GMT
```

```
// prior omitted
},
"_links": {
  "first": {
    "href": "http://localhost:8080/cities?page=0&size=20"
  },
  "self": {
    "href": "http://localhost:8080/cities{?page,size,sort}",
    "templated": true
  },
  "next": {
    "href": "http://localhost:8080/cities?page=1&size=20"
  },
  "last": {
    "href": "http://localhost:8080/cities?page=2137&size=20"
  },
  "profile": {
    "href": "http://localhost:8080/profile/cities"
  },
  "search": {
    "href": "http://localhost:8080/cities/search"
  }
},
"page": {
  "size": 20,
  "totalElements": 42741,
  "totalPages": 2138,
  "number": 0
}
}
```

4. Access the new **search** endpoint:

<http://localhost:8080/cities/search>

```
curl http://localhost:8080/cities/search
```

```
HTTP/1.1 200 OK
```

```
Server: Apache-Coyote/1.1
```

```
X-Application-Context: application
```

```
Content-Type: application/hal+json
```

```
Transfer-Encoding: chunked
```

```
Date: Tue, 27 May 2014 20:38:32 GMT
```

```
{
  "_links": {
    "postalCode": {
      "href":
"http://localhost:8080/cities/search/postalCode{?q,page,size,sort}",
      "templated": true
    },
    "state": {
      "href": "http://localhost:8080/cities/search/state{?q,page,size,sort}",
      "templated": true
    },
    "nameContains": {
      "href":
"http://localhost:8080/cities/search/nameContains{?q,page,size,sort}",
      "templated": true
    },
    "name": {
      "href": "http://localhost:8080/cities/search/name{?q,page,size,sort}",
      "templated": true
    },
    "findByStateCode": {
      "href":
"http://localhost:8080/cities/search/findByStateCode{?stateCode,page,size,sort}",
      "templated": true
    },
    "self": {
      "href": "http://localhost:8080/cities/search"
    }
  }
}
```

Note that we now have new search endpoints for each of the finders that we added.

5. Try a few of these endpoints. Feel free to substitute your own values for the parameters.

<http://localhost:8080/cities/search/postalCode?q=01229>

<http://localhost:8080/cities/search/name?q=Springfield>

<http://localhost:8080/cities/search/nameContains?q=West&size=1>

→ For further details on what's possible with Spring Data JPA, consult the [reference documentation](#)

06. Running with persistence in Docker

So far we use the in-memory H2 database which is good for unit testing, but it's not feasible for production use - all our data will be gone whenever we restart the application.

Setting up the database docker container

First, we'll need to run a database. We'll use MySQL in our example. Searching Dockerhub, it seems that the default *mysql* image is the best option.

Before running the image, we need to setup a new docker network, so that our app container and our db container can talk to each other:

```
docker network create mynet
```

Now let's run the database in docker:

```
docker run --name mysql -p 3306:3306 -e MYSQL_ROOT_PASSWORD=my-secret-pw -d --net mynet mysql:5.7
```

The default user for this image is *root*. This is the first sign that the defaults are not production ready, because you'd rarely run your database as root. Also, the image would run the container but does not take into account responsibilities such as upgrading, backups, auditing etc. These are your responsibility.

Also, the image doesn't create any schemas other than the internal *sys* schema which we cannot use for our application. We'll need to create a new schema first. Let's ssh into our container:

```
docker exec -it mysql bash
```

Once in the container, we need to run the mysql cli (it would default to *localhost:3306* which is what we want):

```
mysql -p
```

Enter the password from above (*my-secret-pw*)

Now that we are in the cli, we can create our schema:

```
mysql> create schema my_db;  
Query OK, 1 row affected (0.00 sec)
```

type *exit* twice to return to the host.

Setting up the application

We now need to add the MySQL JDBC (Java Database Connectivity) driver to our application. Add the following to *build.gradle* under *dependencies*:

```
runtime('mysql:mysql-connector-java')
```

We now have two drivers in our application: H2 and MySQL. How will Spring know which database I want to use?

Like everything else in Spring, it uses *convention over configuration* and common sense. If you didn't provide connection parameters to MySQL, it would fallback to H2 since that's the default, testable database it can use.

Let's now define the connection parameters for our MySQL database. Update the `spring:database` section in `application.yml` so it would look like this:

```
spring:
  datasource:
    hikari:
      connection-timeout: 60000
      maximum-pool-size: 5
    url: jdbc:mysql://${MYSQL_HOST:localhost}:3306/my_db?useSSL=false
    username: root
    password: my-secret-pw
```

We can immediately see another issue - our password is written in clear text in our configuration file. We can think of various ways to overcome this:

1. Using a Spring Cloud Config Server
2. Using environment variables when starting the server
3. Managing secrets when running on Kubernetes (although remember - the default secret plugin is not encrypted so it makes no difference!)

Compile the updated application:

```
./gradlew build
```

We can see another problem: our unit tests now use our "production" database, which is not desirable. Also, if our MySQL database is not running, our tests will fail. run `docker stop mysql` and try building the application again - the tests would fail.

We'd like to keep using our H2 database for tests. We can do that by adding a different `application.yml` under `src/test/resources`. Anything that we'll put in this file will *override* the default configuration only when tests are running.

Create the file `src/test/resources/application.yml` and populate the following for H2 Database:

```
spring:
  datasource:
    hikari:
      connection-timeout: 60000
      maximum-pool-size: 5
    driver-class-name: org.h2.Driver
    url: jdbc:h2:mem:db;DB_CLOSE_DELAY=-1
    username: sa
    password: sa
```

Build the Docker image for our app again:

```
docker build -t cloud-native-spring .
```

And run it (notice the use of `--net` to allow us to communicate between two containers):

```
docker run -p 8080:8080 --net mynet -e MYSQL_HOST=mysql cloud-native-spring
```

See the log output to confirm you are connected to the new MySQL Database:

