# Table of Contents

I. Spring Boot Documentation ......................................................................................... 1
   1. About the documentation ................................................................................. 2
   2. Getting help ..................................................................................................... 3
   3. First steps ......................................................................................................... 4
   4. Working with Spring Boot .............................................................................. 5
   5. Learning about Spring Boot features ............................................................ 6
   6. Moving to production ...................................................................................... 7
   7. Advanced topics .............................................................................................. 8
II. Getting started ........................................................................................................ 9
   8. Introducing Spring Boot .................................................................................. 10
   9. Installing Spring Boot ...................................................................................... 11
      9.1. Installation instructions for the Java developer ........................................ 11
           Maven installation ......................................................................................... 11
           Gradle installation ......................................................................................... 12
      9.2. Installing the Spring Boot CLI ................................................................ 13
           Manual installation ......................................................................................... 13
           Installation with GVM .................................................................................... 13
           OSX Homebrew installation .......................................................................... 14
           Command-line completion ............................................................................. 14
           Quick start Spring CLI example ..................................................................... 14
      9.3. Upgrading from an earlier version of Spring Boot .................................... 15
   10. Developing your first Spring Boot application .................................................. 16
      10.1. Creating the POM ..................................................................................... 16
      10.2. Adding classpath dependencies .............................................................. 17
      10.3. Writing the code ....................................................................................... 17
           The @RestController and @RequestMapping annotations ....................... 18
           The @EnableAutoConfiguration annotation .............................................. 18
           The “main” method ....................................................................................... 18
      10.4. Running the example ............................................................................... 18
      10.5. Creating an executable jar ....................................................................... 19
   11. What to read next .............................................................................................. 21
III. Using Spring Boot .................................................................................................. 22
   12. Build systems .................................................................................................. 23
      12.1. Maven ....................................................................................................... 23
           Inheriting the starter parent .......................................................................... 23
           Using Spring Boot without the parent POM ................................................ 23
           Changing the Java version ............................................................................ 24
           Using the Spring Boot Maven plugin ......................................................... 24
      12.2. Gradle ........................................................................................................ 24
      12.3. Ant ............................................................................................................. 25
      12.4. Starter POMs ............................................................................................ 25
   13. Structuring your code ......................................................................................... 28
      13.1. Using the “default” package ..................................................................... 28
      13.2. Locating the main application class ......................................................... 28
   14. Configuration classes ........................................................................................ 30
      14.1. Importing additional configuration classes ............................................ 30
      14.2. Importing XML configuration .................................................................. 30
## IV. Spring Boot features

20. SpringApplication ................................................................. 38
20.1. Customizing the Banner ............................................. 38
20.2. Customizing SpringApplication .......................................... 38
20.3. Fluent builder API .................................................. 39
20.4. Application events and listeners ................................. 39
20.5. Web environment .................................................... 40
20.6. Using the CommandLineRunner .................................... 40
20.7. Application exit ...................................................... 40

21. Externalized Configuration ............................................. 41
21.1. Accessing command line properties ............................ 42
21.2. Application property files ....................................... 42
21.3. Profile specific properties ....................................... 43
21.4. Placeholders in properties ....................................... 43
21.5. Using YAML instead of Properties .............................. 43
    Loading YAML .......................................................... 43
    Exposing YAML as properties in the Spring Environment ....... 44
    Multi-profile YAML documents .................................... 44
    YAML shortcomings .................................................. 45
21.6. Typesafe Configuration Properties ............................... 45
    Relaxed binding ...................................................... 46
    @ConfigurationProperties Validation ............................. 46

22. Profiles ................................................................. 47
22.1. Adding active profiles ............................................. 47
22.2. Programmatically setting profiles .............................. 47
22.3. Profile specific configuration files ............................ 48

23. Logging ................................................................. 49
23.1. Log format .......................................................... 49
23.2. Console output .................................................... 49
23.3. File output ........................................................ 50
23.4. Log Levels ........................................................ 50
23.5. Custom log configuration ........................................ 50

24. Developing web applications ....................................... 52
24.1. The 'Spring Web MVC framework' ................................ 52
   Spring MVC auto-configuration .................................... 52
   HttpMessageConverters ............................................ 53
   MessageCodesResolver ............................................. 53
   Static Content ...................................................... 53
32. Developing auto-configuration and using conditions .................................................. 76
   32.1. Understanding auto-configured beans ................................................................. 76
   32.2. Locating auto-configuration candidates ......................................................... 76
   32.3. Condition annotations .............................................................. 76
       Class conditions .......................................................... 76
       Bean conditions .......................................................... 76
       Resource conditions ....................................................... 77
       Web Application Conditions ........................................... 77
       SpEL expression conditions ............................................... 77
33. What to read next ........................................................................................................ 78
V. Spring Boot Actuator: Production-ready features ......................................................... 79
34. Enabling production-ready features. ............................................................................ 80
35. Endpoints .................................................................................................................... 81
   35.1. Customizing endpoints .............................................................. 81
   35.2. Custom health information ................................................................. 82
   35.3. Custom application info information ...................................................... 82
       Automatically expand info properties at build time ............................................. 83
       Automatic property expansion using Maven ...................................................... 83
       Automatic property expansion using Gradle ..................................................... 83
       Git commit information .................................................................................. 83
36. Monitoring and management over HTTP ..................................................................... 85
   36.1. Exposing sensitive endpoints ............................................................................ 85
   36.2. Customizing the management server context path ........................................... 85
   36.3. Customizing the management server port ....................................................... 85
   36.4. Customizing the management server address ............................................... 86
   36.5. Disabling HTTP endpoints .............................................................................. 86
37. Monitoring and management over JMX .................................................................... 87
   37.1. Customizing MBean names ............................................................................. 87
   37.2. Disabling JMX endpoints .................................................................................. 87
   37.3. Using Jolokia for JMX over HTTP .................................................................. 87
       Customizing Jolokia ....................................................................................... 87
       Disabling Jolokia ............................................................................................... 87
38. Monitoring and management using a remote shell ...................................................... 89
   38.1. Connecting to the remote shell .......................................................................... 89
       Remote shell credentials .................................................................................. 89
   38.2. Extending the remote shell ............................................................................... 89
       Remote shell commands .................................................................................. 90
       Remote shell plugins ...................................................................................... 90
39. Metrics ....................................................................................................................... 91
   39.1. Recording your own metrics ............................................................................ 91
   39.2. Metric repositories .......................................................................................... 92
   39.3. Coda Hale Metrics ........................................................................................... 92
   39.4. Message channel integration .......................................................................... 92
40. Auditing ....................................................................................................................... 93
41. Tracing ........................................................................................................................ 94
   41.1. Custom tracing ................................................................................................. 94
42. Process monitoring ...................................................................................................... 95
   42.1. Extend configuration ...................................................................................... 95
   42.2. Programmatically ......................................................................................... 95
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.1</td>
<td>Troubleshoot auto-configuration</td>
<td>127</td>
</tr>
<tr>
<td>57.2</td>
<td>Customize the Environment or ApplicationContext before it starts</td>
<td>127</td>
</tr>
<tr>
<td>57.3</td>
<td>Build an ApplicationContext hierarchy (adding a parent or root context)</td>
<td>128</td>
</tr>
<tr>
<td>57.4</td>
<td>Create a non-web application</td>
<td>128</td>
</tr>
<tr>
<td>58.</td>
<td>Properties &amp; configuration</td>
<td>129</td>
</tr>
<tr>
<td>58.1</td>
<td>Externalize the configuration of SpringApplication</td>
<td>129</td>
</tr>
<tr>
<td>58.2</td>
<td>Change the location of external properties of an application</td>
<td>129</td>
</tr>
<tr>
<td>58.3</td>
<td>Use 'short' command line arguments</td>
<td>129</td>
</tr>
<tr>
<td>58.4</td>
<td>Use YAML for external properties</td>
<td>130</td>
</tr>
<tr>
<td>58.5</td>
<td>Set the active Spring profiles</td>
<td>130</td>
</tr>
<tr>
<td>58.6</td>
<td>Change configuration depending on the environment</td>
<td>131</td>
</tr>
<tr>
<td>58.7</td>
<td>Discover built-in options for external properties</td>
<td>131</td>
</tr>
<tr>
<td>59.</td>
<td>Embedded servlet containers</td>
<td>132</td>
</tr>
<tr>
<td>59.1</td>
<td>Add a Servlet, Filter or ServletContextListener to an application</td>
<td>132</td>
</tr>
<tr>
<td>59.2</td>
<td>Change the HTTP port</td>
<td>132</td>
</tr>
<tr>
<td>59.3</td>
<td>Use a random unassigned HTTP port</td>
<td>132</td>
</tr>
<tr>
<td>59.4</td>
<td>Discover the HTTP port at runtime</td>
<td>132</td>
</tr>
<tr>
<td>59.5</td>
<td>Configure SSL</td>
<td>133</td>
</tr>
<tr>
<td>59.6</td>
<td>Configure Tomcat</td>
<td>133</td>
</tr>
<tr>
<td>59.7</td>
<td>Enable Multiple Connectors with Tomcat</td>
<td>133</td>
</tr>
<tr>
<td>59.8</td>
<td>Use Tomcat behind a front-end proxy server</td>
<td>134</td>
</tr>
<tr>
<td>59.9</td>
<td>Use Jetty instead of Tomcat</td>
<td>134</td>
</tr>
<tr>
<td>59.10</td>
<td>Configure Jetty</td>
<td>135</td>
</tr>
<tr>
<td>59.11</td>
<td>Use Tomcat 8</td>
<td>135</td>
</tr>
<tr>
<td>59.12</td>
<td>Use Jetty 9</td>
<td>135</td>
</tr>
<tr>
<td>59.13</td>
<td>Create WebSocket endpoints using @ServerEndpoint</td>
<td>136</td>
</tr>
<tr>
<td>60.</td>
<td>Spring MVC</td>
<td>137</td>
</tr>
<tr>
<td>60.1</td>
<td>Write a JSON REST service</td>
<td>137</td>
</tr>
<tr>
<td>60.2</td>
<td>Write an XML REST service</td>
<td>137</td>
</tr>
<tr>
<td>60.3</td>
<td>Customize the Jackson ObjectMapper</td>
<td>137</td>
</tr>
<tr>
<td>60.4</td>
<td>Customize the @ResponseBody rendering</td>
<td>138</td>
</tr>
<tr>
<td>60.5</td>
<td>Handling Multipart File Uploads</td>
<td>138</td>
</tr>
<tr>
<td>60.6</td>
<td>Switch off the Spring MVC DispatcherServlet</td>
<td>138</td>
</tr>
<tr>
<td>60.7</td>
<td>Switch off the Default MVC configuration</td>
<td>138</td>
</tr>
<tr>
<td>60.8</td>
<td>Customize ViewResolvers</td>
<td>139</td>
</tr>
<tr>
<td>61.</td>
<td>Logging</td>
<td>141</td>
</tr>
<tr>
<td>61.1</td>
<td>Configure Logback for logging</td>
<td>141</td>
</tr>
<tr>
<td>61.2</td>
<td>Configure Log4j for logging</td>
<td>142</td>
</tr>
<tr>
<td>62.</td>
<td>Data Access</td>
<td>143</td>
</tr>
<tr>
<td>62.1</td>
<td>Configure a DataSource</td>
<td>143</td>
</tr>
<tr>
<td>62.2</td>
<td>Configure Two DataSources</td>
<td>143</td>
</tr>
<tr>
<td>62.3</td>
<td>Use Spring Data repositories</td>
<td>143</td>
</tr>
<tr>
<td>62.4</td>
<td>Separate @Entity definitions from Spring configuration</td>
<td>144</td>
</tr>
<tr>
<td>62.5</td>
<td>Configure JPA properties</td>
<td>144</td>
</tr>
<tr>
<td>62.6</td>
<td>Use a custom EntityManagerFactory</td>
<td>144</td>
</tr>
<tr>
<td>62.7</td>
<td>Use Two EntityManagerLayers</td>
<td>144</td>
</tr>
<tr>
<td>62.8</td>
<td>Use a traditional persistence.xml</td>
<td>145</td>
</tr>
<tr>
<td>62.9</td>
<td>Use Spring Data JPA and Mongo repositories</td>
<td>145</td>
</tr>
<tr>
<td>63.</td>
<td>Database initialization</td>
<td>146</td>
</tr>
<tr>
<td>63.1</td>
<td>Initialize a database using JPA</td>
<td>146</td>
</tr>
</tbody>
</table>
63.2. Initialize a database using Hibernate ................................................................. 146
63.3. Initialize a database using Spring JDBC ............................................................. 146
63.4. Initialize a Spring Batch database ..................................................................... 147
63.5. Use a higher level database migration tool .......................................................... 147
   Execute Flyway database migrations on startup ..................................................... 147
   Execute Liquibase database migrations on startup ................................................. 147
64. Batch applications ................................................................................................. 148
64.1. Execute Spring Batch jobs on startup ................................................................ 148
65. Actuator .................................................................................................................. 149
   65.1. Change the HTTP port or address of the actuator endpoints ............................. 149
   65.2. Customize the ‘whitelabel’ error page ............................................................... 149
66. Security .................................................................................................................... 150
   66.1. Switch off the Spring Boot security configuration ............................................. 150
   66.2. Change the AuthenticationManager and add user accounts ......................... 150
   66.3. Enable HTTPS when running behind a proxy server ....................................... 150
67. Hot swapping .......................................................................................................... 152
   67.1. Reload static content ....................................................................................... 152
   67.2. Reload Thymeleaf templates without restarting the container ......................... 152
   67.3. Reload FreeMarker templates without restarting the container ....................... 152
   67.4. Reload Groovy templates without restarting the container .............................. 152
   67.5. Reload Velocity templates without restarting the container ............................. 152
   67.6. Reload Java classes without restarting the container ....................................... 152
       Configuring Spring Loaded for use with Gradle and IntelliJ ................................. 152
68. Build ....................................................................................................................... 154
   68.1. Customize dependency versions with Maven .................................................... 154
   68.2. Create an executable JAR with Maven .............................................................. 154
   68.3. Create an additional executable JAR ............................................................... 155
   68.4. Extract specific libraries when an executable jar runs ....................................... 155
   68.5. Create a non-executable JAR with exclusions .................................................. 156
   68.6. Remote debug a Spring Boot application started with Maven ......................... 157
   68.7. Remote debug a Spring Boot application started with Gradle ......................... 157
   68.8. Build an executable archive with Ant .............................................................. 157
69. Traditional deployment ............................................................................................ 159
   69.1. Create a deployable war file ............................................................................. 159
   69.2. Create a deployable war file for older servlet containers ................................. 159
   69.3. Convert an existing application to Spring Boot ................................................ 159
X. Appendices ............................................................................................................. 161
   A. Common application properties ........................................................................... 162
   B. Auto-configuration classes ................................................................................. 168
       B.1. From the “spring-boot-autoconfigure” module .............................................. 168
       B.2. From the “spring-boot-actuator” module ..................................................... 169
   C. The executable jar format ..................................................................................... 171
       C.1. Nested JARs ...................................................................................................... 171
            The executable JAR file structure .................................................................... 171
            The executable war file structure .................................................................... 171
       C.2. Spring Boot’s “JarFile” class .......................................................................... 172
            Compatibility with the standard Java “JarFile” ................................................. 172
       C.3. Launching executable jars .............................................................................. 172
            Launcher manifest ............................................................................................. 173
            Exploded archives ............................................................................................ 173
C.4. PropertiesLauncher Features ................................................................. 173
C.5. Executable jar restrictions ................................................................. 174
    Zip entry compression ..................................................................... 174
    System ClassLoader ....................................................................... 174
C.6. Alternative single jar solutions ......................................................... 174
D. Dependency versions ......................................................................... 175
Part I. Spring Boot Documentation

