Rishi Yadav

Apache Spark 2.x Cookbook

Cloud-ready recipes to do analytics and data science on Apache Spark

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BIRMINGHAM - MUMBAI

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First published: May 2017

Production reference: 1300517

Published by Packt Publishing Ltd.
Livery Place
35 Livery Street
Birmingham
B3 2PB, UK.
ISBN 978-1-78712-726-5

www.packtpub.com

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About the Author

Rishi Yadav has 19 years of experience in designing and developing enterprise applications. He is an open source software expert and advises American companies on big data and public cloud trends. Rishi was honored as one of Silicon Valley's 40 under 40 in 2014. He earned his bachelor's degree from the prestigious Indian Institute of Technology, Delhi, in 1998.

About 12 years ago, Rishi started InfoObjects, a company that helps data-driven businesses gain new insights into data. InfoObjects combines the power of open source and big data to solve business challenges for its clients and has a special focus on Apache Spark. The company has been on the Inc. 5000 list of the fastest growing companies for 6 years in a row. InfoObjects has also been named the best place to work in the Bay Area in 2014 and 2015.

Rishi is an open source contributor and active blogger.

This book is dedicated to my parents, Ganesh and Bhagwati Yadav; I would not be where I am without their unconditional support, trust, and providing me the freedom to choose a path of my own.

Special thanks go to my life partner, Anjali, for providing immense support and putting up with my long, arduous hours (yet again).

Our 9-year-old son, Vedant, and niece, Kashmira, were the unrelenting force behind keeping me and the book on track.

Big thanks to InfoObjects' CTO and my business partner, Sudhir Jangir, for providing valuable feedback and also contributing with recipes on enterprise security, a topic he is passionate about; to our SVP, Bart Hickenlooper, for taking the charge in leading the company to the next level; to Tanmoy Chowdhury and Neeraj Gupta for their valuable advice; to Yogesh Chandani, Animesh Chauhan, and Katie Nelson for running operations skillfully so that I could focus on this book; and to our internal review team (especially Rakesh Chandran) for ironing out the kinks. I would also like to thank Marcel Izumi for, as always, providing creative visuals. I cannot miss thanking our dog, Sparky, for giving me company on my long nights out. Last but not least, special thanks to our valuable clients, partners, and employees, who have made InfoObjects the best place to work at and, needless to say, an immensely successful organization.

About the Reviewer

Prashant Verma started his IT career in 2011 as a Java developer at Ericsson, working in the telecom domain. After a couple of years of Java EE experience, he moved into the big data domain and has worked on almost all the popular big data technologies, such as Hadoop, Spark, Flume, Mongo, and Cassandra. He has also played with Scala. Currently, he works with QA Infotech as a lead data engineer, working on solving e-learning problems using analytics and machine learning.

Prashant has also been working as a freelance consultant in his spare time.

I want to thank Packt Publishing for giving me the chance to review the book as well as my employer and my family for their patience while I was busy working on this book.

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Table of Contents

Preface

The success of Hadoop as a big data platform raised user expectations, both in terms of solving different analytics challenges and reducing latency. Various tools evolved over time, but when Apache Spark came, it provided a single runtime to address all these challenges. It eliminated the need to combine multiple tools with their own challenges and learning curves. Using memory for persistent storage besides compute, Apache Spark eliminates the need to store intermediate data on disk and increases processing speed up to 100 times. It also provides a single runtime, which addresses various analytics needs, such as machine-learning and real-time streaming, using various libraries.
This book covers the installation and configuration of Apache Spark and building solutions using Spark Core, Spark SQL, Spark Streaming, MLlib, and GraphX libraries.

For more information on this book's recipes, please visit `infoobjects.com/spark-cookbook`.

What this book covers

`Chapter 1`, *Getting Started with Apache Spark*, explains how to install Spark on various environments and cluster managers.

`Chapter 2`, *Developing Applications with Spark*, talks about developing Spark applications on different IDEs and using different build tools.

`Chapter 3`, *Spark SQL*, covers how to read and write to various data sources.

`Chapter 4`, *Working with External Data Sources*, takes you through the Spark SQL module that helps you access the Spark functionality using the SQL interface.