```
2020-02-02 12:24:01.154 INFO 7228 --- [           main]
com.zaxxer.hikari.HikariDataSource      : HikariPool-1 - Starting...
Sun Feb 02 12:24:01 IST 2020 WARN: Establishing SSL connection without server's
identity verification is not recommended. According to MySQL 5.5.45+, 5.6.26+ and
5.7.6+ requirements SSL connection must be established by default if explicit option
isn't set. For compliance with existing applications not using SSL the
verifyServerCertificate property is set to 'false'. You need either to explicitly
disable SSL by setting useSSL=false, or set useSSL=true and provide truststore for
server certificate verification.
2020-02-02 12:24:01.704 INFO 7228 --- [           main]
com.zaxxer.hikari.HikariDataSource      : HikariPool-1 - Start completed.
2020-02-02 12:24:01.707 INFO 7228 --- [           main]
o.f.c.internal.database.DatabaseFactory : Database: jdbc:mysql://localhost:3306/my_db
(MySQL 8.0)
2020-02-02 12:24:03.028 INFO 7228 --- [           main]
o.f.core.internal.command.DbValidate    : Successfully validated 2 migrations
(execution time 00:01.269s)
2020-02-02 12:24:03.056 INFO 7228 --- [           main]
o.f.core.internal.command.DbMigrate     : Current version of schema `my_db`: 1.0
2020-02-02 12:24:03.059 INFO 7228 --- [           main]
o.f.core.internal.command.DbMigrate     : Migrating schema `my_db` to version 1.1 -
seed data
2020-02-02 12:25:51.336 INFO 7228 --- [           main]
o.f.core.internal.command.DbMigrate     : Successfully applied 1 migration to schema
`my_db` (execution time 01:48.294s)
```

Verify you still get a response from <http://localhost:8080/cities>.

07. Running with persistence in Kubernetes

Source of Database

How will we install our database in Kubernetes?

1. We can install a database directly as an image like we just did locally, but that would present issues for upgrades, monitoring etc.
2. We can use helm charts that wrap images with some recommended values and best practices. Who would be responsible for upgrading them?
3. We can purchase database solutions based on Kubernetes operators / CRDs from a well-known vendor. The amount of production ready solutions is still low (Confluent Kafka, Greenplum, MongoDB Enterprise).

Regardless of the solution, we need to think of the following:

1. We need to make sure that *only* our application can access the database and no other pods. This requires Kubernetes *network policies* to be in place.
2. We need to update our application to point to the new database URL, username and password.
3. We need to do this every time we move to other environments (such as other namespaces or Kubernetes clusters).
4. We need to store password in a well-encrypted store. The default kubernetes secret management uses base64 encoding **which is not an encryption solution**

Setting up a database

1. For the sake of speed, you'll be preseted with the final Kubernetes yaml files. However, as you can image, defining all of them from scratch is not easy or trivial.
2. We need to setup a Persistent Volume (PV) to hold our stateful database files. For example:

```

apiVersion: v1
kind: PersistentVolume
metadata:
  name: mysql-pv-volume
  labels:
    type: local
spec:
  storageClassName: standard
  capacity:
    storage: 1Gi
  accessModes:
    - ReadWriteOnce
  hostPath:
    path: "/mnt/data"
  persistentVolumeReclaimPolicy: Delete

```

1. We need to define a Persistent Volume Claim (PVC) that would provision such PVs for us:

```

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: mysql-pv-claim
spec:
  storageClassName: standard
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi

```

1. We need to define a network policy that would only allow access from specific pods with specific labels:

```

kind: NetworkPolicy
apiVersion: networking.k8s.io/v1
metadata:
  name: db-allow
spec:
  podSelector:
    matchLabels:
      app: mysql
  ingress:
    - from:
        - podSelector:
            matchLabels:
              type: backend-app

```

1. Finally, we can define a deployment yaml for our database. Note that we use the password as a clear-text environment variable here. For real production use, we should have used a Kubernetes secret backed by a real encryption store such as Vault.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: mysql
spec:
  selector:
    matchLabels:
      app: mysql
  strategy:
    type: Recreate
  template:
    metadata:
      labels:
        app: mysql
    spec:
      containers:
        - image: mysql:5.7
          name: mysql
          env:
            # Use secret in real usage
            - name: MYSQL_ROOT_PASSWORD
              value: my-secret-pw
          ports:
            - containerPort: 3306
              name: mysql
          volumeMounts:
            - name: mysql-persistent-storage
              mountPath: /var/lib/mysql
      volumes:
        - name: mysql-persistent-storage
          persistentVolumeClaim:
            claimName: mysql-pv-claim
```

1. We also need to define a Kubernetes service to expose our database. Since we only have one pod running, we can define `clusterIP` as `None` for better performance.

```
apiVersion: v1
kind: Service
metadata:
  name: mysql
spec:
  ports:
    - port: 3306
  selector:
    app: mysql
  clusterIP: None
```

1. We'll also need to update our application's deployment yaml to override the MYSQL_HOST from the default set in `application.yml` to the service in our namespace:

```
env:
  # Use secret in real usage
  - name: MYSQL_HOST
    value: mysql.default.svc.cluster.local #replace default with your actual
namespace name!
```

1. Here's the full application deployment.yml for reference:

```

apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  labels:
    run: cloud-native-spring
    type: backend-app
  name: cloud-native-spring
  #namespace: instructor
spec:
  replicas: 1
  selector:
    matchLabels:
      run: cloud-native-spring
  strategy:
    rollingUpdate:
      type: RollingUpdate
  template:
    metadata:
      labels:
        run: cloud-native-spring
        type: backend-app
    spec:
      containers:
        - image: odedia/cloud-native-spring
          env:
            # Use secret in real usage
            - name: MYSQL_HOST
              value: mysql.default.svc.cluster.local
          imagePullPolicy: Always
          name: cloud-native-spring
          ports:
            - containerPort: 8080
              protocol: TCP

```

1. Some considerations for "code smells": Our application's deployment yaml is not portable, since it hardcodes the value of the target MySQL host. It's better to define a ConfigMap or another Kubernetes component to manage the value. Also, the password for the database is set both in our `application.yml` and in the database's deployment yaml file. We're also still using `latest` as the version of our application, which is not a good idea. It's better to manage real versions in our docker registry and update the deployment yaml every time to the newer version. For now, our best option is to delete the deployment and run `kubectl apply` again.

Check the value of the EXTERNAL IP for the service `cloud-native-spring`. Open the URL and check if you can see data in `https://<external-ip>/cities`

The bottom line

Congratulations! We were able to deploy a very simple app with a database to Kubernetes! However, as we saw along the way, getting something to work and getting something to be

production ready are two different things.

1. We haven't configured an external DNS, and are only using an external IP address.
2. Our docker image is not optimized. Every build pushes+pulls the entire 70+mb jar file layer.
3. Our start command is simple and works, but not optimized or tuned with the many JVM options.
4. We don't have aggregated logging, advanced monitoring solution, management UI or any of the items discussed in the previous Kubernetes exercise.
5. Our database exposes the password and does not handle auditing, upgrades, migrations etc.
6. We have **a lot** of yaml files to manage. We need to configure *everything*, there are no assumptions or conventions for our deployments.

08. Introduction to CF CLI

So far we discussed Java, but Cloud Foundry supports all the modern, cloud-native languages. Let's deploy some simple sample apps in various languages.

- Change the working directory to be *devops-workshop/labs/samples*

Note the sub-directories present..

```
samples
├── dotnet-core-sample
├── go-sample
├── nodejs-sample
└── python-sample
```

== Open Apps Manager

Go to the URL <https://apps.run.pcfone.io> and login with the credentials provided by your instructor.

How to target a foundation and login

1. Open a Terminal (e.g., *cmd* or *bash* shell)
2. Target a foundation and login

```
$ cf login -a https://api.run.pcfone.io
```

+ Enter your account username and password, then select an org and space unless those were chosen for you automatically.