This section provides a brief overview of Spring Boot reference documentation. Think of it as a map for the rest of the document. You can read this reference guide in a linear fashion, or you can skip sections if something doesn’t interest you.
1. About the documentation

The Spring Boot reference guide is available as html, pdf and epub documents. The latest copy is available at docs.spring.io/spring-boot/docs/current/reference.

Copies of this document may be made for your own use and for distribution to others, provided that you do not charge any fee for such copies and further provided that each copy contains this Copyright Notice, whether distributed in print or electronically.
2. Getting help

Having trouble with Spring Boot, We'd like to help!

• Try the How-to's — they provide solutions to the most common questions.

• Learn the Spring basics — Spring Boot is builds on many other Spring projects, check the spring.io web-site for a wealth of reference documentation. If you are just starting out with Spring, try one of the guides.

• Ask a question - we monitor stackoverflow.com for questions tagged with spring-boot.

• Report bugs with Spring Boot at github.com/spring-projects/spring-boot/issues.

Note

All of Spring Boot is open source, including the documentation! If you find problems with the docs; or if you just want to improve them, please get involved.
3. First steps

If you’re just getting started with Spring Boot, or ‘Spring’ in general, this is the place to start!

- From scratch: [Overview](#) | [Installation](#)
- Tutorial: [Part 1](#) | [Part 2](#)
- Running your example: [Part 1](#) | [Part 2](#)
4. Working with Spring Boot

Ready to actually start using Spring Boot? We’ve got you covered.

- **Build systems:** Maven | Gradle | Ant | Starter POMs
- **Best practices:** Code Structure | @Configuration | @EnableAutoConfiguration | Beans and Dependency Injection
- **Running your code** IDE | Packaged | Maven | Gradle
- **Packaging your app:** Production jars
- **Spring Boot CLI:** Using the CLI
5. Learning about Spring Boot features

Need more details about Spring Boot's core features? This is for you!

- **Core Features:** [SpringApplication](#) | [External Configuration](#) | [Profiles](#) | [Logging](#)
- **Web Applications:** [MVC](#) | [Embedded Containers](#)
- **Working with data:** [SQL](#) | [NO-SQL](#)
- **Messaging:** [Overview](#) | [JMS](#)
- **Testing:** [Overview](#) | [Boot Applications](#) | [Utils](#)
- **Extending:** [Auto-configuration](#) | [@Conditions](#)
6. Moving to production

When you’re ready to push your Spring Boot application to production, we’ve got some tricks that you might like!

- **Management endpoints**: Overview | Customization

- **Connection options**: HTTP | JMX | SSH

- **Monitoring**: Metrics | Auditing | Tracing | Process
7. Advanced topics

Lastly, we have a few topics for the more advanced user.

- **Deploy to the cloud:** [Cloud Foundry](https://www.cloudfoundry.org) | [Heroku](https://www.heroku.com) | [CloudBees](https://cloudbees.com)
- **Build tool plugins:** [Maven](https://maven.apache.org) | [Gradle](https://gradle.org)
- **Appendix:** [Application Properties](https://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#appendix.application-properties) | [Auto-configuration classes](https://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#appendix.reactive.auto-configuration) | [Executable Jars](https://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#appendix.executable-jars)
Part II. Getting started

If you're just getting started with Spring Boot, or 'Spring' in general, this is the section for you! Here we answer the basic "what?", "how?" and "why?" questions. You'll find a gentle introduction to Spring Boot along with installation instructions. We'll then build our first Spring Boot application, discussing some core principles as we go.
8. Introducing Spring Boot

Spring Boot makes it easy to create stand-alone, production-grade Spring based Applications that you can “just run”. We take an opinionated view of the Spring platform and third-party libraries so you can get started with minimum fuss. Most Spring Boot applications need very little Spring configuration.

You can use Spring Boot to create Java applications that can be started using `java -jar` or more traditional war deployments. We also provide a command line tool that runs “spring scripts”.

Our primary goals are:

- Provide a radically faster and widely accessible getting started experience for all Spring development.
- Be opinionated out of the box, but get out of the way quickly as requirements start to diverge from the defaults.
- Provide a range of non-functional features that are common to large classes of projects (e.g. embedded servers, security, metrics, health checks, externalized configuration).
- Absolutely no code generation and no requirement for XML configuration.
9. Installing Spring Boot

Spring Boot can be used with “classic” Java development tools or installed as a command line tool. Regardless, you will need Java SDK v1.6 or higher. You should check your current Java installation before you begin:

```
$ java -version
```

If you are new to Java development, or if you just want to experiment with Spring Boot you might want to try the Spring Boot CLI first, otherwise, read on for “classic” installation instructions.

**Tip**

Although Spring Boot is compatible with Java 1.6, if possible, you should consider using the latest version of Java.

9.1 Installation instructions for the Java developer

You can use Spring Boot in the same way as any standard Java library. Simply include the appropriate spring-boot-*.jar files on your classpath. Spring Boot does not require any special tools integration, so you can use any IDE or text editor; and there is nothing special about a Spring Boot application, so you can run and debug as you would any other Java program.

Although you could just copy Spring Boot jars, we generally recommend that you use a build tool that supports dependency management (such as Maven or Gradle).

**Maven installation**

Spring Boot is compatible with Apache Maven 3.0 or above. If you don’t already have Maven installed you can follow the instructions at maven.apache.org.

**Tip**

On many operating systems Maven can be installed via a package manager. If you’re an OSX Homebrew user try brew install maven. Ubuntu users can run sudo apt-get install maven.

Spring Boot dependencies use the org.springframework.boot groupId. Typically your Maven POM file will inherit from the spring-boot-starter-parent project and declare dependencies to one or more “Starter POMs”. Spring Boot also provides an optional Maven plugin to create executable jars.

Here is a typical pom.xml file:

```xml
<?xml version="1.0" encoding="UTF-8"?>
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.example</groupId>
  <artifactId>myproject</artifactId>
  <version>0.0.1- SNAPSHOT</version>

  <!-- Inherit defaults from Spring Boot -->
</project>
```
<parent>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-parent</artifactId>
  <version>1.1.9.RELEASE</version>
</parent>

<!-- Add typical dependencies for a web application -->
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
  </dependency>
</dependencies>

<!-- Package as an executable jar -->
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
    </plugin>
  </plugins>
</build>
</project>

**Tip**

The **spring-boot-starter-parent** is a great way to use Spring Boot, but it might not be suitable all of the time. Sometimes you may need to inherit from a different parent POM, or you might just not like our default settings. See the section called “Using Spring Boot without the parent POM” for an alternative solution that uses an import scope.

**Gradle installation**

Spring Boot is compatible with Gradle 1.6 or above. If you don’t already have Gradle installed you can follow the instructions at [www.gradle.org/](http://www.gradle.org/).

Spring Boot dependencies can be declared using the **org.springframework.boot** group. Typically your project will declare dependencies to one or more **Starter POMs**. Spring Boot provides a useful [Gradle plugin](http://www.gradle.org/docs/current/userguide/gradle_plugin.html) that can be used to simplify dependency declarations and to create executable jars.

**Gradle Wrapper**

The Gradle Wrapper provides a nice way of “obtaining” Gradle when you need to build a project. It’s a small script and library that you commit alongside your code to bootstrap the build process. See [www.gradle.org/docs/current/userguide/gradle_wrapper.html](http://www.gradle.org/docs/current/userguide/gradle_wrapper.html) for details.

Here is a typical **build.gradle** file:

```groovy
buildscript {
    repositories {
        mavenCentral()
        maven { url "http://repo.spring.io/snapshot" }
        maven { url "http://repo.spring.io/milestone" }
    }
    dependencies {
        classpath("org.springframework.boot:spring-boot-gradle-plugin:1.1.9.RELEASE")
    }
}
```
apply plugin: 'java'
apply plugin: 'spring-boot'

jar {
    baseName = 'myproject'
    version = '0.0.1-SNAPSHOT'
}

repositories {
    mavenCentral()
    maven { url "http://repo.spring.io/snapshot" }
    maven { url "http://repo.spring.io/milestone" }
}

dependencies {
    compile("org.springframework.boot:spring-boot-starter-web")
    testCompile("org.springframework.boot:spring-boot-starter-test")
}

9.2 Installing the Spring Boot CLI

The Spring Boot CLI is a command line tool that can be used if you want to quickly prototype with Spring. It allows you to run Groovy scripts, which means that you have a familiar Java-like syntax, without so much boilerplate code.

You don’t need to use the CLI to work with Spring Boot but it’s definitely the quickest way to get a Spring application off the ground.

Manual installation

You can download the Spring CLI distribution from the Spring software repository:

- spring-boot-cli-1.1.9.RELEASE-bin.zip
- spring-boot-cli-1.1.9.RELEASE-bin.tar.gz

Cutting edge snapshot distributions are also available.

Once downloaded, follow the INSTALL.txt instructions from the unpacked archive. In summary: there is a spring script (spring.bat for Windows) in a bin/ directory in the .zip file, or alternatively you can use java -jar with the .jar file (the script helps you to be sure that the classpath is set correctly).

Installation with GVM

GVM (the Groovy Environment Manager) can be used for managing multiple versions of various Groovy and Java binary packages, including Groovy itself and the Spring Boot CLI. Get gvm from gvmtool.net and install Spring Boot with

$ gvm install springboot
$ spring --version
Spring Boot v1.1.9.RELEASE

If you are developing features for the CLI and want easy access to the version you just built, follow these extra instructions.

$ gvm install springboot dev /path/to/spring-boot/spring-boot-cli/target/spring-boot-cli-1.1.9.RELEASE-bin/spring-1.1.9.RELEASE/
$ gvm use springboot dev
$ spring --version
Spring CLI v1.1.9.RELEASE
This will install a local instance of spring called the dev instance inside your gvm repository. It points at your target build location, so every time you rebuild Spring Boot, spring will be up-to-date.

You can see it by doing this:

```
$ gvm ls springboot
+-------------------------------+---------------------------------------+-------------------------------+
| Available Springboot Versions |
+-------------------------------+---------------------------------------+-------------------------------+
| > + dev                       |
| * 1.1.9.RELEASE               |
+-------------------------------+---------------------------------------+-------------------------------+
+ - local version              |
| * - installed                 |
| > - currently in use          |
+-------------------------------+---------------------------------------+-------------------------------+
```

**OSX Homebrew installation**

If you are on a Mac and using Homebrew, all you need to do to install the Spring Boot CLI is:

```
$ brew tap pivotal/tap
$ brew install springboot
```

Homebrew will install spring to /usr/local/bin.

**Note**

If you don’t see the formula, your installation of brew might be out-of-date. Just execute brew update and try again.

**Command-line completion**

Spring Boot CLI ships with scripts that provide command completion for BASH and zsh shells. You can source the script (also named spring) in any shell, or put it in your personal or system-wide bash completion initialization. On a Debian system the system-wide scripts are in /shell-completion/bash and all scripts in that directory are executed when a new shell starts. To run the script manually, e.g. if you have installed using GVM

```
$ . ~/.gvm/springboot/current/shell-completion/bash/spring
$ spring <HIT TAB HERE>
  grab  help  jar  run  test  version
```

**Note**

If you install Spring Boot CLI using Homebrew, the command-line completion scripts are automatically registered with your shell.