`Chapter 5`, *Spark Streaming*, explores the Spark Streaming library to analyze data from real-time data sources, such as Kafka.

`Chapter 6`, *Getting Started with Machine Learning*, covers an introduction to machine learning and basic artifacts, such as vectors and matrices.

`Chapter 7`, *Supervised Learning with MLlib – Regression*, walks through supervised learning when the outcome variable is continuous.

`Chapter 8`, *Supervised Learning with MLlib – Classification*, discusses supervised learning when the outcome variable is discrete.

`Chapter 9`, *Unsupervised Learning*, covers unsupervised learning algorithms, such as k-means.

`Chapter 10`, *Recommendations Using Collaborative Filtering*, introduces building recommender systems using various techniques, such as ALS.

`Chapter 11`, *Graph Processing Using GraphX and GraphFrames*, talks about various graph processing algorithms using GraphX.

`Chapter 12`, *Optimizations and Performance Tuning*, covers various optimizations on Apache Spark and performance tuning techniques.

What you need for this book

There are two ways to work with the recipes in this book:

- The first is to use Databricks Community Cloud at `https://community.cloud.databricks.com`. It is a free notebook provided by Databricks. All the sample data for this book has also been uploaded in the Amazon Web Service S3 bucket, namely `sparkcookbook`.
- The second option is to use InfoObjects Big Data Sandbox, which is a virtual machine built on top of Ubuntu. This software can be downloaded from `http://www.infoobjects.com`.

Who this book is for

If you are a data engineer, an application developer, or a data scientist who would like to leverage the power of Apache Spark to get better insights from big data, then this is the book for you.

Sections

In this book, you will find several headings that appear frequently (Getting ready, How to do it..., How it works..., There's more..., and See also).

To give clear instructions on how to complete a recipe, we use these sections as follows:

Getting ready

This section tells you what to expect in the recipe, and describes how to set up any software or any preliminary settings required for the recipe.

How to do it...

This section contains the steps required to follow the recipe.

How it works...

This section usually consists of a detailed explanation of what happened in the previous section.

There's more...

This section consists of additional information about the recipe in order to make the reader more knowledgeable about the recipe.

See also

This section provides helpful links to other useful information the recipe.

Conventions

In this book, you will find a number of text styles that distinguish between different kinds of information. Here are some examples of these styles and an explanation of their meaning.

Code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles are shown as follows: "Spark expects Java to be installed and the `JAVA_HOME` environment variable to be set."

A block of code is set as follows:

```
[{ "firstName" : "Bill", "lastName": "Clinton", "age": 70 }
        {"firstName": "Barack","lastName": "Obama", "age": 55}]
```

Any command-line input or output is written as follows:

```
scala> val people = spark.sql("select * from person")
```

New terms and **important** words are shown in bold. Words that you see on the screen, for example, in menus or dialog boxes, appear in the text like this: "Click on **Create cluster** and select the last option in the **Applications** option box."

Warnings or important notes appear in a box like this.

Tips and tricks appear like this.

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1
Getting Started with Apache Spark

In this chapter, we will set up Spark and configure it. This chapter contains the following recipes:

- Leveraging Databricks Cloud
- Deploying Spark using Amazon EMR
- Installing Spark from binaries
- Building the Spark source code with Maven
- Launching Spark on Amazon EC2
- Deploying Spark on a cluster in standalone mode
- Deploying Spark on a cluster with Mesos
- Deploying Spark on a cluster with YARN
- Understanding SparkContext and SparkSession
- Understanding Resilient Distributed Datasets (RDD)

Introduction

Apache Spark is a general-purpose cluster computing system to process big data workloads. What sets Spark apart from its predecessors, such as **Hadoop MapReduce**, is its speed, ease of use, and sophisticated analytics.

It was originally developed at *AMPLab*, *UC Berkeley*, in *2009*. It was made open source in 2010 under the BSD license and switched to the Apache 2.0 license in 2013. Toward the later part of 2013, the creators of Spark founded Databricks to focus on Spark's development and future releases.

Databricks offers Spark as a service in the **Amazon Web Services**(**AWS**) Cloud, called Databricks Cloud. In this book, we are going to maximize the use of AWS as a data storage layer.