How to deploy an application

1. Let's take a look at the CF CLI options

```
cf help -a
```

2. Let's see what buildpacks are available to us

```
cf buildpacks
```

3. Peruse the services you can provision and bind your applications to

```
cf marketplace
```

4. Time to deploy an app. How about Node.js? Before running *cf push*, always inspect the *manifest.yml* file in each directory.

```
cd nodejs-sample
cf push -c "node server.js"
```

Notice that PCF also *built* the application for you before creating the container and running the app. You can also build your application locally (if you have *yarn* installed), and just provide the final artifact to PCF:

```
yarn config set yarn-offline-mirror ./npm-packages-offline-cache
cp ~/.yarnrc .
rm -rf node_modules/ yarn.lock
yarn install

cf push -c "node server.js"
```

5. Next, let's try deploying a Python app. Note that again, PCF builds the application for you:

```
cd ../python-sample
cf push my_pyapp
```

6. Rinse and repeat for .Net Core (again, built during deployment):

```
cd ../dotnet-core-sample
cf push
```

7. Now let's push a Go app. Notice there's no *manifest.yml* in this directory. How did PCF know it's a Go app?

```
cd ../go-sample
cf push awesome-go-sample
```

8. So far we let the platform create our container images during deployment. But what about docker images that were already built? We can deploy those too.

```
cd ../docker-sample
cf push
```

9. Check what applications have been deployed so far

```
cf apps
```

→ Take some time to visit each of the applications you've just deployed.

Open Apps Manager and review your applications from the UI:

<https://apps.run.pcfone.io>

Click the "View App" link on the top right side of each app's overview screen.

1. Let's scale an app

```
cf scale cf-nodejs -i 3
cf apps
```

Refresh the App's URL and see how *INSTANCE INDEX* changes with each refresh.

2. Let's stop an app, then check that it has indeed been stopped

```
cf stop cf-nodejs
cf apps
```

How to cleanup after yourself

1. Finally, let's delete an app

```
cf delete cf-nodejs
```

→ Repeat **cf delete** for each app you deployed.

Where to go for more help

→ [Getting Started with the CF CLI](#)

→ [Cloud Foundry Cheat Sheet](#)

09. Deploy app with persistence to Pivotal Cloud Foundry

We've built and run the application locally. We deployed our application to Kubernetes. Now we'll deploy it to Cloud Foundry. Our application needs to use a MySQL database. How will we deploy one to PCF? Simple, we'll use the marketplace:

1. Run the following command to review the various services available in the marketplace:

```
cf marketplace
```

2. Review the various plans that are available for the `mysql` service:

```
cf marketplace -s p.mysql
```

3. Let's create a small MySQL Database:

```
cf create-service p.mysql db-small my-database
```

4. Our database is being created. You can check its status by running:

```
cf service my-database
```

→ All of these can also be done directly from the Apps Manager GUI. Go to the Marketplace link on the left-hand side. → Who was responsible for creating this database? It the operations team, not the development team. They added the service from the Pivotal Marketplace. The MySQL service in this case is a supported service from Pivotal. It also handles upgrades, backups, self-healing, monitoring with Healthwatch, auditing, and many other tasks that are not immediately obvious.

5. Create an application manifest in the root folder `devops-workshop/labs/my_work/cloud-native-spring touch manifest.yml`
6. Add application metadata, using a text editor (of choice)

```

---
applications:
- name: cloud-native-spring
  random-route: true
  path: ./build/libs/cloud-native-spring-1.0-SNAPSHOT.jar
  services:
  - my-database
  env:
    JBP_CONFIG_OPEN_JDK_JRE: '{ jre: { version: 11.+ } }'

```

→ Notice the simplified configuration file? We reduced 133 lines in Kubernetes to just 8 lines in PCF.

→ Notice the service in the `manifest.yml`? It's the service we just created. **That's all you need to do to make the connection between the application and the service.** Remember how much work that required in Kubernetes?

7. Push application into Cloud Foundry

```
cf push
```

→ To specify an alternate manifest and buildpack, you could run something like this:

```
cf push -f my-other-manifest.yml -b java_buildpack
```

8. Check the `start command` at the end of the log deployment:

```

JAVA_OPTS="-agentpath:$PWD/.java-buildpack/open_jdk_jre/bin/jvmskill-
1.16.0_RELEASE=printHeapHistogram=1 -Djava.io.tmpdir=$TMPDIR
-XX:ActiveProcessorCount=$(nproc)
-Djava.ext.dirs=$PWD/.java-buildpack/container_security_provider:$PWD/.java
-buildpack/open_jdk_jre/lib/ext
-Djava.security.properties=$PWD/.java-buildpack/java_security/java.security
$JAVA_OPTS" &&
  CALCULATED_MEMORY=$( $PWD/.java-buildpack/open_jdk_jre/bin/java-buildpack-memory-
calculator-3.13.0_RELEASE -totMemory=$MEMORY_LIMIT -loadedClasses=16787
  -poolType=metaspace -stackThreads=250 -vmOptions="$JAVA_OPTS") && echo JVM
Memory Configuration: $CALCULATED_MEMORY && JAVA_OPTS="$JAVA_OPTS
$CALCULATED_MEMORY" &&
  MALLOC_ARENA_MAX=2 SERVER_PORT=$PORT eval exec $PWD/.java-
buildpack/open_jdk_jre/bin/java $JAVA_OPTS -cp $PWD/.
org.springframework.boot.loader.JarLauncher

```

9. The reason for this long start command is that PCF optimizes the container and the JVM for production use. That includes running a memory calculator as part of the deployment to understand the optimal memory settings for the JVM, along with other fine-tuning. As you

recall, our start command in the Dockerfile was simply `java -jar app.jar`. Notice how many things need to be taken into consideration when you need to be production ready!

10. Find the URL created for your app in the health status report. Browse to your app's `/hello` endpoint.
11. Check the log output

```
cf logs cloud-native-spring --recent
```

12. Check the `/cities` endpoint by going to `https://<your-specific-route>/cities`. Wait a minute! How did this even work?! We didn't update the properties under `src/main/resources/application.yml`, yet somehow our app created the `city` table and populated it on startup using flyway. Not only that - we didn't even need to create a schema manually! How is that possible? That's the power of the **Open Service Broker API (OSBAPI)**.
13. To fully understand this magic, run the following command: `cf env cloud-native-spring`
14. Notice the `p.mysql` entry under `VCAP_SERVICES`? That was injected when we told our application that we'd like to **bind** our app to the `my-database` service. Binding provides all the environment variables needed to connect to the database (or any other service, such as a message broker). Even more impressive - Spring (and .NET with Steeltoe) knows how to autoconfigure itself and bind to this new database auto-magically. The parameters injected by the platform will override the settings in your `application.yml`, so your code will always remain portable. Eventually you'll move to a production environment and bind to a different database instance called `my-database`, but that's ok - all the parameters would be injected again, no code changes or recompile is required.
15. Perhaps even more important - you no longer have passwords scattered all over your code and your environment. **Only** users that are authorized to access this particular space and app will have the option to view the parameters of the database that includes the password. You can also leverage a PCF service called *Credhub*, which is an encrypted database for properties. If you were to use Credhub, you wouldn't even see the parameters when running `cf env`. **Only** the application's PID process would be able to automatically fetch the parameters on container startup.
16. How fast would it be to change one line in our code and have it running in "production"? Let's change `GreetingController.java` to greet us with `Hello VMware on PCF!`. All that's left to do is:

```
./gradlew build && cf push
```