**Quick start Spring CLI example**

Here’s a really simple web application that you can use to test you installation. Create a file called app.groovy:

```
@RestController
class ThisWillActuallyRun {
```

```
@RequestMapping("/")
String home() { 
    "Hello World!"
}

Then simply run it from a shell:

$ spring run app.groovy

**Note**

It will take some time when you first run the application as dependencies are downloaded, subsequent runs will be much quicker.

Open localhost:8080 in your favorite web browser and you should see the following output:

Hello World!

### 9.3 Upgrading from an earlier version of Spring Boot

If you are upgrading from an earlier release of Spring Boot check the “release notes” hosted on the project wiki. You’ll find upgrade instructions along with a list of “new and noteworthy” features for each release.

To upgrade an existing CLI installation use the appropriate package manager command (for example `brew upgrade`) or, if you manually installed the CLI, follow the standard instructions remembering to update your `PATH` environment variable to remove any older references.
10. Developing your first Spring Boot application

Let's develop a simple “Hello World!” web application in Java that highlights some of Spring Boot's key features. We'll use Maven to build this project since most IDEs support it.

Tip

The spring.io web site contains many “Getting Started” guides that use Spring Boot. If you're looking to solve a specific problem; check there first.

Before we begin, open a terminal to check that you have valid versions of Java and Maven installed.

```
$ java -version
java version "1.7.0_51"
Java(TM) SE Runtime Environment (build 1.7.0_51-b13)
Java HotSpot(TM) 64-Bit Server VM (build 24.51-b03, mixed mode)
```

```
$ mvn -v
Apache Maven 3.1.1 (0728685237757ffbf44136acac9402957f73d9a; 2013-09-17 08:22:22-0700)
Maven home: /Users/user/tools/apache-maven-3.1.1
Java version: 1.7.0_51, vendor: Oracle Corporation
```

Note

This sample needs to be created in its own folder. Subsequent instructions assume that you have created a suitable folder and that it is your “current directory”.

10.1 Creating the POM

We need to start by creating a Maven pom.xml file. The pom.xml is the recipe that will be used to build your project. Open you favorite text editor and add the following:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/xsd/maven-4.0.0.xsd">
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.example</groupId>
  <artifactId>myproject</artifactId>
  <version>0.0.1-SNAPSHOT</version>
  <parent>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-parent</artifactId>
    <version>1.1.9.RELEASE</version>
  </parent>
  <!-- Additional lines to be added here... -->
</project>
```

This should give you a working build, you can test it out by running mvn package (you can ignore the "jar will be empty - no content was marked for inclusion!"’ warning for now).

Note

At this point you could import the project into an IDE (most modern Java IDE’s include built-in support for Maven). For simplicity, we will continue to use a plain text editor for this example.
10.2 Adding classpath dependencies

Spring Boot provides a number of “Starter POMs” that make easy to add jars to your classpath. Our sample application has already used spring-boot-starter-parent in the parent section of the POM. The spring-boot-starter-parent is a special starter that provides useful Maven defaults. It also provides a dependency-management section so that you can omit version tags for “blessed” dependencies.

Other “Starter POMs” simply provide dependencies that you are likely to need when developing a specific type of application. Since we are developing a web application, we will add a spring-boot-starter-web dependency — but before that, let’s look at what we currently have.

```bash
$ mvn dependency:tree
[INFO] com.example:myproject:jar:0.0.1-SNAPSHOT
```

The mvn dependency:tree command prints tree representation of your project dependencies. You can see that spring-boot-starter-parent provides no dependencies by itself. Let’s edit our pom.xml and add the spring-boot-starter-web dependency just below the parent section:

```xml
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
  </dependency>
</dependencies>
```

If you run mvn dependency:tree again, you will see that there are now a number of additional dependencies, including the Tomcat web server and Spring Boot itself.

10.3 Writing the code

To finish our application we need to create a single Java file. Maven will compile sources from src/main/java by default so you need to create that folder structure, then add a file named src/main/java/Example.java:

```java
import org.springframework.boot.*;
import org.springframework.boot.autoconfigure.*;
import org.springframework.stereotype.*;
import org.springframework.web.bind.annotation.*;

@RestController
@EnableAutoConfiguration
public class Example {

    @RequestMapping("/")
    String home() { return "Hello World!"; }

    public static void main(String[] args) throws Exception {
        SpringApplication.run(Example.class, args);
    }
}
```

Although there isn’t much code here, quite a lot is going on. Let’s step through the important parts.
The `@RestController` and `@RequestMapping` annotations

The first annotation on our `Example` class is `@RestController`. This is known as a *stereotype* annotation. It provides hints for people reading the code, and for Spring, that the class plays a specific role. In this case, our class is a web `@Controller` so Spring will consider it when handling incoming web requests.

The `@RequestMapping` annotation provides “routing” information. It is telling Spring that any HTTP request with the path “/” should be mapped to the `home` method. The `@RestController` annotation tells Spring to render the resulting string directly back to the caller.

**Tip**

The `@RestController` and `@RequestMapping` annotations are Spring MVC annotations (they are not specific to Spring Boot). See the `<MVC section` in the Spring Reference Documentation for more details.

The `@EnableAutoConfiguration` annotation

The second class-level annotation is `@EnableAutoConfiguration`. This annotation tells Spring Boot to “guess” how you will want to configure Spring, based on the jar dependencies that you have added. Since `spring-boot-starter-web` added Tomcat and Spring MVC, the auto-configuration will assume that you are developing a web application and setup Spring accordingly.

The “main” method

The final part of our application is the `main` method. This is just a standard method that follows the Java convention for an application entry point. Our main method delegates to Spring Boot’s `SpringApplication` class by calling `run`. `SpringApplication` will bootstrap our application, starting Spring which will in turn start the auto-configured Tomcat web server. We need to pass `Example.class` as an argument to the `run` method to tell `SpringApplication` which is the primary Spring component. The `args` array is also passed through to expose any command-line arguments.

10.4 Running the example

At this point our application should work. Since we have used the `spring-boot-starter-parent` POM we have a useful `run` goal that we can use to start the application. Type `mvn spring-boot:run` from the root project directory to start the application:

```bash
$ mvn spring-boot:run
```

```
\ / __\___ ___ ___ \___\____ \\
( ('\_)\_\//// _//// \
  |\_\_//// _//// __
  =/_//// _//// =/_////
```

```
```

----------
```
If you open a web browser to localhost:8080 you should see the following output:

Hello World!

To gracefully exit the application hit `ctrl-c`.

### 10.5 Creating an executable jar

Let’s finish our example by creating a completely self-contained executable jar file that we could run in production. Executable jars (sometimes called “fat jars”) are archives containing your compiled classes along with all of the jar dependencies that your code needs to run.

**Executable jars and Java**

Java does not provide any standard way to load nested jar files (i.e. jar files that are themselves contained within a jar). This can be problematic if you are looking to distribute a self-contained application.

To solve this problem, many developers use “shaded” jars. A shaded jar simply packages all classes, from all jars, into a single “uber jar”. The problem with shaded jars is that it becomes hard to see which libraries you are actually using in your application. It can also be problematic if the the same filename is used (but with different content) in multiple jars.

Spring Boot takes a different approach and allows you to actually nest jars directly.

To create an executable jar we need to add the `spring-boot-maven-plugin` to our `pom.xml`. Insert the following lines just below the `dependencies` section:

```xml
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
    </plugin>
  </plugins>
</build>
```

**Note**

The `spring-boot-starter-parent` POM includes `<executions>` configuration to bind the repackage goal. If you are not using the parent POM you will need to declare this configuration yourself. See the plugin documentation for details.

Save your `pom.xml` and run `mvn package` from the command line:

```
$ mvn package
[INFO] Scanning for projects...
[INFO]
[INFO] ------------------------------------------------------------------------
[INFO] Building myproject 0.0.1-SNAPSHOT
[INFO] ------------------------------------------------------------------------
```
If you look in the `target` directory you should see `myproject-0.0.1-SNAPSHOT.jar`. The file should be around 10 Mb in size. If you want to peek inside, you can use `jar tvf`:

```bash
$ jar tvf target/myproject-0.0.1-SNAPSHOT.jar
```

You should also see a much smaller file named `myproject-0.0.1-SNAPSHOT.jar.original` in the `target` directory. This is the original jar file that Maven created before it was repackaged by Spring Boot.

To run that application, use the `java -jar` command:

```bash
$ java -jar target/myproject-0.0.1-SNAPSHOT.jar
```

As before, to gracefully exit the application hit `ctrl-c`. 
11. What to read next

Hopefully this section has provided you with some of the Spring Boot basics, and got you on your way to writing your own applications. If you’re a task-oriented type of developer you might want to jump over to spring.io and check out some of the getting started guides that solve specific “How do I do that with Spring” problems; we also have Spring Boot-specific How-to reference documentation.

Otherwise, the next logical step is to read Part III, “Using Spring Boot”. If you’re really impatient, you could also jump ahead and read about Spring Boot features.
Part III. Using Spring Boot

This section goes into more detail about how you should use Spring Boot. It covers topics such as build systems, auto-configuration and run/deployment options. We also cover some Spring Boot best practices. Although there is nothing particularly special about Spring Boot (it is just another library that you can consume), there are a few recommendations that, when followed, will make your development process just a little easier.

If you’re just starting out with Spring Boot, you should probably read the Getting Started guide before diving into this section.
12. Build systems

It is strongly recommended that you choose a build system that supports dependency management, and one that can consume artifacts published to the “Maven Central” repository. We would recommend that you choose Maven or Gradle. It is possible to get Spring Boot to work with other build systems (Ant for example), but they will not be particularly well supported.

12.1 Maven

Maven users can inherit from the spring-boot-starter-parent project to obtain sensible defaults. The parent project provides the following features:

- Java 1.6 as the default compiler level.
- UTF-8 source encoding.
- A Dependency Management section, allowing you to omit <version> tags for common dependencies, inherited from the spring-boot-dependencies POM.
- Sensible resource filtering.
- Sensible plugin configuration (exec plugin, surefire, Git commit ID, shade).

Inheriting the starter parent

To configure your project to inherit from the spring-boot-starter-parent simply set the parent:

```xml
<!-- Inherit defaults from Spring Boot -->
<parent>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-parent</artifactId>
  <version>1.1.9.RELEASE</version>
</parent>
```

Note

You should only need to specify the Spring Boot version number on this dependency. If you import additional starters, you can safely omit the version number.

Using Spring Boot without the parent POM

Not everyone likes inheriting from the spring-boot-starter-parent POM. You may have your own corporate standard parent that you need to use, or you may just prefer to explicitly declare all your Maven configuration.

If you don’t want to use the spring-boot-starter-parent, you can still keep the benefit of the dependency management (but not the plugin management) by using a scope=import dependency:

```xml
<dependencyManagement>
  <dependencies>
    <!-- Import dependency management from Spring Boot -->
    <dependency>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-dependencies</artifactId>
      <version>1.1.9.RELEASE</version>
      <type>pom</type>
    </dependency>
  </dependencies>
</dependencyManagement>
```
Changing the Java version

The `spring-boot-starter-parent` chooses fairly conservative Java compatibility. If you want to follow our recommendation and use a later Java version you can add a `java.version` property:

```xml
<properties>
  <java.version>1.8</java.version>
</properties>
```

Using the Spring Boot Maven plugin

Spring Boot includes a [Maven plugin](https://mvn.apache.org/) that can package the project as an executable jar. Add the plugin to your `<plugins>` section if you want to use it:

```xml
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
    </plugin>
  </plugins>
</build>
```

**Note**

If you use the Spring Boot starter parent pom, you only need to add the plugin, there is no need for to configure it unless you want to change the settings defined in the parent.

12.2 Gradle

Gradle users can directly import “starter POMs” in their `<dependencies>` section. Unlike Maven, there is no “super parent” to import to share some configuration.

```gradle
apply plugin: 'java'

repositories { mavenCentral() }
dependencies {
  compile("org.springframework.boot:spring-boot-starter-web:1.1.9.RELEASE")
}
```

The `spring-boot-gradle-plugin` is also available and provides tasks to create executable jars and run projects from source. It also adds a `ResolutionStrategy` that enables you to [omit the version number for “blessed” dependencies](https):