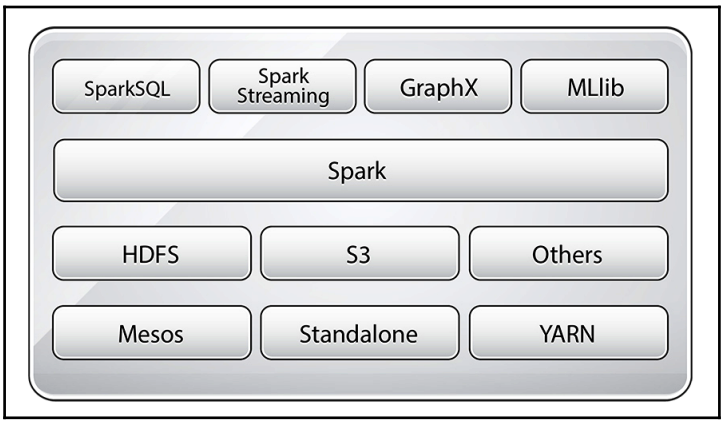
Talking about speed, Spark can achieve subsecond latency on big data workloads. To achieve such low latency, Spark makes use of memory for storage. In MapReduce, memory is primarily used for the actual computation. Spark uses memory both to compute and store objects.

Spark also provides a unified runtime connecting to various big data storage sources, such as HDFS, Cassandra, and S3. It also provides a rich set of high-level libraries for different big data compute tasks, such as machine learning, SQL processing, graph processing, and real-time streaming. These libraries make development faster and can be combined in an arbitrary fashion.

Though Spark is written in Scala--and this book only focuses on recipes on Scala--it also supports Java, Python, and R.

Spark is an open source community project, and everyone uses the pure open source Apache distributions for deployments, unlike Hadoop, which has multiple distributions available with vendor enhancements.

The following figure shows the Spark ecosystem:



Spark's runtime runs on top of a variety of cluster managers, including **YARN** (Hadoop's compute framework), **Mesos**, and Spark's own cluster manager called **Standalone** mode. Alluxio is a memory-centric distributed file system that enables reliable file sharing at memory speed across cluster frameworks. In short, it is an off-heap storage layer in memory that helps share data across jobs and users. Mesos is a cluster manager, which is evolving into a data center operating system. YARN is Hadoop's compute framework and has a robust resource management feature that Spark can seamlessly use.

Apache Spark, initially devised as a replacement of MapReduce, had a good proportion of workloads running in an on-premises manner. Now, most of the workloads have been moved to public clouds (AWS, Azure, and GCP). In a public cloud, we see two types of applications:

- Outcome-driven applications
- Data transformation pipelines

For outcome-driven applications, where the goal is to derive a predefined signal/outcome from the given data, Databricks Cloud fits the bill perfectly. For traditional data transformation pipelines, Amazon's **Elastic MapReduce** (**EMR**) does a great job.

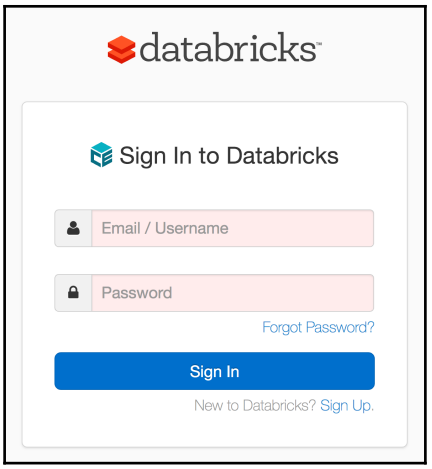
Leveraging Databricks Cloud

Databricks is the company behind Spark. It has a cloud platform that takes out all of the complexity of deploying Spark and provides you with a ready-to-go environment with notebooks for various languages. Databricks Cloud also has a community edition that provides one node instance with 6 GB of RAM for free. It is a great starting place for developers. The Spark cluster that is created also terminates after 2 hours of sitting idle.