Check the updated results under `https://<your-specific-route>/hello`

Exploring actuator in Apps Manager

1. When running a Spring Boot (or .NET with Steeltoe) application on Pivotal Cloud Foundry with the actuator endpoints enabled, you can visualize actuator management information in the Apps Manager dashboard.
2. Visit the route created for your app and append `/actuator/health` to see the health status report. See the same details in the Apps Manager UI:

APP **cloud-native-spring** Running [View App](#)

Buildpack: java_buildpack_offline Git: b57992b

Overview Services Route (1) Logs Tasks Settings

Events Last Push: 03:24 PM 03/22/17

- Started app azwickey 03/22/2017 at 07:24:47 PM UTC
- Updated app azwickey 03/22/2017 at 07:24:33 PM UTC

Scaling [Cancel](#) [Scale App](#)

Instances: 1 Memory Limit: 1 GB Disk Limit: 1 GB

Instances

| # | APP HEALTH | CPU | MEMORY | DISK | UPTIME |
|---|------------|-----|-----------|-----------|--------|
| 0 | Up | 4% | 520.58 MB | 158.11 MB | 1 min |

[Health Check](#) [View JSON](#)

flapping status: UP flapper: ok random: 54

diskSpace status: UP total: 1056858112 free: 891064320 threshold: 10485760

db status: UP database: H2 hello: 1

The Logs tab provides an **aggregated** view of all logs from all instances on our application. You can also change the logging level per class/package at runtime without having to restart:

Configure Logging Levels

Filter Loggers 8 / 436

| LOGGER | OFF | FATAL | ERROR | WARN | INFO | DEBUG | TRACE |
|--|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|--------------------------|--------------------------|
| ROOT | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.apache.catalina.startup.DigesterFactory | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.apache.catalina.util.LifecycleBase | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.apache.coyote.http11.Http11Protocol | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.apache.sshd.common.util.SecurityUtils | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.apache.tomcat.util.net.NioSelectorPool | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.eclipse.jetty.util.component.AbstractLifeCycle | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| org.hibernate.validator.internal.util.Version | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

[CLOSE](#)

2018-03-17T21:40:28.134+02:00 [RTR/3] [OUT] spring-boot-docker-010.cfapps.io - [2018-03-17T19:40:28.067+0000] "GET /cloudfoundryapplication/health HTTP/1.1" 200 0 124 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/64.0.3282.186 Safari/537.36" "10.10.2.163:2561" "10.10.149.134:61068" x_forwarded_for:"141.226.173.45, 10.10.2.163" x_forwarded_proto:"https" vcap_request_id:"5d4fef47-3c9a-4b1c-4900-98de6f7cd2bf" response_time:0.039098305 app_id:"76441bff-7709-42d5-a493-e42a6c083db6" app_index:"0" x_b3_traceid:"53b0a7877ce5e1e1" x_b3_spanid:"53b0a7877ce5e1e1" x_b3_parentspanid:"-"

2018-03-17T21:40:28.138+02:00 [RTR/11] [OUT] spring-boot-docker-010.cfapps.io - [2018-03-17T19:40:28.084+0000] "GET /cloudfoundryapplication/info HTTP/1.1" 200 0 2 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/64.0.3282.186 Safari/537.36" "10.10.2.163:33728" "10.10.149.134:61068" x_forwarded_for:"141.226.173.45, 10.10.2.163" x_forwarded_proto:"https" vcap_request_id:"ab7915ee-61c1-4e10-4e88-41930b0303ae" response_time:0.053205565 app_id:"76441bff-7709-42d5-a493-e42a6c083db6" app_index:"1" x_b3_traceid:"8ebb57d74ac7960c" x_b3_spanid:"8ebb57d74ac7960c" x_b3_parentspanid:"-"

2018-03-17T21:40:28.341+02:00 [RTR/11] [OUT] spring-boot-docker-010.cfapps.io - [2018-03-17T19:40:28.304+0000] "GET /cloudfoundryapplication/mappings HTTP/1.1" 200 0 24332 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/64.0.3282.186 Safari/537.36" "10.10.2.163:33744" "10.10.149.164:61096" x_forwarded_for:"141.226.173.45, 10.10.2.163" x_forwarded_proto:"https" vcap_request_id:"6330a81f-e760-4724-4232-0f659c6a0a09" response_time:0.036320803 app_id:"76441bff-7709-42d5-a493-e42a6c083db6" app_index:"1" x_b3_traceid:"ac571f9287ee833f" x_b3_spanid:"ac571f9287ee833f" x_b3_parentspanid:"-"

2018-03-17T21:40:28.386+02:00 [RTR/1] [OUT] spring-boot-docker-010.cfapps.io - [2018-03-17T19:40:28.359+0000] "GET /cloudfoundryapplication/health HTTP/1.1" 200 0 124 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/64.0.3282.186 Safari/537.36" "10.10.2.163:33744" "10.10.149.134:61068" x_forwarded_for:"141.226.173.45, 10.10.2.163" x_forwarded_proto:"https" vcap_request_id:"6330a81f-e760-4724-4232-0f659c6a0a09" response_time:0.036320803 app_id:"76441bff-7709-42d5-a493-e42a6c083db6" app_index:"1" x_b3_traceid:"ac571f9287ee833f" x_b3_spanid:"ac571f9287ee833f" x_b3_parentspanid:"-"

The Trace tab shows you the recent REST API calls made to your application:

ORG

DemoOrgMedium

SPACES

production

Marketplace

Docs

Support

Tools

Blog

Status

APP

spring-boot-docker-0.1.0

Running

VIEW APP

Overview

Service (1)

Route (1)

Logs

Tasks

Trace

Threads

Settings

Buildpack: N/A

Instance

ALL

Hide Pivotal Web Services Requests

Last refresh: 03/17/18 21:38 PM

REFRESH

>

#0

21:38:51.335

200

GET /favicon.ico

>

#0

21:38:49.954

200

GET /

6ms

Request:

host: spring-boot-docker-010.cfapps.io
user-agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/64.0.3282.186 S
accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/apng,*/*;q=0.8
accept-encoding: gzip, deflate, br
accept-language: en-US,en;q=0.9,he;q=0.8
cache-control: max-age=0
upgrade-insecure-requests: 1
x-b3-spanid: c277cff5c4867f1c
x-b3-traceid: c277cff5c4867f1c
x-cf-applicationid: 76441bff-7709-42d5-a493-e42a6c083db6
x-cf-instanceid: 3b5d6492-df1c-48cd-6439-156b
x-cf-instanceindex: 0
x-vcap-request-id: f7b37b10-af0f-4163-70dd-97a85b5d8015
x-forwarded-port: 443
x-forwarded-proto: https
x-request-start: 1521315529950

Response:
Content-Type: text/html;charset=UTF-8
Content-Length: 18
Date: Sat, 17 Mar 2018 19:38:49 GMT
status: 200