```gradle
buildscript {
  repositories { mavenCentral() }
  dependencies {
    classpath("org.springframework.boot:spring-boot-gradle-plugin:1.1.9.RELEASE")
  }
}

apply plugin: 'java'
apply plugin: 'spring-boot'

repositories { mavenCentral() }
dependencies {
```
12.3 Ant

It is possible to build a Spring Boot project using Apache Ant, however, no special support or plugins are provided. Ant scripts can use the Ivy dependency system to import starter POMs.

See the Section 68.8, “Build an executable archive with Ant” “How-to” for more complete instructions.

12.4 Starter POMs

Starter POMs are a set of convenient dependency descriptors that you can include in your application. You get a one-stop-shop for all the Spring and related technology that you need, without having to hunt through sample code and copy paste loads of dependency descriptors. For example, if you want to get started using Spring and JPA for database access, just include the `spring-boot-starter-data-jpa` dependency in your project, and you are good to go.

The starters contain a lot of the dependencies that you need to get a project up and running quickly and with a consistent, supported set of managed transitive dependencies.

What’s in a name

All starters follow a similar naming pattern; `spring-boot-starter-*`, where * is a particular type of application. This naming structure is intended to help when you need to find a starter. The Maven integration in many IDEs allow you to search dependencies by name. For example, with the appropriate Eclipse or STS plugin installed, you can simply hit `ctrl-space` in the POM editor and type "spring-boot-starter" for a complete list.

The following application starters are provided by Spring Boot under the `org.springframework.boot` group:

Table 12.1. Spring Boot application starters

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spring-boot-starter</td>
<td>The core Spring Boot starter, including auto-configuration support, logging and YAML.</td>
</tr>
<tr>
<td>spring-boot-starter-amqp</td>
<td>Support for the “Advanced Message Queuing Protocol” via <code>spring-rabbit</code>.</td>
</tr>
<tr>
<td>spring-boot-starter-aop</td>
<td>Support for aspect-oriented programming including <code>spring-aop</code> and AspectJ.</td>
</tr>
<tr>
<td>spring-boot-starter-batch</td>
<td>Support for “Spring Batch” including HSQLDB database.</td>
</tr>
<tr>
<td>spring-boot-starter-data-elasticsearch</td>
<td>Support for the Elasticsearch search and analytics engine including <code>spring-data-elasticsearch</code>.</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>spring-boot-starter-data-jpa</td>
<td>Support for the “Java Persistence API” including spring-data-jpa, spring-orm and Hibernate.</td>
</tr>
<tr>
<td>spring-boot-starter-data-mongodb</td>
<td>Support for the MongoDB NoSQL Database, including spring-data-mongodb.</td>
</tr>
<tr>
<td>spring-boot-starter-data-rest</td>
<td>Support for exposing Spring Data repositories over REST via spring-data-rest-webmvc.</td>
</tr>
<tr>
<td>spring-boot-starter-data-solr</td>
<td>Support for the Apache Solr search platform, including spring-data-solr.</td>
</tr>
<tr>
<td>spring-boot-starter-freemarker</td>
<td>Support for the FreeMarker templating engine</td>
</tr>
<tr>
<td>spring-boot-starter-groovy-templates</td>
<td>Support for the Groovy templating engine</td>
</tr>
<tr>
<td>spring-boot-starter-hornetq</td>
<td>Support for “Java Message Service API” via HornetQ.</td>
</tr>
<tr>
<td>spring-boot-starter-integration</td>
<td>Support for common spring-integration modules.</td>
</tr>
<tr>
<td>spring-boot-starter-jdbc</td>
<td>JDBC Database support.</td>
</tr>
<tr>
<td>spring-boot-starter-mobile</td>
<td>Support for spring-mobile</td>
</tr>
<tr>
<td>spring-boot-starter-redis</td>
<td>Support for the REDIS key-value data store, including spring-redis.</td>
</tr>
<tr>
<td>spring-boot-starter-security</td>
<td>Support for spring-security.</td>
</tr>
<tr>
<td>spring-boot-starter-social-facebook</td>
<td>Support for spring-social-facebook.</td>
</tr>
<tr>
<td>spring-boot-starter-social-linkedin</td>
<td>Support for spring-social-linkedin.</td>
</tr>
<tr>
<td>spring-boot-starter-social-twitter</td>
<td>Support for spring-social-twitter.</td>
</tr>
<tr>
<td>spring-boot-starter-test</td>
<td>Support for common test dependencies, including JUnit, Hamcrest and Mockito along with the spring-test module.</td>
</tr>
<tr>
<td>spring-boot-starter-thymeleaf</td>
<td>Support for the Thymeleaf templating engine, including integration with Spring.</td>
</tr>
<tr>
<td>spring-boot-starter-velocity</td>
<td>Support for the Velocity templating engine</td>
</tr>
<tr>
<td>spring-boot-starter-web</td>
<td>Support for full-stack web development, including Tomcat and spring-webmvc.</td>
</tr>
<tr>
<td>spring-boot-starter-websocket</td>
<td>Support for websocket development with Tomcat.</td>
</tr>
<tr>
<td>spring-boot-starter-ws</td>
<td>Support for Spring Web Services</td>
</tr>
</tbody>
</table>

In addition to the application starters, the following starters can be used to add production ready features.
Table 12.2. Spring Boot production ready starters

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spring-boot-starter-actuator</td>
<td>Adds production ready features such as metrics and monitoring.</td>
</tr>
<tr>
<td>spring-boot-starter-remote-shell</td>
<td>Adds remote ssh shell support.</td>
</tr>
</tbody>
</table>

Finally, Spring Boot includes some starters that can be used if you want to exclude or swap specific technical facets.

Table 12.3. Spring Boot technical starters

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spring-boot-starter-jetty</td>
<td>Imports the Jetty HTTP engine (to be used as an alternative to Tomcat)</td>
</tr>
<tr>
<td>spring-boot-starter-log4j</td>
<td>Support the Log4J logging framework</td>
</tr>
<tr>
<td>spring-boot-starter-logging</td>
<td>Import Spring Boot's default logging framework (Logback).</td>
</tr>
<tr>
<td>spring-boot-starter-tomcat</td>
<td>Import Spring Boot's default HTTP engine (Tomcat).</td>
</tr>
</tbody>
</table>

Tip

For a list of additional community contributed starter POMs, see the README file in the spring-boot-starters module on GitHub.
13. Structuring your code

Spring Boot does not require any specific code layout to work, however, there are some best practices that help.

13.1 Using the “default” package

When a class doesn’t include a package declaration it is considered to be in the “default package”. The use of the “default package” is generally discouraged, and should be avoided. It can cause particular problems for Spring Boot applications that use @ComponentScan or @EntityScan annotations, since every class from every jar, will be read.

Tip

We recommend that you follow Java’s recommended package naming conventions and use a reversed domain name (for example, com.example.project).

13.2 Locating the main application class

We generally recommend that you locate your main application class in a root package above other classes. The @EnableAutoConfiguration annotation is often placed on your main class, and it implicitly defines a base “search package” for certain items. For example, if you are writing a JPA application, the package of the @EnableAutoConfiguration annotated class will be used to search for @Entity items.

Using a root package also allows the @ComponentScan annotation to be used without needing to specify a basePackage attribute.

Here is a typical layout:

```
com
 +-- example
    +-- myproject
       +-- Application.java
        |    +-- domain
        |    |    +-- Customer.java
        |    |    +-- CustomerRepository.java
        |    |    +-- service
        |    |    |    +-- CustomerService.java
        |    |    +-- web
        |    |    |    +-- CustomerController.java

The Application.java file would declare the main method, along with the basic @Configuration.
```

```java
package com.example.myproject;

import org.springframework.boot.SpringApplication;
import org.springframework.boot.autoconfigure.EnableAutoConfiguration;
import org.springframework.context.annotation.ComponentScan;
import org.springframework.context.annotation.Configuration;

@Configuration
@EnableAutoConfiguration
@ComponentScan
public class Application {
```

```java
public static void main(String[] args) {
    SpringApplication.run(Application.class, args);
}
```
14. Configuration classes

Spring Boot favors Java-based configuration. Although it is possible to call SpringApplication.run() with an XML source, we generally recommend that your primary source is a @Configuration class. Usually the class that defines the main method is also a good candidate as the primary @Configuration.

Tip

Many Spring configuration examples have been published on the Internet that use XML configuration. Always try to use the equivalent Java-base configuration if possible. Searching for enable* annotations can be a good starting point.

14.1 Importing additional configuration classes

You don’t need to put all your @Configuration into a single class. The @Import annotation can be used to import additional configuration classes. Alternatively, you can use @ComponentScan to automatically pickup all Spring components, including @Configuration classes.

14.2 Importing XML configuration

If you absolutely must use XML based configuration, we recommend that you still start with a @Configuration class. You can then use an additional @ImportResource annotation to load XML configuration files.
15. Auto-configuration

Spring Boot auto-configuration attempts to automatically configure your Spring application based on the jar dependencies that you have added. For example, if HSQLDB is on your classpath, and you have not manually configured any database connection beans, then we will auto-configure an in-memory database.

You need to opt-in to auto-configuration by adding the @EnableAutoConfiguration annotation to one of your @Configuration classes.

**Tip**

You should only ever add one @EnableAutoConfiguration annotation. We generally recommend that you add it to your primary @Configuration class.

15.1 Gradually replacing auto-configuration

Auto-configuration is noninvasive, at any point you can start to define your own configuration to replace specific parts of the auto-configuration. For example, if you add your own DataSource bean, the default embedded database support will back away.

If you need to find out what auto-configuration is currently being applied, and why, starting your application with the --debug switch. This will log an auto-configuration report to the console.

15.2 Disabling specific auto-configuration

If you find that specific auto-configure classes are being applied that you don’t want, you can use the exclude attribute of @EnableAutoConfiguration to disable them.

```java
import org.springframework.boot.autoconfigure.*;
import org.springframework.boot.autoconfigure.jdbc.*;
import org.springframework.context.annotation.*;
@Configuration
@EnableAutoConfiguration(exclude={DataSourceAutoConfiguration.class})
public class MyConfiguration {
}
```
16. Spring Beans and dependency injection

You are free to use any of the standard Spring Framework techniques to define your beans and their injected dependencies. For simplicity, we often find that using @ComponentScan to find your beans, in combination with @Autowired constructor injection works well.

If you structure your code as suggested above (locating your application class in a root package), you can add @ComponentScan without any arguments. All of your application components (@Component, @Service, @Repository, @Controller etc.) will be automatically registered as Spring Beans.

Here is an example @Service Bean that uses constructor injection to obtain a required RiskAssessor bean.

```java
package com.example.service;

import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.stereotype.Service;

@Service
public class DatabaseAccountService implements AccountService {
    private final RiskAssessor riskAssessor;

    @Autowired
    public DatabaseAccountService(RiskAssessor riskAssessor) {
        this.riskAssessor = riskAssessor;
    }

    // ...
}
```

Tip

Notice how using constructor injection allows the riskAssessor field to be marked as final, indicating that it cannot be subsequently changed.
17. Running your application

One of the biggest advantages of packaging your application as jar and using an embedded HTTP server is that you can run your application as you would any other. Debugging Spring Boot applications is also easy; you don’t need any special IDE plugins or extensions.

Note

This section only covers jar based packaging. If you choose to package your application as a war file you should refer to your server and IDE documentation.

17.1 Running from an IDE

You can run a Spring Boot application from your IDE as a simple Java application, however, first you will need to import your project. Import steps will vary depending on your IDE and build system. Most IDEs can import Maven projects directly, for example Eclipse users can select Import → Existing Maven Projects from the File menu.

If you can’t directly import your project into your IDE, you may be able to generate IDE metadata using a build plugin. Maven includes plugins for Eclipse and IDEA; Gradle offers plugins for various IDEs.

Tip

If you accidentally run a web application twice you will see a “Port already in use” error. STS users can use the Relaunch button rather than Run to ensure that any existing instance is closed.

17.2 Running as a packaged application

If you use the Spring Boot Maven or Gradle plugins to create an executable jar you can run your application using java –jar. For example:

$ java -jar target/myproject-0.0.1-SNAPSHOT.jar

It is also possible to run a packaged application with remote debugging support enabled. This allows you to attach a debugger to your packaged application:

$ java -Xdebug -Xrunjdwp:server=y,transport=dt_socket,address=8000,suspend=n -jar target/myproject-0.0.1-SNAPSHOT.jar

17.3 Using the Maven plugin

The Spring Boot Maven plugin includes a run goal which can be used to quickly compile and run your application. Applications run in an exploded form, and you can edit resources for instant “hot” reload.

$ mvn spring-boot:run

Useful operating system environment variable:

$ export MAVEN_OPTS=-Xmx1024m -XX:MaxPermSize=128M -Djava.security.egd=file:/dev/.urandom

(The “egd” setting is to speed up Tomcat startup by giving it a faster source of entropy for session keys.)
17.4 Using the Gradle plugin

The Spring Boot Gradle plugin also includes a run goal which can be used to run your application in an exploded form. The bootRun task is added whenever you import the spring-boot-plugin

$ gradle bootRun

Useful operating system environment variable:

$ export JAVA_OPTS=-Xmx1024m -XX:MaxPermSize=128M -Djava.security.egd=file:/dev/./urandom

17.5 Hot swapping

Since Spring Boot applications are just plain Java applications, JVM hot-swapping should work out of the box. JVM hot swapping is somewhat limited with the bytecode that it can replace, for a more complete solution the Spring Loaded project, or JRebel can be used.

See the Hot swapping "How-to" section for details.
18. Packaging your application for production

Executable jars can be used for production deployment. As they are self-contained, they are also ideally suited for cloud-based deployment.

For additional “production ready” features, such as health, auditing and metric REST or JMX endpoints; consider adding spring-boot-actuator. See Part V, “Spring Boot Actuator: Production-ready features” for details.
19. What to read next

You should now have good understanding of how you can use Spring Boot along with some best practices that you should follow. You can now go on to learn about specific Spring Boot features in depth, or you could skip ahead and read about the “production ready” aspects of Spring Boot.
Part IV. Spring Boot features

This section dives into the details of Spring Boot. Here you can learn about the key features that you will want to use and customize. If you haven't already, you might want to read the Part II, “Getting started” and Part III, “Using Spring Boot” sections so that you have a good grounding of the basics.
20. SpringApplication

The **SpringApplication** class provides a convenient way to bootstrap a Spring application that will be started from a `main()` method. In many situations you can just delegate to the static `SpringApplication.run` method:

```java
public static void main(String[] args) {
    SpringApplication.run(MySpringConfiguration.class, args);
}
```

When your application starts you should see something similar to the following:

```
\/\ _ __ _ __ _ _ _ _ _ _ _  
( ( )| `_ `| `_ `| `_ `| `_ `| \ / \
\_/| | | | | | | ( ) ( ) ( ) )
\ | | | | | | | | | | | / / / 
=========|==============|___/=/_/_/_/
:: Spring Boot :: v1.1.9.RELEASE
```

By default `INFO` logging messages will be shown, including some relevant startup details such as the user that launched the application.

### 20.1 Customizing the Banner

The banner that is printed on start up can be changed by adding a `banner.txt` file to your classpath, or by setting `banner.location` to the location of such a file. If the file has an unusual encoding you can set `banner.encoding` (default is UTF-8).

### 20.2 Customizing SpringApplication

If the `SpringApplication` defaults aren't to your taste you can instead create a local instance and customize it. For example, to turn off the banner you would write:

```java
public static void main(String[] args) {
    SpringApplication app = new SpringApplication(MySpringConfiguration.class);
    app.setShowBanner(false);
    app.run(args);
}
```

**Note**

The constructor arguments passed to `SpringApplication` are configuration sources for spring beans. In most cases these will be references to `@Configuration` classes, but they could also be references to XML configuration or to packages that should be scanned.

It is also possible to configure the `SpringApplication` using an `application.properties` file. See Chapter 21, Externalized Configuration for details.
For a complete list of the configuration options, see the [SpringApplication Javadoc](https://docs.spring.io/spring-boot/docs/current/api/org/springframework/boot/context/support/SpringApplication.html).

### 20.3 Fluent builder API

If you need to build an `ApplicationContext` hierarchy (multiple contexts with a parent/child relationship), or if you just prefer using a ‘fluent’ builder API, you can use the `SpringApplicationBuilder`.

The `SpringApplicationBuilder` allows you to chain together multiple method calls, and includes `parent` and `child` methods that allow you to create a hierarchy.

For example:

```java
new SpringApplicationBuilder()
    .showBanner(false)
    .sources(Parent.class)
    .child(Application.class)
    .run(args);
```

**Note**

There are some restrictions when creating an `ApplicationContext` hierarchy, e.g. Web components must be contained within the child context, and the same `Environment` will be used for both parent and child contexts. See the `SpringApplicationBuilder` javadoc for full details.

### 20.4 Application events and listeners

In addition to the usual Spring Framework events, such as `ContextRefreshedEvent`, a `SpringApplication` sends some additional application events. Some events are actually triggered before the `ApplicationContext` is created.

You can register event listeners in a number of ways, the most common being `SpringApplication.addListeners(…)` method.

Application events are sent in the following order, as your application runs:

1. An `ApplicationStartedEvent` is sent at the start of a run, but before any processing except the registration of listeners and initializers.
2. An `ApplicationEnvironmentPreparedEvent` is sent when the `Environment` to be used in the context is known, but before the context is created.
3. An `ApplicationPreparedEvent` is sent just before the refresh is started, but after bean definitions have been loaded.
4. An `ApplicationFailedEvent` is sent if there is an exception on startup.

**Tip**

You often won’t need to use application events, but it can be handy to know that they exist. Internally, Spring Boot uses events to handle a variety of tasks.
20.5 Web environment

A SpringApplication will attempt to create the right type of ApplicationContext on your behalf. By default, an AnnotationConfigApplicationContext or AnnotationConfigEmbeddedWebApplicationContext will be used, depending on whether you are developing a web application or not.

The algorithm used to determine a ‘web environment’ is fairly simplistic (based on the presence of a few classes). You can use setWebEnvironment(boolean webEnvironment) if you need to override the default.

It is also possible to take complete control of the ApplicationContext type that will be used by calling setApplicationContextClass(...).

Tip

It is often desirable to call setWebEnvironment(false) when using SpringApplication within a JUnit test.

20.6 Using the CommandLineRunner

If you want access to the raw command line arguments, or you need to run some specific code once the SpringApplication has started you can implement the CommandLineRunner interface. The run(String... args) method will be called on all Spring beans implementing this interface.

```java
import org.springframework.boot.*
import org.springframework.stereotype.*

@Component
public class MyBean implements CommandLineRunner {

    public void run(String... args) {
        // Do something...
    }
}
```

You can additionally implement the org.springframework.core.Ordered interface or use the org.springframework.core.annotation.Order annotation if several CommandLineRunner beans are defined that must be called in a specific order.

20.7 Application exit

Each SpringApplication will register a shutdown hook with the JVM to ensure that the ApplicationContext is closed gracefully on exit. All the standard Spring lifecycle callbacks (such as the DisposableBean interface, or the @PreDestroy annotation) can be used.

In addition, beans may implement the org.springframework.boot.ExitCodeGenerator interface if they wish to return a specific exit code when the application ends.
21. Externalized Configuration

Spring Boot allows you to externalize your configuration so you can work with the same application code in different environments. You can use properties files, YAML files, environment variables and command-line arguments to externalize configuration. Property values can be injected directly into your beans using the @Value annotation, accessed via Spring’s Environment abstraction or bound to structured objects.

Spring Boot uses a very particular PropertySource order that is designed to allow sensible overriding of values. Properties are considered in the following order:

1. Command line arguments.
2. JNDI attributes from java:comp/env.
3. Java System properties (System.getProperties()).
4. OS environment variables.
5. A RandomValuePropertySource that only has properties in random.*.
6. Application properties outside of your packaged jar (application.properties including YAML and profile variants).
7. Application properties packaged inside your jar (application.properties including YAML and profile variants).
8. @PropertySource annotations on your @Configuration classes.

To provide a concrete example, suppose you develop a @Component that uses a name property:

```java
import org.springframework.stereotype.*
import org.springframework.beans.factory.annotation.*

@Component
public class MyBean {
    @Value("${name}")
    private String name;
    // ...
}
```

You can bundle an application.properties inside your jar that provides a sensible default name. When running in production, an application.properties can be provided outside of your jar that overrides name; and for one-off testing, you can launch with a specific command line switch (e.g. java -jar app.jar --name="Spring").

The RandomValuePropertySource is useful for injecting random values (e.g. into secrets or test cases). It can produce integers, longs or strings, e.g.

```java
my.secret=${random.value}
my.number=${random.int}
my.bignumber=${random.long}
my.number.less.than.ten=${random.int(10)}
```
my.number.in.range=${random.int[1024,65536]}

The random.int* syntax is OPEN value (,max) CLOSE where the OPEN, CLOSE are any character and value,max are integers. If max is provided then value is the minimum value and max is the maximum (exclusive).

21.1 Accessing command line properties

By default SpringApplication will convert any command line option arguments (starting with '--', e.g. --server.port=9000) to a property and add it to the Spring Environment. As mentioned above, command line properties always take precedence over other property sources.

If you don’t want command line properties to be added to the Environment you can disable them using SpringApplication.setAddCommandLineProperties(false).

21.2 Application property files

SpringApplication will load properties from application.properties files in the following locations and add them to the Spring Environment:

1. A /config subdir of the current directory.
2. The current directory
3. A classpath /config package
4. The classpath root

The list is ordered by precedence (locations higher in the list override lower items).

Note

You can also use YAML (’.yml’) files as an alternative to ‘.properties’.

If you don’t like application.properties as the configuration file name you can switch to another by specifying a spring.config.name environment property. You can also refer to an explicit location using the spring.config.location environment property (comma-separated list of directory locations, or file paths).

$ java -jar myproject.jar --spring.config.name=myproject

or

$ java -jar myproject.jar --spring.config.location=classpath:/default.properties,classpath:/override.properties

If spring.config.location contains directories (as opposed to files) they should end in / (and will be appended with the names generated from spring.config.name before being loaded). The default search path classpath:,classpath:/config,file:,file:config/ is always used, irrespective of the value of spring.config.location. In that way you can set up default values for your application in application.properties (or whatever other basename you choose with spring.config.name) and override it at runtime with a different file, keeping the defaults.
Note

if you use environment variables not system properties, most operating systems disallow period-separated key names, but you can use underscores instead (e.g. `SPRING_CONFIG_NAME` instead of `spring.config.name`).

Note

If you are running in a container then JNDI properties (in `java:comp/env`) or servlet context initialization parameters can be used instead of, or as well as, environment variables or system properties.

21.3 Profile specific properties

In addition to `application.properties` files, profile specific properties can also be defined using the naming convention `application-{profile}.properties`.

Profile specific properties are loaded from the same locations as standard `application.properties`, with profiles specific files overriding the default ones.

21.4 Placeholders in properties

The values in `application.properties` are filtered through the existing Environment when they are used so you can refer back to previously defined values (e.g. from System properties).

<table>
<thead>
<tr>
<th>app.name</th>
<th>MyApp</th>
</tr>
</thead>
<tbody>
<tr>
<td>app.description</td>
<td><code>${app.name} is a Spring Boot application</code></td>
</tr>
</tbody>
</table>

Tip

You can also use this technique to create ‘short’ variants of existing Spring Boot properties. See the Section 58.3, "Use ‘short’ command line arguments" how-to for details.

21.5 Using YAML instead of Properties

YAML is a superset of JSON, and as such is a very convenient format for specifying hierarchical configuration data. The `SpringApplication` class will automatically support YAML as an alternative to properties whenever you have the `SnakeYAML` library on your classpath.

Note

If you use ‘starter POMs’ SnakeYAML will be automatically provided via `spring-boot-starter`.

Loading YAML

Spring Boot provides two convenient classes that can be used to load YAML documents. The `YamlPropertiesFactoryBean` will load YAML as `Properties` and the `YamlMapFactoryBean` will load YAML as a `Map`.

For example, the following YAML document:
environments:
  dev:
    url: http://dev.bar.com
    name: Developer Setup
  prod:
    url: http://foo.bar.com
    name: My Cool App

Would be transformed into these properties:

environments.dev.url=http://dev.bar.com
environments.dev.name=Developer Setup
environments.prod.url=http://foo.bar.com
environments.prod.name=My Cool App

YAML lists are represented as property keys with [index] dereferencers, for example this YAML:

my:
  servers:
    - dev.bar.com
    - foo.bar.com

Would be transformed into these properties:

my.servers[0]=dev.bar.com
my.servers[1]=foo.bar.com

To bind to properties like that using the Spring DataBinder utilities (which is what @ConfigurationProperties does) you need to have a property in the target bean of type java.util.List (or Set) and you either need to provide a setter, or initialize it with a mutable value, e.g. this will bind to the properties above

@ConfigurationProperties(prefix="my")
public class Config {
  private List<String> servers = new ArrayList<String>();

  public List<String> getServers() {
    return this.servers;
  }
}

Exposing YAML as properties in the Spring Environment

The YamlPropertySourceLoader class can be used to expose YAML as a PropertySource in the Spring Environment. This allows you to use the familiar @Value annotation with placeholders syntax to access YAML properties.

Multi-profile YAML documents

You can specify multiple profile-specific YAML documents in a single file by by using a spring.profiles key to indicate when the document applies. For example:

server:
  address: 192.168.1.100
---
spring:
  profiles: development
server:
  address: 127.0.0.1
---
spring:
  profiles: production
server:
  address: 192.168.1.120

In the example above, the server.address property will be 127.0.0.1 if the development profile is active. If the development and production profiles are not enabled, then the value for the property will be 192.168.1.100

YAML shortcomings

YAML files can’t be loaded via the @PropertySource annotation. So in the case that you need to load values that way, you need to use a properties file.

21.6 Typesafe Configuration Properties

Using the @Value("${property}") annotation to inject configuration properties can sometimes be cumbersome, especially if you are working with multiple properties or your data is hierarchical in nature. Spring Boot provides an alternative method of working with properties that allows strongly typed beans to govern and validate the configuration of your application. For example:

```java
@Component
@ConfigurationProperties(prefix="connection")
public class ConnectionSettings {
    private String username;
    private InetAddress remoteAddress;
    // ... getters and setters
}
```

When the @EnableConfigurationProperties annotation is applied to your @Configuration, any beans annotated with @ConfigurationProperties will be automatically configured from the Environment properties. This style of configuration works particularly well with the SpringApplication external YAML configuration:

```
# application.yml

connection:
    username: admin
    remoteAddress: 192.168.1.1

# additional configuration as required
```

To work with @ConfigurationProperties beans you can just inject them in the same way as any other bean.

```java
@Service
public class MyService {

    @Autowired
    private ConnectionSettings connection;

    //...

    @PostConstruct
    public void openConnection() {
        Server server = new Server();
        this.connection.configure(server);
    }
}
```
It is also possible to shortcut the registration of `@ConfigurationProperties` bean definitions by simply listing the properties classes directly in the `@EnableConfigurationProperties` annotation:

```java
@Configuration
@EnableConfigurationProperties(ConnectionSettings.class)
public class MyConfiguration {
}
```

**Relaxed binding**

Spring Boot uses some relaxed rules for binding `Environment` properties to `@ConfigurationProperties` beans, so there doesn't need to be an exact match between the `Environment` property name and the bean property name. Common examples where this is useful include underscore separated (e.g. `context_path` binds to `contextPath`), and capitalized (e.g. `PORT` binds to `port`) environment properties.

Spring will attempt to coerce the external application properties to the right type when it binds to the `@ConfigurationProperties` beans. If you need custom type conversion you can provide a `ConversionService` bean (with bean id `conversionService`) or custom property editors (via a `CustomEditorConfigurer` bean).

**@ConfigurationProperties Validation**

Spring Boot will attempt to validate external configuration, by default using JSR-303 (if it is on the classpath). You can simply add JSR-303 `javax.validation` constraint annotations to your `@ConfigurationProperties` class:

```java
@Component
@ConfigurationProperties(prefix="connection")
public class ConnectionSettings {

    @NotNull
    private InetAddress remoteAddress;

    // ... getters and setters
}
```

You can also add a custom Spring `Validator` by creating a bean definition called `configurationPropertiesValidator`.

**Tip**

The `spring-boot-actuator` module includes an endpoint that exposes all `@ConfigurationProperties` beans. Simply point your web browser to `/configprops` or use the equivalent JMX endpoint. See the `Production ready features` section for details.
22. Profiles

Spring Profiles provide a way to segregate parts of your application configuration and make it only available in certain environments. Any `@Component` or `@Configuration` can be marked with `@Profile` to limit when it is loaded:

```java
@Configuration
@Profile("production")
public class ProductionConfiguration {
    // ...
}
```

In the normal Spring way, you can use a `spring.profiles.active` Environment property to specify which profiles are active. You can specify the property in any of the usual ways, for example you could include it in your `application.properties`:

```properties
spring.profiles.active=dev,hsqldb
```

or specify on the command line using the switch `--spring.profiles.active=dev,hsqldb`.

22.1 Adding active profiles

The `spring.profiles.active` property follows the same ordering rules as other properties, the highest `PropertySource` will win. This means that you can specify active profiles in `application.properties` then replace them using the command line switch.

Sometimes it is useful to have profile specific properties that add to the active profiles rather than replace them. The `spring.profiles.include` property can be used to unconditionally add active profiles. The SpringApplication entry point also has a Java API for setting additional profiles (i.e. on top of those activated by the `spring.profiles.active` property): see the `setAdditionalProfiles()` method.

For example, when an application with following properties is run using the switch `--spring.profiles.active=prod` the proddb and prodmq profiles will also be activated:

```yaml
---
my.property: fromyamlfile
---
spring.profiles: prod
spring.profiles.include: proddb,prodmq
```

Note

Remember that the `spring.profiles` property can be defined in a YAML document to determine when this particular document is included in the configuration. See Section 58.6, “Change configuration depending on the environment” for more details.

22.2 Programatically setting profiles

You can programatically set active profiles by calling `SpringApplication.setAdditionalProfiles(...)` before your application runs. It is also possible to activate profiles using Spring’s `ConfigurableEnvironment` interface.
22.3 Profile specific configuration files

Profile specific variants of both application.properties (or application.yml) and files referenced via @ConfigurationProperties are considered as files are loaded. See Section 21.3, “Profile specific properties” for details.
23. Logging

Spring Boot uses Commons Logging for all internal logging, but leaves the underlying log implementation open. Default configurations are provided for Java Util Logging, Log4J and Logback. In each case there is console output and file output (rotating, 10 Mb file size).

By default, if you use the ‘Starter POMs’, Logback will be used for logging. Appropriate Logback routing is also included to ensure that dependent libraries that use Java Util Logging, Commons Logging, Log4J or SLF4J will all work correctly.

Tip

There are a lot of logging frameworks available for Java. Don’t worry if the above list seems confusing, generally you won’t need to change your logging dependencies and the Spring Boot defaults will work just fine.

23.1 Log format

The default log output from Spring Boot looks like this:

```
2014-03-05 10:57:51.698  INFO 45469 --- [ost-startStop-1] o.s.b.c.e.ServletRegistrationBean        : Mapping servlet: 'dispatcherServlet' to [/
```

The following items are output:

- Date and Time — Milisecond precision and easily sortable.
- Log Level — ERROR, WARN, INFO, DEBUG or TRACE.
- Process ID.
- A --- separator to distinguish the start of actual log messages.
- Logger name — This is usually the source class name (often abbreviated).
- The log message.

23.2 Console output

The default log configuration will echo messages to the console as they are written. By default ERROR, WARN and INFO level messages are logged. To also log DEBUG level messages to the console you can start your application with a --debug flag.

```
$ java -jar myapp.jar --debug
```

If your terminal supports ANSI, color output will be used to aid readability.
23.3 File output

By default, log files are written to `spring.log` in your temp directory and rotate at 10 Mb. You can easily customize the output folder by setting the `logging.path` property (for example in your `application.properties`). It is also possible to change the filename using a `logging.file` property. Note that if `logging.file` is used, then setting `logging.path` has no effect.

As with console output, ERROR, WARN and INFO level messages are logged by default.

23.4 Log Levels

All the supported logging systems can have the logger levels set in the Spring Environment (so for example in `application.properties`) using `logging.level.*=LEVEL` where ‘LEVEL’ is one of TRACE, DEBUG, INFO, WARN, ERROR, FATAL, OFF. Example `application.properties`:

```
logging.level.org.springframework.web: DEBUG
logging.level.org.hibernate: ERROR
```

23.5 Custom log configuration

The various logging systems can be activated by including the appropriate libraries on the classpath, and further customized by providing a suitable configuration file in the root of the classpath, or in a location specified by the Spring Environment property `logging.config`. (Note however that since logging is initialized before the ApplicationContext is created, it isn’t possible to control logging from @PropertySources in Spring @Configuration files. System properties and the conventional Spring Boot external configuration files work just fine.)

Depending on your logging system, the following files will be loaded:

<table>
<thead>
<tr>
<th>Logging System</th>
<th>Customization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logback</td>
<td>logback.xml</td>
</tr>
<tr>
<td>Log4j</td>
<td>log4j.properties or log4j.xml</td>
</tr>
<tr>
<td>JDK (Java Util Logging)</td>
<td>logging.properties</td>
</tr>
</tbody>
</table>

To help with the customization some other properties are transferred from the Spring Environment to System properties:

<table>
<thead>
<tr>
<th>Spring Environment</th>
<th>System Property</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>logging.file</td>
<td>LOG_FILE</td>
<td>Used in default log configuration if defined.</td>
</tr>
<tr>
<td>logging.path</td>
<td>LOG_PATH</td>
<td>Used in default log configuration if defined.</td>
</tr>
<tr>
<td>PID</td>
<td>PID</td>
<td>The current process ID (discovered if possible and when not already defined as an OS environment variable).</td>
</tr>
</tbody>
</table>
All the logging systems supported can consult System properties when parsing their configuration files. See the default configurations in spring-boot.jar for examples.

**Warning**

There are known classloading issues with Java Util Logging that cause problems when running from an ‘executable jar’. We recommend that you avoid it if at all possible.
24. Developing web applications

Spring Boot is well suited for web application development. You can easily create a self-contained HTTP server using embedded Tomcat or Jetty. Most web applications will use the spring-boot-starter-web module to get up and running quickly.

If you haven’t yet developed a Spring Boot web application you can follow the "Hello World!” example in the Getting started section.

24.1 The ‘Spring Web MVC framework’

The Spring Web MVC framework (often referred to as simply ‘Spring MVC’) is a rich ‘model view controller’ web framework. Spring MVC lets you create special @Controller or @RestController beans to handle incoming HTTP requests. Methods in your controller are mapped to HTTP using @RequestMapping annotations.

Here is a typical example @RestController to serve JSON data:

```java
@RestController
@RequestMapping(value="/users")
public class MyRestController {
    @RequestMapping(value="/\{user\}" method=RequestMethod.GET)
    public User getUser(@PathVariable Long user) {
        // ...
    }

    @RequestMapping(value="/\{user\}/customers", method=RequestMethod.GET)
    List<Customer> getUserCustomers(@PathVariable Long user) {
        // ...
    }

    @RequestMapping(value="/\{user\}" method=RequestMethod.DELETE)
    public User deleteUser(@PathVariable Long user) {
        // ...
    }
}
```

Spring MVC is part of the core Spring Framework and detailed information is available in the reference documentation. There are also several guides available at spring.io/guides that cover Spring MVC.

Spring MVC auto-configuration

Spring Boot provides auto-configuration for Spring MVC that works well with most applications.

The auto-configuration adds the following features on top of Spring’s defaults:

- Inclusion of ContentNegotiatingViewResolver and BeanNameViewResolver beans.
- Support for serving static resources, including support for WebJars (see below).
- Automatic registration of Converter, GenericConverter, Formatter beans.
- Support for HttpMessageConverters (see below).
- Automatic registration of MessageCodeResolver (see below)
• **Static** index.html support.

• **Custom Favicon** support.

If you want to take complete control of Spring MVC, you can add your own @Configuration annotated with @EnableWebMvc. If you want to keep Spring Boot MVC features, and you just want to add additional **MVC configuration** (interceptors, formatters, view controllers etc.) you can add your own @Bean of type WebMvcConfigurerAdapter, but **without** @EnableWebMvc.

**HttpMessageConverters**

Spring MVC uses the HttpMessageConverter interface to convert HTTP requests and responses. Sensible defaults are included out of the box, for example Objects can be automatically converted to JSON (using the Jackson library) or XML (using JAXB).

If you need to add or customize converters you can use Spring Boot’s HttpMessageConverters class:

```java
import org.springframework.boot.autoconfigure.web.HttpMessageConverters;
import org.springframework.context.annotation.*;
import org.springframework.http.converter.*;

@Configuration
public class MyConfiguration {
    @Bean
    public HttpMessageConverters customConverters() {
        HttpMessageConverter<?> additional = ...;
        HttpMessageConverter<?> another = ...;
        return new HttpMessageConverters(additional, another);
    }
}
```

**MessageCodesResolver**

Spring MVC has a strategy for generating error codes for rendering error messages from binding errors: MessageCodesResolver. Spring Boot will create one for you if you set the spring.mvc.message-codes-resolver.format property PREFIX_ERROR_CODE or POSTFIX_ERROR_CODE (see the enumeration in DefaultMessageCodesResolver.Format).

**Static Content**

By default Spring Boot will serve static content from a folder called /static (or /public or /resources or /META-INF/resources) in the classpath or from the root of the ServletContext. It uses the ResourceHttpRequestHandler from Spring MVC so you can modify that behavior by adding your own WebMvcConfigurerAdapter and overriding the addResourceHandlers method.

In a stand-alone web application the default servlet from the container is also enabled, and acts as a fallback, serving content from the root of the ServletContext if Spring decides not to handle it. Most of the time this will not happen (unless you modify the default MVC configuration) because Spring will always be able to handle requests through the DispatcherServlet.

In addition to the ‘standard’ static resource locations above, a special case is made for **Webjars content**. Any resources with a path in /webjars/** will be served from jar files if they are packaged in the Webjars format.
Tip

Do not use the `src/main/webapp` folder if your application will be packaged as a jar. Although this folder is a common standard, it will only work with war packaging and it will be silently ignored by most build tools if you generate a jar.

Template engines

As well as REST web services, you can also use Spring MVC to serve dynamic HTML content. Spring MVC supports a variety of templating technologies including Velocity, FreeMarker and JSPs. Many other templating engines also ship their own Spring MVC integrations.

Spring Boot includes auto-configuration support for the following templating engines:

- FreeMarker
- Groovy
- Thymeleaf
- Velocity

When you’re using one of these templating engines with the default configuration, your templates will be picked up automatically from `src/main/resources/templates`.

Tip

JSPs should be avoided if possible, there are several known limitations when using them with embedded servlet containers.

Error Handling

Spring Boot provides an `/error` mapping by default that handles all errors in a sensible way, and it is registered as a ‘global’ error page in the servlet container. For machine clients it will produce a JSON response with details of the error, the HTTP status and the exception message. For browser clients there is a ‘whitelabel’ error view that renders the same data in HTML format (to customize it just add a `View` that resolves to ‘error’). To replace the default behaviour completely you can implement `ErrorController` and register a bean definition of that type, or simply add a bean of type `ErrorAttributes` to use the existing mechanism but replace the contents.

If you want more specific error pages for some conditions, the embedded servlet containers support a uniform Java DSL for customizing the error handling. For example:

```java
@Configuration
public class MyCustomizer implements EmbeddedServletContainerCustomizer {

    @Override
    public void customize(ConfigurableEmbeddedServletContainer container) {
        container.addErrorPages(new ErrorPage(HttpStatus.BAD_REQUEST, "/400"));
    }
}
```
You can also use regular Spring MVC features like `@ExceptionHandler` methods and `@ControllerAdvice`. The ErrorController will then pick up any unhandled exceptions.

N.B. if you register an `ErrorPage` with a path that will end up being handled by a `Filter` (e.g. as is common with some non-Spring web frameworks, like Jersey and Wicket), then the `Filter` has to be explicitly registered as an `ERROR` dispatcher, e.g.

```java
@Bean
class myFilter() {
    FilterRegistrationBean registration = new FilterRegistrationBean();
    registration.setFilter(new MyFilter());
    registration.setDispatcherTypes(EnumSet.of(DispatcherType.ERROR));
    return registration;
}
```

(the default `FilterRegistrationBean` does not include the `ERROR` dispatcher type).

### Error Handling on WebSphere Application Server

When deployed to a servlet container, a Spring Boot uses its error page filter to forward a request with an error status to the appropriate error page. The request can only be forwarded to the correct error page if the response has not already been committed. By default, WebSphere Application Server 8.0 and later commits the response upon successful completion of a servlet’s service method. You should disable this behaviour by setting `com.ibm.ws.webcontainer.invokeFlushAfterService` to `false`.

#### 24.2 Embedded servlet container support

Spring Boot includes support for embedded Tomcat and Jetty servers. Most developers will simply use the appropriate ‘Starter POM’ to obtain a fully configured instance. By default both Tomcat and Jetty will listen for HTTP requests on port 8080.

### Servlets and Filters

When using an embedded servlet container you can register Servlets and Filters directly as Spring beans. This can be particularly convenient if you want to refer to a value from your `application.properties` during configuration.

By default, if the context contains only a single Servlet it will be mapped to `/`. In the case of multiple Servlet beans the bean name will be used as a path prefix. Filters will map to `/*`.

If convention-based mapping is not flexible enough you can use the `ServletRegistrationBean` and `FilterRegistrationBean` classes for complete control. You can also register items directly if your bean implements the `ServletContextInitializer` interface.

### The EmbeddedWebApplicationContext

Under the hood Spring Boot uses a new type of `ApplicationContext` for embedded servlet container support. The `EmbeddedWebApplicationContext` is a special type of `WebApplicationContext` that bootstraps itself by searching for a single `EmbeddedServletContainerFactory` bean. Usually a `TomcatEmbeddedServletContainerFactory` or `JettyEmbeddedServletContainerFactory` will have been auto-configured.
Note

You usually won’t need to be aware of these implementation classes. Most applications will be auto-configured and the appropriate ApplicationContext and EmbeddedServletContainerFactory will be created on your behalf.

Customizing embedded servlet containers

Common servlet container settings can be configured using Spring Environment properties. Usually you would define the properties in your application.properties file.

Common server settings include:

• server.port — The listen port for incoming HTTP requests.
• server.address — The interface address to bind to.
• server.sessionTimeout — A session timeout.

See the ServerProperties class for a complete list.

Programmatic customization

If you need to configure your embedded servlet container programmatically you can register a Spring bean that implements the EmbeddedServletContainerCustomizer interface. EmbeddedServletContainerCustomizer provides access to the ConfigurableEmbeddedServletContainer which includes numerous customization setter methods.