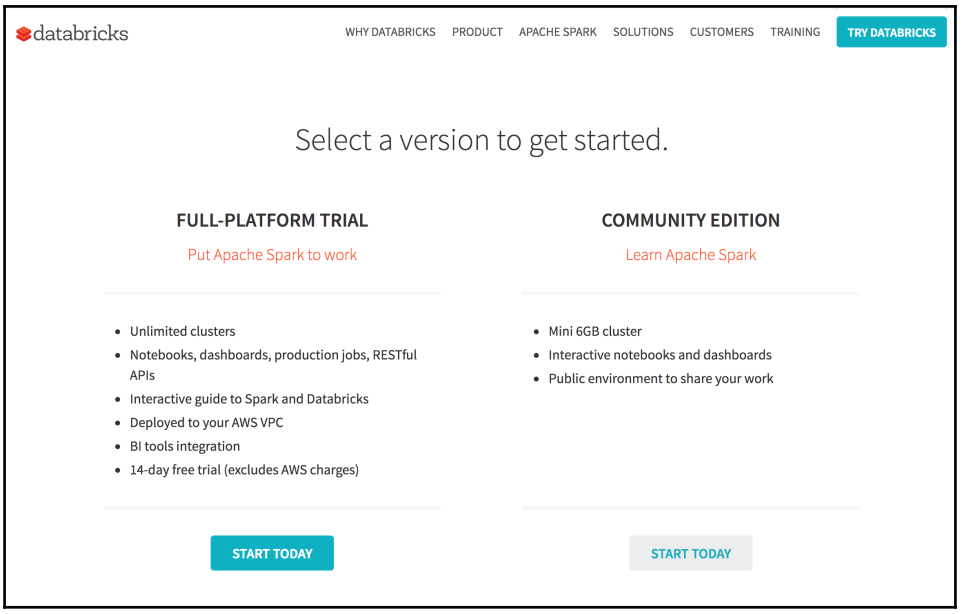
All the recipes in this book can be run on either the `InfoObjects` Sandbox or Databricks Cloud community edition. The entire data for the recipes in this book has also been ported to a public bucket called `sparkcookbook` on S3. Just put these recipes on the Databricks Cloud community edition, and they will work seamlessly.

How to do it...

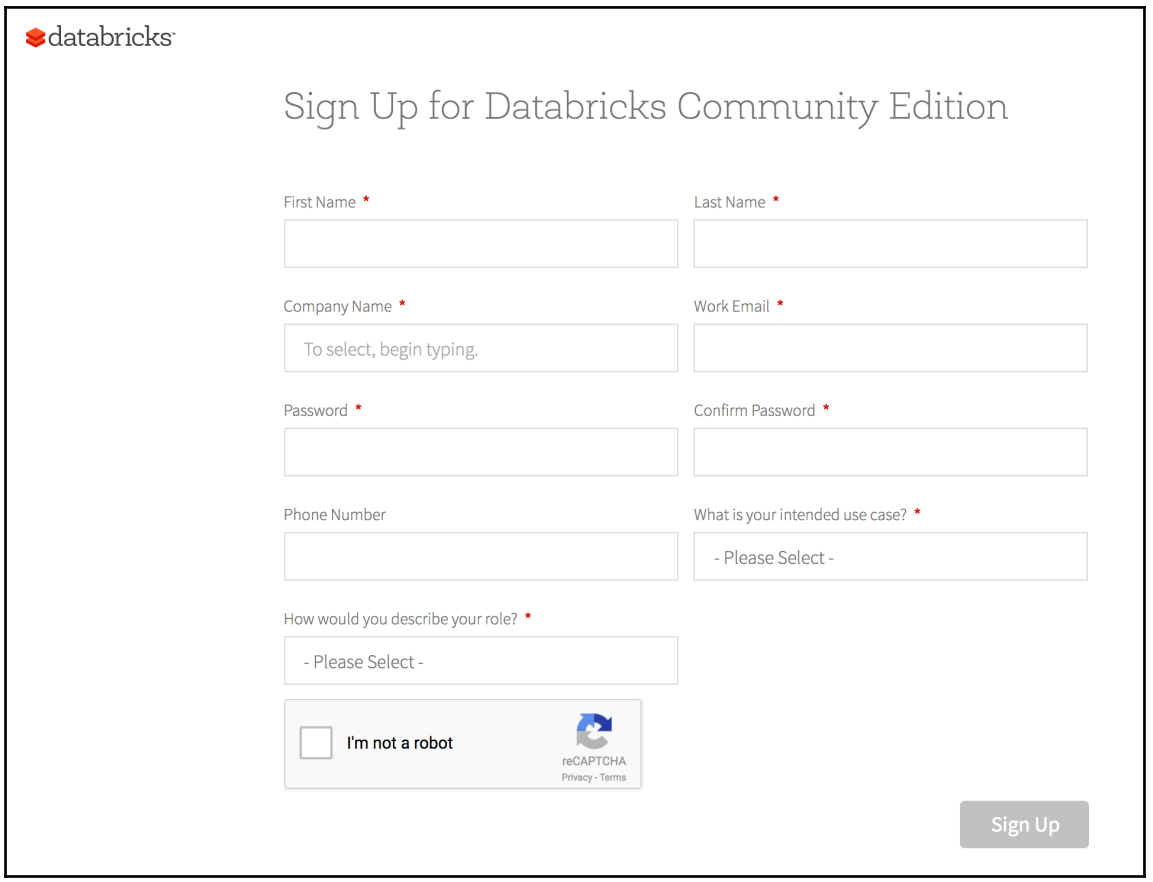
1. Go to `https://community.cloud.databricks.com`:



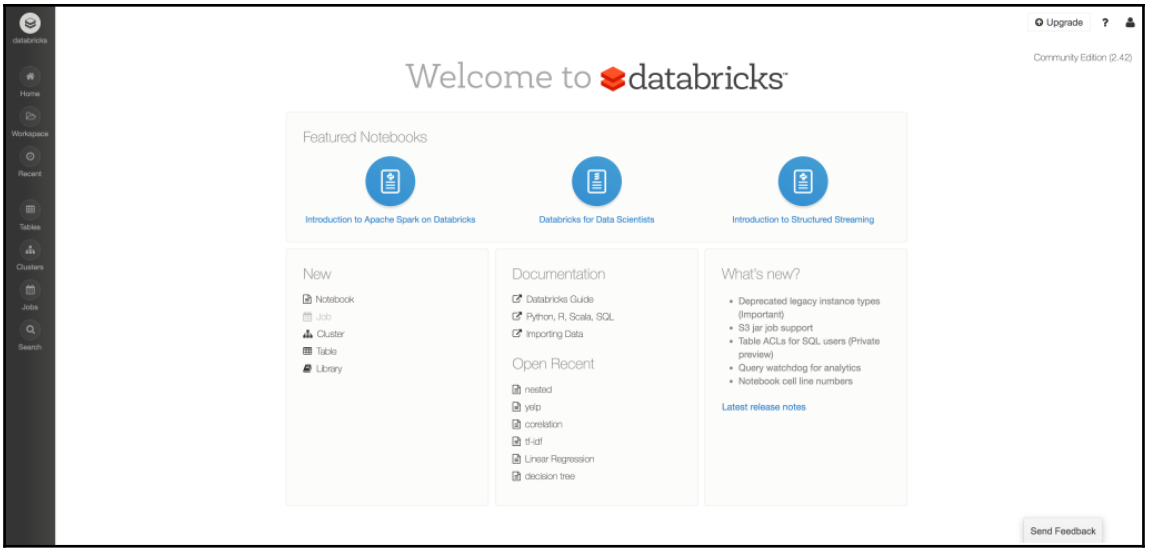
2. Click on **Sign Up :**



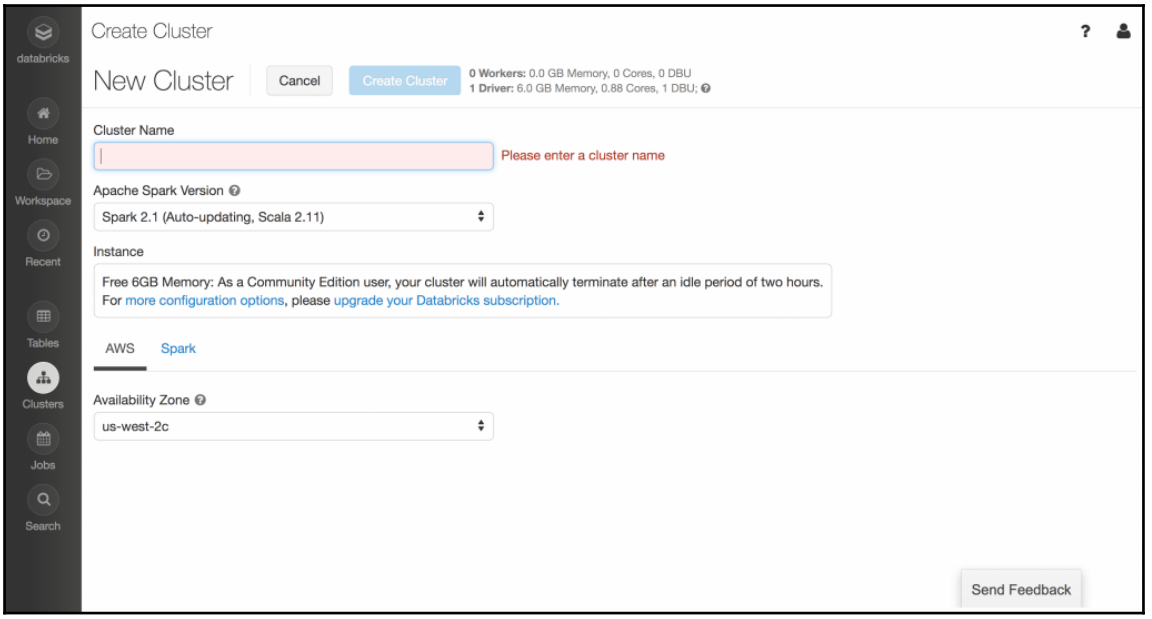
3. Choose **COMMUNITY EDITION** (or full platform):