>

#0

21:38:49.703

200

GET /

>

#0

21:38:49.362

200

GET /

>

#0

21:38:49.086

200

GET /

>

#0

21:38:48.859

200

GET /

>

#0

21:38:48.404

200

GET /

>

#0

21:38:47.760

200

GET /

>

#1

21:38:47.512

200

GET /

>

#1

21:38:47.274

200

GET /

The Threads tab provides visibility into all threads currently running in your JVM. You can also download a heap dump for offline investigation:

ORG

DemoOrgMedium

SPACES

production

Marketplace

Docs

Support

Tools

Blog

Status

APP

spring-boot-docker-0.1.0

Running

VIEW APP

Overview

Service (1)

Route (1)

Logs

Tasks

Trace

Threads

Settings

Buildpack: N/A

Instance

0

Show

ALL

DUMP THREADS

Last refresh: 03/17/18 21:39 PM

REFRESH

| | | |
|---|--|---------------|
| > | container-0 | TIMED_WAITING |
| > | ContainerBackgroundProcessor[StandardEngine[Tomcat]] | TIMED_WAITING |
| > | DestroyJavaVM | RUNNABLE |
| > | file-watcher-/etc/cf-instance-credentials/instance.crt | WAITING |
| > | file-watcher-/etc/cf-instance-credentials/instance.key | WAITING |
| > | file-watcher-/etc/ssl/certs/ca-certificates.crt | WAITING |
| > | Finalizer | WAITING |
| > | http-nio-8080-Acceptor-0 | RUNNABLE |
| > | http-nio-8080-AsyncTimeout | TIMED_WAITING |
| > | http-nio-8080-ClientPoller-0 | RUNNABLE |
| > | http-nio-8080-ClientPoller-1 | RUNNABLE |
| > | http-nio-8080-exec-1 | WAITING |
| > | http-nio-8080-exec-10 | WAITING |
| > | http-nio-8080-exec-2 | RUNNABLE |
| > | http-nio-8080-exec-3 | WAITING |
| > | http-nio-8080-exec-4 | WAITING |
| > | http-nio-8080-exec-5 | WAITING |
| > | http-nio-8080-exec-6 | WAITING |
| > | http-nio-8080-exec-7 | WAITING |

From the overview screen, clicking on PCF Metrics takes you to a full-blown monitoring dashboard where you can correlate system events along with the logs that happened at that time. Excellent for troubleshooting.

Dashboard

Monitors ALPHA

spring-boot-docker-0.1.0

ORG: DemoOrgMedium

SPACE: production

STATUS: Running

STATIC Mar 17, 9:22 pm — Mar 17, 9:36 pm (local)

Instances

aggregate

ADD CHART

cf.system.latency

cf.system.request-count

cf.system.request-error-count

cf.system.cpu

cf.system.disk

cf.system.memory

cf.system.events

LOGS

All selected (8)

newest first

DOWNLOAD

Keyword

Highlight

CLEAR

APPLY

50

9:22 pm 9:23 pm 9:24 pm 9:25 pm 9:26 pm 9:27 pm 9:28 pm 9:29 pm 9:30 pm 9:31 pm 9:32 pm 9:33 pm 9:34 pm 9:35 pm 9:36

Sat Mar 17 2018 [CELL/0] 21:28:39.618 OUT Container became healthy

Sat Mar 17 2018 [APP/0] 21:28:37.704 OUT 2018-03-17 19:28:37.701 INFO 17 --- [main] hello.Application : Started Application in 12.191 seconds (JVM running for 14.175)

Sat Mar 17 2018 [APP/0] 21:28:37.692 OUT 2018-03-17 19:28:37.692 INFO 17 --- [main] o.s.b.w.embedded.tomcat.TomcatWebServer : Tomcat started on port(s): 8080 (http) with context path ''

Sat Mar 17 2018 [APP/0] 21:28:37.541 OUT 2018-03-17 19:28:37.540 INFO 17 --- [main] o.s.j.e.a.AnnotationMBeanExporter : Registering beans for JMX exposure on startup

Sat Mar 17 2018 [APP/0] 21:28:37.298 OUT 2018-03-17 19:28:37.298 INFO 17 --- [main] s.b.a.e.w.s.WebMvcEndpointHandlerMapping : Mapped "[/actuator],methods=[GET] produces=[application/vnd.spring-boot-actuator-v2+json-1] application/json" onto protected java.util.ManicJavaLang.String

Congratulations! You've just deployed a full-blown application to PCF along with a supporting database!

10. Adding Spring Cloud Config to Boot Application

In this lab we'll utilize Spring Boot and Spring Cloud to configure our application from a configuration dynamically retrieved from a Git repository. We'll then deploy it to Pivotal Cloud Foundry and auto-provision an instance of a configuration server using Pivotal Spring Cloud Services.

Why Spring Cloud Config?

In the Kubernetes world, we have the concept of ConfigMaps. They work well, but are mostly for simple key-value pairs. Spring have a framework called Spring Cloud Kubernetes that lets you load configuration parameters from a ConfigMap, but it is out of scope for this workshop. The main advantage of Spring Cloud Config (beyond the ability to change configuration with zero downtime or recompile), is auditing. Spring Cloud Config uses a git repository as the source of truth, and git audits the users that made changes including history and the ability to roll back changes in case there's an issue. Spring Cloud Config also lets you build hierarchies of configuration where a specific configuration would override a generic configuration, making it more robust for large and complex projects.

Update *Hello* REST service

These features are added by adding *spring-cloud-services-starter-config-client* to the classpath.

1. Delete your existing Gradle build file, found here: **/cloud-native-spring/build.gradle**. We're going to make a few changes. Create a new **/cloud-native-spring/build.gradle** then cut-and-paste the content below into it and save.