```java
import org.springframework.boot.context.embedded.*;
import org.springframework.stereotype.Component;

@Component
public class CustomizationBean implements EmbeddedServletContainerCustomizer {
    @Override
    public void customize(ConfigurableEmbeddedServletContainer container) {
        container.setPort(9000);
    }
}
```

Customizing ConfigurableEmbeddedServletContainer directly

If the above customization techniques are too limited, you can register the TomcatEmbeddedServletContainerFactory or JettyEmbeddedServletContainerFactory bean yourself.

```java
@Bean
public EmbeddedServletContainerFactory servletContainer() {
    TomcatEmbeddedServletContainerFactory factory = new TomcatEmbeddedServletContainerFactory();
    factory.setPort(9000);
    factory.setSessionTimeout(10, TimeUnit.MINUTES);
    factory.addErrorPages(new ErrorPage(HttpStatus.404, "/notfound.html");
    return factory;
}
```

Setters are provided for many configuration options. Several protected method ‘hooks’ are also provided should you need to do something more exotic. See the source code documentation for details.
**JSP limitations**

When running a Spring Boot application that uses an embedded servlet container (and is packaged as an executable archive), there are some limitations in the JSP support.

- With Tomcat it should work if you use war packaging, i.e. an executable war will work, and will also be deployable to a standard container (not limited to, but including Tomcat). An executable jar will not work because of a hard coded file pattern in Tomcat.

- Jetty does not currently work as an embedded container with JSPs.

There is a [JSP sample](#) so you can see how to set things up.
25. Security

If Spring Security is on the classpath then web applications will be secure by default with ‘basic’ authentication on all HTTP endpoints. To add method-level security to a web application you can also add @EnableGlobalMethodSecurity with your desired settings. Additional information can be found in the Spring Security Reference.

The default AuthenticationManager has a single user (‘user’ username and random password, printed at INFO level when the application starts up)

```
Using default security password: 78fa095d-3f4c-48b1-ad50-e24c31d5cf35
```

You can change the password by providing a security.user.password. This and other useful properties are externalized via SecurityProperties (properties prefix "security").

The default security configuration is implemented in SecurityAutoConfiguration and in the classes imported from there (SpringBootWebSecurityConfiguration for web security and AuthenticationManagerConfiguration for authentication configuration which is also relevant in non-web applications). To switch off the Boot default configuration completely in a web application you can add a bean with @EnableWebSecurity. To customize it you normally use external properties and beans of type WebSecurityConfigurerAdapter (e.g. to add form-based login). There are several secure applications in the Spring Boot samples to get you started with common use cases.

The basic features you get out of the box in a web application are:

- An AuthenticationManager bean with in-memory store and a single user (see SecurityProperties.User for the properties of the user).
- Ignored (unsecure) paths for common static resource locations (/css/**, /js/**, /images/** and **/favicon.ico).
- HTTP Basic security for all other endpoints.
- Security events published to Spring’s ApplicationEventPublisher (successful and unsuccessful authentication and access denied).
- Common low-level features (HSTS, XSS, CSRF, caching) provided by Spring Security are on by default.

All of the above can be switched on and off or modified using external properties (security.*). To override the access rules without changing any other autoconfigured features add a @Bean of type WebSecurityConfigurerAdapter with @Order(SecurityProperties.ACCESS_OVERRIDE_ORDER).

If the Actuator is also in use, you will find:

- The management endpoints are secure even if the application endpoints are unsecure.
- Security events are transformed into AuditEvents and published to the AuditService.
- The default user will have the ADMIN role as well as the USER role.

The Actuator security features can be modified using external properties (management.security.*). To override the application access rules add a @Bean of type WebSecurityConfigurerAdapter and
use @Order(SecurityProperties.ACCESS_OVERRIDE_ORDER) if you don’t want to override the actuator access rules, or @Order(ManagementServerProperties.ACCESS_OVERRIDE_ORDER) if you do want to override the actuator access rules.
26. Working with SQL databases

The Spring Framework provides extensive support for working with SQL databases. From direct JDBC access using JdbcTemplate to complete ‘object relational mapping’ technologies such as Hibernate. Spring Data provides an additional level of functionality, creating Repository implementations directly from interfaces and using conventions to generate queries from your method names.

26.1 Configure a DataSource

Java’s javax.sql.DataSource interface provides a standard method of working with database connections. Traditionally a DataSource uses a URL along with some credentials to establish a database connection.

Embedded Database Support

It’s often convenient to develop applications using an in-memory embedded database. Obviously, in-memory databases do not provide persistent storage; you will need to populate your database when your application starts and be prepared to throw away data when your application ends.

Tip

The ‘How-to’ section includes a section on how to initialize a database.

Spring Boot can auto-configure embedded H2, HSQL and Derby databases. You don’t need to provide any connection URLs, simply include a build dependency to the embedded database that you want to use.

For example, typical POM dependencies would be:

```xml
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-data-jpa</artifactId>
</dependency>
<dependency>
    <groupId>org.hsqldb</groupId>
    <artifactId>hsqldb</artifactId>
    <scope>runtime</scope>
</dependency>
```

Note

You need a dependency on spring-jdbc for an embedded database to be auto-configured. In this example it’s pulled in transitively via spring-boot-starter-data-jpa.

Connection to a production database

Production database connections can also be auto-configured using a pooling DataSource. Here’s the algorithm for choosing a specific implementation:

- We prefer the Tomcat pooling DataSource for its performance and concurrency, so if that is available we always choose it.
- If commons-dbcp is available we will use that, but we don’t recommend it in production.
If you use the `spring-boot-starter-jdbc` or `spring-boot-starter-data-jpa` 'starter POMs' you will automatically get a dependency to `tomcat-jdbc`.

**Note**

Additional connection pools can always be configured manually. If you define your own `DataSource` bean, auto-configuration will not occur.

DataSource configuration is controlled by external configuration properties in `spring.datasource.*`. For example, you might declare the following section in `application.properties`:

```java
spring.datasource.url=jdbc:mysql://localhost/test
spring.datasource.username=dbuser
spring.datasource.password=dbpass
spring.datasource.driverClassName=com.mysql.jdbc.Driver
```

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

**Note**

For a pooling `DataSource` to be created we need to be able to verify that a valid `Driver` class is available, so we check for that before doing anything. I.e. if you set `spring.datasource.driverClassName=com.mysql.jdbc.Driver` then that class has to be loadable.

### 26.2 Using JdbcTemplate

Spring's `JdbcTemplate` and `NamedParameterJdbcTemplate` classes are auto-configured and you can `@Autowired` them directly into your own beans:

```java
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.jdbc.core.JdbcTemplate;
import org.springframework.stereotype.Component;

@Component
public class MyBean {

    private final JdbcTemplate jdbcTemplate;

    @Autowired
    public MyBean(JdbcTemplate jdbcTemplate) {
        this.jdbcTemplate = jdbcTemplate;
    }

    // ...
}
```

### 26.3 JPA and ‘Spring Data’

The Java Persistence API is a standard technology that allows you to ‘map’ objects to relational databases. The `spring-boot-starter-data-jpa` POM provides a quick way to get started. It provides the following key dependencies:

- Hibernate — One of the most popular JPA implementations.
- Spring Data JPA — Makes it easy to easily implement JPA-based repositories.
• Spring ORMs — Core ORM support from the Spring Framework.

Tip

We won’t go into too many details of JPA or Spring Data here. You can follow the ‘Accessing Data with JPA’ guide from spring.io and read the Spring Data JPA and Hibernate reference documentation.

Entity Classes

Traditionally, JPA ‘Entity’ classes are specified in a persistence.xml file. With Spring Boot this file is not necessary and instead ‘Entity Scanning’ is used. By default all packages below your main configuration class (the one annotated with @EnableAutoConfiguration) will be searched.

Any classes annotated with @Entity, @Embeddable or @MappedSuperclass will be considered. A typical entity class would look something like this:

```java
package com.example.myapp.domain;

import java.io.Serializable;
import javax.persistence.*

@Entity
public class City implements Serializable {

@Id
@GeneratedValue
private Long id;

@Column(nullable = false)
private String name;

@Column(nullable = false)
private String state;

// ... additional members, often include @OneToMany mappings

protected City() {
    // no-args constructor required by JPA spec
    // this one is protected since it shouldn't be used directly
}

public City(String name, String state) {
    this.name = name;
    this.country = country;
}

public String getName() {
    return this.name;
}

public String getState() {
    return this.state;
}

// ... etc
}
```

Tip

You can customize entity scanning locations using the @EntityScan annotation. See the Section 62.4, “Separate @Entity definitions from Spring configuration” how-to.
Spring Data JPA Repositories

Spring Data JPA repositories are interfaces that you can define to access data. JPA queries are created automatically from your method names. For example, a CityRepository interface might declare a findAllByState(String state) method to find all cities in a given state.

For more complex queries you can annotate your method using Spring Data’s Query annotation.

Spring Data repositories usually extend from the Repository or CrudRepository interfaces. If you are using auto-configuration, repositories will be searched from the package containing your main configuration class (the one annotated with @EnableAutoConfiguration) down.

Here is a typical Spring Data repository:

```java
package com.example.myapp.domain;

import org.springframework.data.domain.*;
import org.springframework.data.repository.*;

public interface CityRepository extends Repository<City, Long> {
    Page<City> findAll(Pageable pageable);
    City findByNameAndCountryAllIgnoringCase(String name, String country);
}
```

Tip

We have barely scratched the surface of Spring Data JPA. For complete details check their reference documentation.

Creating and dropping JPA databases

By default, JPA databases will be automatically created only if you use an embedded database (H2, HSQL or Derby). You can explicitly configure JPA settings using spring.jpa.* properties. For example, to create and drop tables you can add the following to your application.properties.

```
spring.jpa.hibernate.ddl-auto=create-drop
```

Note

Hibernate’s own internal property name for this (if you happen to remember it better) is hibernate.hbm2ddl.auto. You can set it, along with other Hibernate native properties, using spring.jpa.properties.* (the prefix is stripped before adding them to the entity manager).

Example:

```
spring.jpa.properties.hibernate.globally_quoted_identifiers=true
```

passes hibernate.globally_quoted_identifiers to the Hibernate entity manager.

By default the DDL execution (or validation) is deferred until the ApplicationContext has started. There is also a spring.jpa.generate-ddl flag, but it is not used if Hibernate autoconfig is active because the ddl-auto settings are more fine-grained.
27. Working with NoSQL technologies

Spring Data provides additional projects that help you access a variety of NoSQL technologies including MongoDB, Neo4J, Elasticsearch, Solr, Redis, Gemfire, Couchbase and Cassandra. Spring Boot provides auto-configuration for Redis, MongoDB, Elasticsearch, Solr and Gemfire; you can make use of the other projects, but you will need to configure them yourself. Refer to the appropriate reference documentation at projects.spring.io/spring-data.

27.1 Redis

Redis is a cache, message broker and richly-featured key-value store. Spring Boot offers basic auto-configuration for the Jedis client library and abstractions on top of it provided by Spring Data Redis. There is a spring-boot-starter-redis ‘Starter POM’ for collecting the dependencies in a convenient way.

Connecting to Redis

You can inject an auto-configured RedisConnectionFactory, StringRedisTemplate or vanilla RedisTemplate instance as you would any other Spring Bean. By default the instance will attempt to connect to a Redis server using localhost:6379:

```java
@Component
public class MyBean {

    private StringRedisTemplate template;

    @Autowired
    public MyBean(StringRedisTemplate template) {
        this.template = template;
    }

    // ...
}
```

If you add a @Bean of your own of any of the auto-configured types it will replace the default (except in the case of RedisTemplate the exclusion is based on the bean name ‘redisTemplate’ not its type). If commons-pool2 is on the classpath you will get a pooled connection factory by default.

27.2 MongoDB

MongoDB is an open-source NoSQL document database that uses a JSON-like schema instead of traditional table-based relational data. Spring Boot offers several conveniences for working with MongoDB, including the The spring-boot-starter-data-mongodb ‘Starter POM’.

Connecting to a MongoDB database

You can inject an auto-configured com.mongodb.Mongo instance as you would any other Spring Bean. By default the instance will attempt to connect to a MongoDB server using the URL mongodb:// localhost/test:

```java
import com.mongodb.Mongo;

@Component
public class MyBean {

```
private final Mongo mongo;

@Autowired
public MyBean(Mongo mongo) {
    this.mongo = mongo;
}

// ...
import org.springframework.data.domain.*;
import org.springframework.data.repository.*;

public interface CityRepository extends Repository<City, Long> {
    Page<City> findAll(Pageable pageable);
    City findByNameAndCountryAllIgnoringCase(String name, String country);
}

**Tip**

For complete details of Spring Data MongoDB, including its rich object mapping technologies, refer to their reference documentation.

### 27.3 Gemfire

**Spring Data Gemfire** provides convenient Spring-friendly tools for accessing the **Pivotal Gemfire** data management platform. There is a spring-boot-starter-data-gemfire 'Starter POM' for collecting the dependencies in a convenient way. There is currently no auto-config support for Gemfire, but you can enable Spring Data Repositories with a single annotation.

### 27.4 Solr

**Apache Solr** is a search engine. Spring Boot offers basic auto-configuration for the solr client library and abstractions on top of it provided by **Spring Data Solr**. There is a spring-boot-starter-data-solr ‘Starter POM’ for collecting the dependencies in a convenient way.

#### Connecting to Solr

You can inject an auto-configured SolrServer instance as you would any other Spring Bean. By default the instance will attempt to connect to a server using localhost:8983/solr:

```java
@Component
public class MyBean {
    private SolrServer solr;

    @Autowired
    public MyBean(SolrServer solr) {
        this.solr = solr;
    }

    // ...
}
```

If you add a @Bean of your own of type SolrServer it will replace the default.

#### Spring Data Solr repositories

Spring Data includes repository support for Apache Solr. As with the JPA repositories discussed earlier, the basic principle is that queries are constructed for you automatically based on method names.

In fact, both Spring Data JPA and Spring Data Solr share the same common infrastructure; so you could take the JPA example from earlier and, assuming that City is now a @SolrDocument class rather than a JPA @Entity, it will work in the same way.
**Tip**

For complete details of Spring Data Solr, refer to their [reference documentation](#).

### 27.5 Elasticsearch

**Elastic Search** is an open source, distributed, real-time search and analytics engine. Spring Boot offers basic auto-configuration for the Elasticsearch and abstractions on top of it provided by [Spring Data Elasticsearch](#). There is a `spring-boot-starter-data-elasticsearch` 'Starter POM' for collecting the dependencies in a convenient way.

#### Connecting to Elasticsearch

You can inject an auto-configured `ElasticsearchTemplate` or `ElasticsearchClient` instance as you would any other Spring Bean. By default the instance will attempt to connect to a local in-memory server (a `NodeClient` in Elasticsearch terms), but you can switch to a remote server (i.e. a `TransportClient`) by setting `spring.data.elasticsearch.clusterNodes` to a comma-separated `host:port` list.