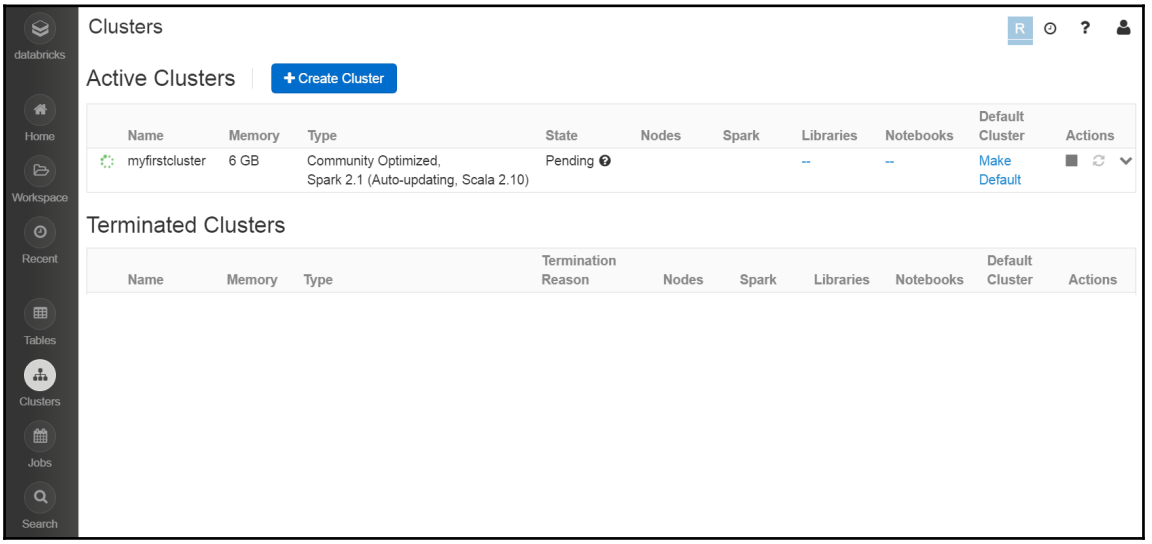
4. Fill in the details and you'll be presented with a landing page, as follows:



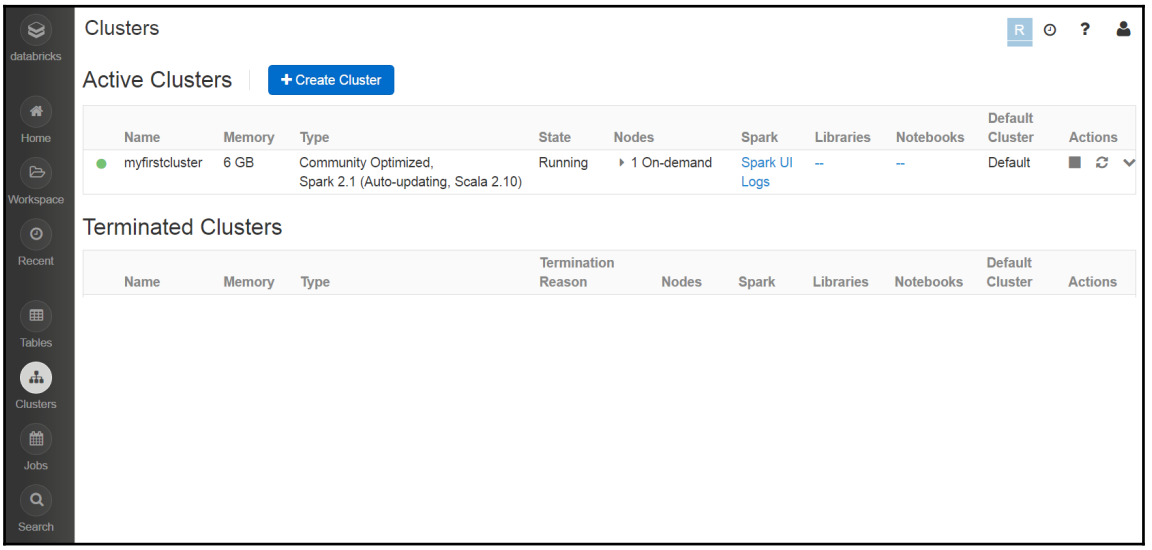
5. Click on **Clusters**, then **Create Cluster** (showing community edition below it):



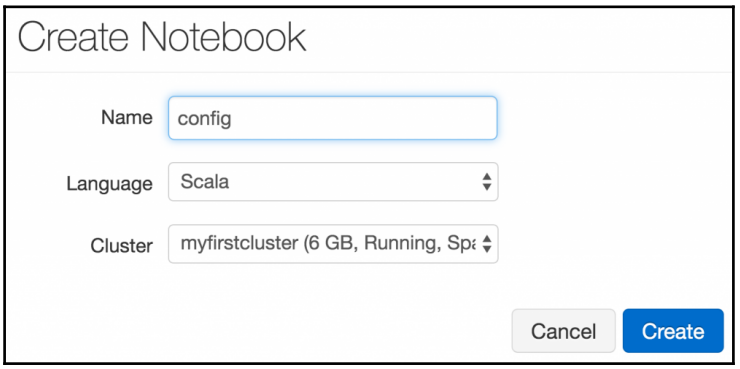
6. Enter the cluster name, for example, `myfirstcluster`, and choose **Availability Zone** (more about AZs in the next recipe). Then click on **Create Cluster**:



7. Once the cluster is created, the blinking green signal will become solid green, as follows:



8. Now go to **Home** and click on **Notebook**. Choose an appropriate notebook name, for example, `config`, and choose **Scala** as the language:



9. Then set the AWS access parameters. There are two access parameters:
   - `ACCESS_KEY`: This is referred to as `fs.s3n.awsAccessKeyId` in SparkContext's Hadoop configuration.
   - `SECRET_KEY`: This is referred to as `fs.s3n.awsSecretAccessKey` in SparkContext's Hadoop configuration.
10. Set `ACCESS_KEY` in the `config` notebook:

```
sc.hadoopConfiguration.set("fs.s3n.awsAccessKeyId", "<replace
  with your key>")
```

11. Set `SECRET_KEY` in the `config` notebook:

```
sc.hadoopConfiguration.set("fs.s3n.awsSecretAccessKey","
  <replace with your secret key>")
```

12. Load a folder from the `sparkcookbook` bucket (all of the data for the recipes in this book are available in this bucket:

```
val yelpdata =
  spark.read.textFile("s3a://sparkcookbook/yelpdata")
```

13. The problem with the previous approach was that if you were to publish your notebook, your keys would be visible. To avoid the use of this approach, use **Databricks File System** (**DBFS**).