Adding a dependency management plugin and other miscellaneous configuration.

```
plugins {
    id 'com.gorylenko.gradle-git-properties' version '2.2.0'
    id 'org.springframework.boot' version '2.0.9.RELEASE'
    id 'io.spring.dependency-management' version '1.0.7.RELEASE'
    id 'java'
}

gitProperties {
    dateFormat = "yyyy-MM-dd'T'HH:mmZ"
    dateFormatTimeZone = "UTC"
    dotGitDirectory = "${project.rootDir}/../.."
}

import org.apache.tools.ant.filters.*

processResources {
    filter ReplaceTokens, tokens: [
```

```

        "application.name": project.property("application.name"),
        "application.description": project.property("application.description"),
        "application.version": project.property("version")
    ]
}

dependencyManagement {
    imports {
        mavenBom
    }
    org.springframework.boot.gradle.plugin.SpringBootPlugin.BOM_COORDINATES
        mavenBom "org.springframework.cloud:spring-cloud-dependencies:Finchley.SR3"
        mavenBom "io.pivotal.spring.cloud:spring-cloud-services-
dependencies:2.0.3.RELEASE"
    }
}

dependencies {
    implementation('org.glassfish.jaxb:jaxb-runtime:2.4.0-b180830.0438')
    if (JavaVersion.current() != JavaVersion.VERSION_1_8) {
        implementation('org.javassist:javassist:3.23.0-GA')
    } else {
        implementation('org.javassist:javassist:3.22.0-GA')
    }
    annotationProcessor('org.projectlombok:lombok:1.18.6')
    implementation('org.projectlombok:lombok:1.18.6')
    implementation('org.springframework.boot:spring-boot-starter-actuator')
    implementation('org.springframework.boot:spring-boot-starter-data-jpa')
    implementation('org.springframework.boot:spring-boot-starter-data-rest')
    implementation('org.springframework.boot:spring-boot-starter-hateoas')
    implementation('org.springframework.data:spring-data-rest-hal-browser')
    implementation('org.springframework.boot:spring-boot-starter-web')
    implementation('org.springframework.boot:spring-boot-starter-security')
    implementation('io.pivotal.spring.cloud:spring-cloud-services-starter-config-
client')
    implementation('org.flywaydb:flyway-core:5.2.4')
    implementation('com.zaxxer:HikariCP:3.3.0')
    runtime('com.h2database:h2')
    runtime('mysql:mysql-connector-java:8.0.15')
    testImplementation('org.springframework.boot:spring-boot-starter-test')
}

repositories {
    maven { url "https://repo.spring.io/plugins-release" }
    mavenCentral()
}

bootRun {
    // support passing -Dsystem.property=value to bootRun task
    systemProperties = System.properties
}

```

```
tasks.withType(Test) {
    if (JavaVersion.current() != JavaVersion.VERSION_1_8) {
        jvmArgs += ["--add-opens", "java.base/java.lang=ALL-UNNAMED"]
    }
}
```

2. Add an `@Value` annotation, private field, and update the existing `@GetMapping` annotated method to employ it in `io.pivotal.controller.GreetingController` (/cloud-native-spring/src/main/java/io/pivotal/controller/GreetingController.java):

```
@Value("${greeting:Hola}")
private String greeting;

@GetMapping("/hello")
public String hello() {
    return String.join(" ", greeting, "World!");
}
```

3. Add a `@RefreshScope` annotation to the top of the `GreetingController` class declaration

```
@RefreshScope
@RestController
public class GreetingController {
```

Completed:

```
package io.pivotal.controller;

import org.springframework.web.bind.annotation.RestController;
import org.springframework.web.bind.annotation.GetMapping;
import org.springframework.beans.factory.annotation.Value;
import org.springframework.cloud.context.config.annotation.RefreshScope;

@RefreshScope
@RestController
public class GreetingController {

    @Value("${greeting:Hola}")
    private String greeting;

    @GetMapping("/hello")
    public String hello() {
        return String.join(" ", greeting, "World!");
    }

}
```

4. When we introduced the Spring Cloud Services Starter Config Client dependency Spring Security will also be included at runtime (Config servers will be protected by OAuth2). However, this will also enable basic authentication to all our service endpoints. We will need to add the following to conditionally open security (to ease local workstation deployment).

In **build.gradle**, we'll need to add an *implementation* dependency

```
implementation('org.springframework.security:spring-security-config')
```

In **/cloud-native-spring/src/main/java/io/pivotal/CloudNativeSpringApplication.java** right underneath the **public static void main** method implementation, add

```
@Configuration
static class ApplicationSecurityOverride extends WebSecurityConfigurerAdapter {

    @Override
    public void configure(HttpSecurity http) throws Exception {
        http.csrf().disable();
        http.authorizeRequests().antMatchers("/**").permitAll();
    }
}
```

Examine this [Spring Boot reference](#) for further details. We're going to disable cross-site request forgery. We are also explicitly deactivating security, allowing unauthorized requests to all endpoints.

5. We'll also want to give our Spring Boot App a name so that it can lookup application-specific configuration from the config server later. Add the following configuration to **/cloud-native-spring/src/main/resources/bootstrap.yml**. (You'll need to create this file.)

```
spring:
  application:
    name: cloud-native-spring
```

Run the *cloud-native-spring* Application and verify dynamic config is working

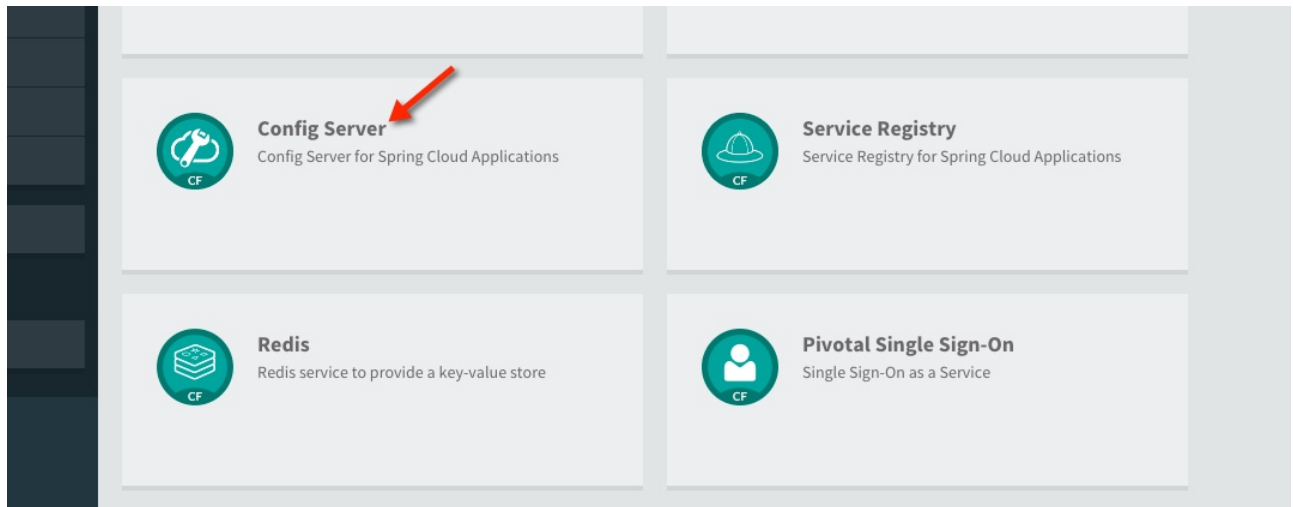
1. Run the application

```
./gradlew clean bootRun
```

2. Browse to <http://localhost:8080/hello> and verify you now see your new greeting.
3. Stop the *cloud-native-spring* application

Create Spring Cloud Config Server instance

1. Now that our application is ready to read its config from a Cloud Config server, we need to deploy one! This can be done through Cloud Foundry using the services Marketplace (see image below), however we'll use the command line.



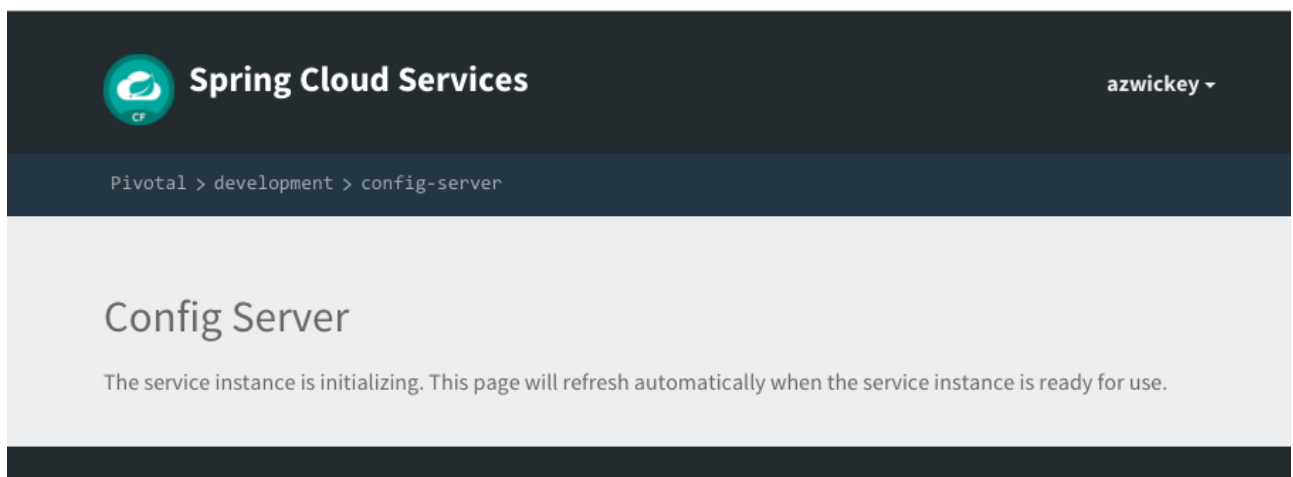
2. Create a file named `config.json` and update its contents to be

```
{
  "git": {
    "uri": "https://github.com/pacphi/config-repo"
  }
}
```

Using the Cloud Foundry CLI execute the following update service command:

```
cf create-service p.config-server standard my-config -c config.json
```

3. You can see the config server management dashboard under the "Services" tab.



4. We will now bind our application to our config-server within our Cloud Foundry deployment manifest. Add these entries to the bottom of `/cloud-native-spring/manifest.yml`


```
services:
- config-server
```

Complete:

```
---
applications:
- name: cloud-native-spring
  random-route: true
  path: ./build/libs/cloud-native-spring-1.0-SNAPSHOT.jar
  services:
  - my-database
  env:
    JBP_CONFIG_OPEN_JDK_JRE: '{ jre: { version: 11.+ } }'
```

Deploy and test application

1. Build the application

```
./gradlew clean build
```

2. Push application into Cloud Foundry

```
cf push
```

3. Test your application by navigating to the /hello endpoint of the application. You should now see a greeting that is read from the Cloud Config Server!

Ohai World!

What just happened??

→ A Spring component within the Spring Cloud Starter Config Client module called a *service connector* automatically detected that there was a Cloud Config service bound into the application. The service connector configured the application automatically to connect to the Cloud Config Server and downloaded the configuration and wired it into the application

4. If you navigate to the Git repo we specified for our configuration, <https://github.com/pacphi/config-repo>, you'll see a file named *cloud-native-spring.yml*. This filename is the same as our *spring.application.name* value for our Boot application. The configuration is read from this file, in our case the following property:

```
greeting: Ohai
```

— Loading order of properties: <https://docs.spring.io/spring-boot/docs/1.0.1.RELEASE/reference/html/boot-features-external-config.html>

5. Next we'll learn how to register our service with a Service Registry and load balance requests using Spring Cloud components.

11. Adding Service Registration and Discovery with Spring Cloud

In this lab we'll utilize Spring Boot and Spring Cloud to configure our application register itself with a Service Registry. To do this we'll also need to provision an instance of a Eureka service registry using Pivotal Cloud Foundry Spring Cloud Services. We'll also add a simple client application that looks up our application from the service registry and makes requests to our Cities service.

Update *Cloud-Native-Spring Boot* Application to Register with Eureka

1. These features are added by adding *spring-cloud-services-starter-service-registry* to the classpath. Open your Gradle build file, found here: **/cloud-native-spring/build.gradle**. Add the following spring cloud services dependency:

```
dependencies {  
    // add this dependency  
    implementation('io.pivotal.spring.cloud:spring-cloud-services-starter-service-  
registry')  
}
```

2. Thanks to Spring Cloud instructing your application to register with Eureka is as simple as adding a single annotation to your app! Add an *@EnableDiscoveryClient* annotation to the class *io.pivotal.CloudNativeSpringApplication* (/cloud-native-spring/src/main/java/io/pivotal/CloudNativeApplication.java):

```
@SpringBootApplication  
@EnableDiscoveryClient  
public class CloudNativeSpringApplication {
```

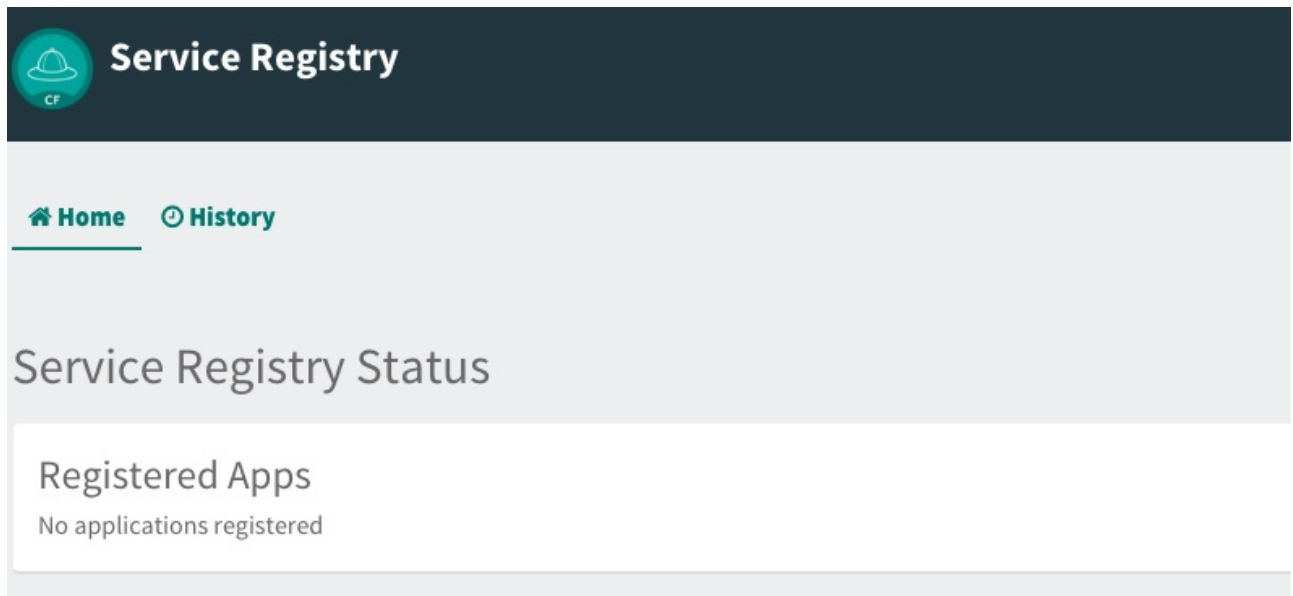
Create Spring Cloud Service Registry instance and deploy application

1. Now that our application is ready to register with an Eureka instance, we need to deploy one! This can be done through Cloud Foundry using the services Marketplace. Previously we did this through the Marketplace UI. This time around we will use the Cloud Foundry CLI:

```
cf create-service p-service-registry standard service-registry
```

2. After you create the service registry instance navigate to your Cloud Foundry space in the Apps Manager UI and refresh the page. You should now see the newly create Service Registry instance. Select the Manage link to view the registry dashboard. Note that there are not any registered

applications at the moment:



3. We will now bind our application to our service-registry within our Cloud Foundry deployment manifest. Add an additional reference to the service at the bottom of **/cloud-native-spring/manifest.yml** in the services list:

```
services:  
- config-server  
- service-registry
```

Deploy and test application

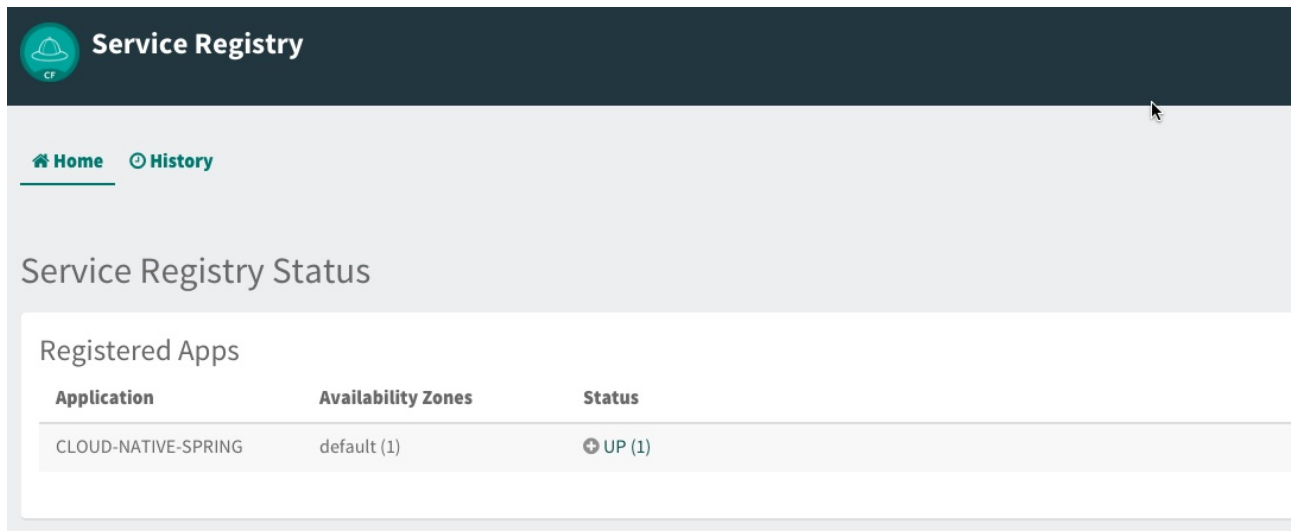
1. Build the application

```
./gradlew build
```

2. Push application into Cloud Foundry

```
cf push
```

3. If we now test our application URLs we will notice no significant changes. However, if we view the Service Registry dashboard (accessible from the *Manage* link in Apps Manager) you will see that a service named cloud-native-spring has registered:



4. Next we'll create a simple UI application that will read from the Service Registry to discover the location of our cities REST service and connect.

Create another Spring Boot Project as a Client UI

As in Lab 1 we will start with a project that has most of what we need to get going.

1. Open a Terminal (e.g., *cmd* or *bash* shell)
2. Change the working directory to be *devops-workshop/labs/my_work/cloud-native-spring-ui*

```
cd devops-workshop/labs/my_work/cloud-native-spring-ui  
idea .
```

Deploy and test application

1. Build the application. We have to skip the tests otherwise we may fail because of having 2 spring boot apps on the classpath

```
./gradlew build -x test
```

→ Note that we're skipping tests here (because we now have a dependency on a running instance of *cloud-native-spring*).

2. Create an application manifest in the root folder */cloud-native-spring-ui*

```
$ touch manifest.yml
```

3. Add application metadata

```

---
applications:
- name: cloud-native-spring
  random-route: true
  path: ./build/libs/cloud-native-spring-ui-1.0-SNAPSHOT.jar
  services:
  - my-database
  env:
    JBP_CONFIG_OPEN_JDK_JRE: '{ jre: { version: 11.+ } }'
  services:
  - service-registry

```

4. Push application into Cloud Foundry

```
cf push
```

5. Test your application by navigating to the `/` endpoint, which will invoke the Vaadin UI. You should now see a table listing the first set of rows returned from the cities microservice:

| County | Id | Latitude | Longitude | Name | Postal Code | State Code |
|-------------|----|------------|-------------|-------------|-------------|------------|
| SUFFOLK | 0 | +40.922326 | -072.637078 | HOLTSVILLE | 00501 | NY |
| SUFFOLK | 0 | +40.922326 | -072.637078 | HOLTSVILLE | 00544 | NY |
| ADJUNTAS | 0 | +18.165273 | -066.722583 | ADJUNTAS | 00601 | PR |
| AGUADA | 0 | +18.393103 | -067.180953 | AGUADA | 00602 | PR |
| AGUADILLA | 0 | +18.455913 | -067.145780 | AGUADILLA | 00603 | PR |
| AGUADILLA | 0 | +18.493520 | -067.135883 | AGUADILLA | 00604 | PR |
| AGUADILLA | 0 | +18.465162 | -067.141486 | AGUADILLA | 00605 | PR |
| MARICAO | 0 | +18.172947 | -066.944111 | MARICAO | 00606 | PR |
| ANASCO | 0 | +18.288685 | -067.139696 | ANASCO | 00610 | PR |
| UTUADO | 0 | +18.279531 | -066.802170 | ANGELES | 00611 | PR |
| ARECIBO | 0 | +18.450674 | -066.698262 | ARECIBO | 00612 | PR |
| ARECIBO | 0 | +18.458093 | -066.732732 | ARECIBO | 00613 | PR |
| ARECIBO | 0 | +18.429675 | -066.674506 | ARECIBO | 00614 | PR |
| ARECIBO | 0 | +18.444792 | -066.640678 | BAJADERO | 00616 | PR |
| BARCELONETA | 0 | +18.447092 | -066.544255 | BARCELONETA | 00617 | PR |
| CABO ROJO | 0 | +17.998531 | -067.187318 | BOQUERON | 00622 | PR |
| CABO ROJO | 0 | +18.062201 | -067.149541 | CABO ROJO | 00623 | PR |