```java
@Component
public class MyBean {
    private ElasticsearchTemplate template;

    @Autowired
    public MyBean(ElasticsearchTemplate template) {
        this.template = template;
    }

    // ...
}
```

If you add a `@Bean` of your own of type `ElasticsearchTemplate` it will replace the default.

#### Spring Data Elasticsearch repositories

Spring Data includes repository support for Elasticsearch. As with the JPA repositories discussed earlier, the basic principle is that queries are constructed for you automatically based on method names.

In fact, both Spring Data JPA and Spring Data Elasticsearch share the same common infrastructure; so you could take the JPA example from earlier and, assuming that `City` is now an Elasticsearch `@Document` class rather than a JPA `@Entity`, it will work in the same way.

**Tip**

For complete details of Spring Data Elasticsearch, refer to their [reference documentation](#).
28. Messaging

The Spring Framework provides extensive support for integrating with messaging systems: from simplified use of the JMS API using JmsTemplate to a complete infrastructure to receive messages asynchronously. Spring AMQP provides a similar feature set for the ‘Advanced Message Queuing Protocol’ and Boot also provides auto-configuration options for RabbitTemplate and RabbitMQ. There is also support for STOMP messaging natively in Spring Websocket and Spring Boot has support for that through starters and a small amount of auto configuration.

28.1 JMS

The javax.jms.ConnectionFactory interface provides a standard method of creating a javax.jms.Connection for interacting with a JMS broker. Although Spring needs a ConnectionFactory to work with JMS, you generally won’t need to use it directly yourself and you can instead rely on higher level messaging abstractions (see the relevant section of the Spring Framework reference documentation for details).

HornetQ support

Spring Boot can auto-configure a ConnectionFactory when it detects that HornetQ is available on the classpath. If the broker is present, an embedded broker is started and configured automatically (unless the mode property has been explicitly set). The supported modes are: embedded (to make explicit that an embedded broker is required and should lead to an error if the broker is not available in the classpath), and native to connect to a broker using the netty transport protocol. When the latter is configured, Spring Boot configures a ConnectionFactory connecting to a broker running on the local machine with the default settings.

Note

If you are using spring-boot-starter-hornetq the necessary dependencies to connect to an existing HornetQ instance are provided, as well as the Spring infrastructure to integrate with JMS. Adding org.hornetq:hornetq-jms-server to your application allows you to use the embedded mode.

HornetQ configuration is controlled by external configuration properties in spring.hornetq.*. For example, you might declare the following section in application.properties:

```properties
spring.hornetq.mode=native
spring.hornetq.host=192.168.1.210
spring.hornetq.port=9876
```

When embedding the broker, you can chose if you want to enable persistence, and the list of destinations that should be made available. These can be specified as a comma-separated list to create them with the default options; or you can define bean(s) of type org.hornetq.jms.server.config.JMSQueueConfiguration or org.hornetq.jms.server.config.TopicConfiguration, for advanced queue and topic configurations respectively.

See HornetQProperties for more of the supported options.

No JNDI lookup is involved at all and destinations are resolved against their names, either using the ‘name’ attribute in the HornetQ configuration or the names provided through configuration.
ActiveMQ support

Spring Boot can also configure a ConnectionFactory when it detects that ActiveMQ is available on the classpath. If the broker is present, an embedded broker is started and configured automatically (as long as no broker URL is specified through configuration).

ActiveMQ configuration is controlled by external configuration properties in spring.activemq.*. For example, you might declare the following section in application.properties:

```properties
spring.activemq.broker-url=tcp://192.168.1.210:9876
spring.activemq.user=admin
spring.activemq.password=secret
```

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

By default, ActiveMQ creates a destination if it does not exist yet, so destinations are resolved against their provided names.

Using JmsTemplate

Spring's JmsTemplate is auto-configured and you can @Autowired it directly into your own beans:

```java
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.jms.core.JmsTemplate;
import org.springframework.stereotype.Component;

@Component
public class MyBean {
    private final JmsTemplate jmsTemplate;

    @Autowired
    public MyBean(JmsTemplate jmsTemplate) {
        this.jmsTemplate = jmsTemplate;
    }

    // ...
}
```
29. Spring Integration

Spring Integration provides abstractions over messaging and also other transports such as HTTP, TCP etc. If Spring Integration is available on your classpath it will be initialized through the `@EnableIntegration` annotation. Message processing statistics will be published over JMX if 'spring-integration-jmx' is also on the classpath. See the `IntegrationAutoConfiguration` class for more details.
30. Monitoring and management over JMX

Java Management Extensions (JMX) provide a standard mechanism to monitor and manage applications. By default Spring Boot will create an MBeanServer with bean id ‘mbeanServer’ and expose any of your beans that are annotated with Spring JMX annotations (@ManagedResource, @ManagedAttribute, @ManagedOperation).

See the JmxAutoConfiguration class for more details.
31. Testing

Spring Boot provides a number of useful tools for testing your application. The spring-boot-starter-test POM provides Spring Test, JUnit, Hamcrest and Mockito dependencies. There are also useful test utilities in the core spring-boot module under the org.springframework.boot.test package.

31.1 Test scope dependencies

If you use the spring-boot-starter-test ‘Starter POM’ (in the test scope), you will find the following provided libraries:

- Spring Test — integration test support for Spring applications.
- JUnit — The de-facto standard for unit testing Java applications.
- Hamcrest — A library of matcher objects (also known as constraints or predicates) allowing `assertThat` style JUnit assertions.
- Mockito — A Java mocking framework.

These are common libraries that we generally find useful when writing tests. You are free to add additional test dependencies of your own if these don’t suit your needs.

31.2 Testing Spring applications

One of the major advantages of dependency injection is that it should make your code easier to unit test. You can simply instantiate objects using the `new` operator without even involving Spring. You can also use mock objects instead of real dependencies.

Often you need to move beyond ‘unit testing’ and start ‘integration testing’ (with a Spring ApplicationContext actually involved in the process). It’s useful to be able to perform integration testing without requiring deployment of your application or needing to connect to other infrastructure.

The Spring Framework includes a dedicated test module for just such integration testing. You can declare a dependency directly to `org.springframework:spring-test` or use the spring-boot-starter-test ‘Starter POM’ to pull it in transitively.

If you have not used the spring-test module before you should start by reading the relevant section of the Spring Framework reference documentation.

31.3 Testing Spring Boot applications

A Spring Boot application is just a Spring ApplicationContext so nothing very special has to be done to test it beyond what you would normally do with a vanilla Spring context. One thing to watch out for though is that the external properties, logging and other features of Spring Boot are only installed in the context by default if you use SpringApplication to create it.

Spring Boot provides a `@SpringApplicationConfiguration` annotation as an alternative to the standard `spring-test` `@ContextConfiguration` annotation. If you use `@SpringApplicationConfiguration` to configure the ApplicationContext used in your tests, it will be created via SpringApplication and you will get the additional Spring Boot features.
For example:

```java
@RunWith(SpringJUnit4ClassRunner.class)
@SpringApplicationConfiguration(classes = SampleDataJpaApplication.class)
public class CityRepositoryIntegrationTests {
    @Autowired
    CityRepository repository;
    // ...
}
```

**Tip**

The context loader guesses whether you want to test a web application or not (e.g. with MockMVC) by looking for the @WebAppConfiguration annotation. (MockMVC and @WebAppConfiguration are part of spring-test).

If you want a web application to start up and listen on its normal port, so you can test it with HTTP (e.g. using RestTemplate), annotate your test class (or one of its superclasses) with @IntegrationTest. This can be very useful because it means you can test the full stack of your application, but also inject its components into the test class and use them to assert the internal state of the application after an HTTP interaction. For example:

```java
@RunWith(SpringJUnit4ClassRunner.class)
@SpringApplicationConfiguration(classes = SampleDataJpaApplication.class)
@WebAppConfiguration
@IntegrationTest
public class CityRepositoryIntegrationTests {
    @Autowired
    CityRepository repository;

    RestTemplate restTemplate = new TestRestTemplate();
    // ... interact with the running server
}
```

**Note**

Spring’s test framework will cache application contexts between tests. Therefore, as long as your tests share the same configuration, the time consuming process of starting and stopping the server will only happen once, regardless of the number of tests that actually run.

To change the port you can add environment properties to @IntegrationTest as colon- or equals-separated name-value pairs, e.g. @IntegrationTest("server.port:9000"). Additionally you can set the server.port and management.port properties to 0 in order to run your integration tests using random ports. For example:

```java
@RunWith(SpringJUnit4ClassRunner.class)
@SpringApplicationConfiguration(classes = MyApplication.class)
@WebAppConfiguration
@IntegrationTest({"server.port=0", "management.port=0"})
public class SomeIntegrationTests {
    // ...
}
```
See Section 59.4, “Discover the HTTP port at runtime” for a description of how you can discover the actual port that was allocated for the duration of the tests.

### Using Spock to test Spring Boot applications

If you wish to use Spock to test a Spring Boot application you should add a dependency on Spock’s spock-spring module to your application’s build. spock-spring integrates Spring’s test framework into Spock.

Please note that you cannot use the `@SpringApplicationConfiguration` annotation that was described above as Spock does not find the `@ContextConfiguration` meta-annotation. To work around this limitation, you should use the `@ContextConfiguration` annotation directly and configure it to use the Spring Boot specific context loader:

```java
@ContextConfiguration(loader = SpringApplicationContextLoader.class)
class ExampleSpec extends Specification {
    // ...
}
```

### 31.4 Test utilities

A few test utility classes are packaged as part of spring-boot that are generally useful when testing your application.

#### ConfigFileApplicationContextInitializer

`ConfigFileApplicationContextInitializer` is an ApplicationContextInitializer that can apply to your tests to load Spring Boot application.properties files. You can use this when you don’t need the full features provided by `@SpringApplicationConfiguration`.

```java
@ContextConfiguration(classes = Config.class,
    initializers = ConfigFileApplicationContextInitializer.class)
```

#### EnvironmentTestUtils

`EnvironmentTestUtils` allows you to quickly add properties to a ConfigurableEnvironment or ConfigurableApplicationContext. Simply call it with key=value strings:

```java
EnvironmentTestUtils.addEnvironment(env, "org=Spring", "name=Boot");
```

#### OutputCapture

`OutputCapture` is a JUnit Rule that you can use to capture System.out and System.err output. Simply declare the capture as a `@Rule` then use `toString()` for assertions:

```java
import org.junit.Rule;
import org.junit.Test;
import org.springframework.boot.test.OutputCapture;

import static org.hamcrest.Matchers.*;
import static org.junit.Assert.*;

public class MyTest {
    @Rule
    public OutputCapture capture = new OutputCapture();
```
@Test
public void testName() throws Exception {
    System.out.println("Hello World!");
    assertThat(capture.toString(), containsString("World"));
}

TestRestTemplate

TestRestTemplate is a convenience subclass of Spring's RestTemplate that is useful in integration
tests. You can get a vanilla template or one that sends Basic HTTP authentication (with a username
and password). In either case the template will behave in a test-friendly way: not following redirects (so
you can assert the response location), ignoring cookies (so the template is stateless), and not throwing
exceptions on server-side errors. It is recommended, but not mandatory, to use Apache HTTP Client
(version 4.3.2 or better), and if you have that on your classpath the TestRestTemplate will respond
by configuring the client appropriately.

public class MyTest {

    RestTemplate template = new TestRestTemplate();

    @Test
    public void testRequest() throws Exception {
        HttpHeaders headers = template.getForEntity("http://myhost.com", String.class).getHeaders();
        assertThat(headers.getLocation().toString(), containsString("myotherhost"));
    }
}

32. Developing auto-configuration and using conditions

If you work in a company that develops shared libraries, or if you work on an open-source or commercial library, you might want to develop your own auto-configuration. Auto-configuration classes can be bundled in external jars and still be picked-up by Spring Boot.

32.1 Understanding auto-configured beans

Under the hood, auto-configuration is implemented with standard @Configuration classes. Additional @Conditional annotations are used to constrain when the auto-configuration should apply. Usually auto-configuration classes use @ConditionalOnClass and @ConditionalOnMissingBean annotations. This ensures that auto-configuration only applies when relevant classes are found and when you have not declared your own @Configuration.

You can browse the source code of spring-boot-autoconfigure to see the @Configuration classes that we provide (see the META-INF/spring.factories file).

32.2 Locating auto-configuration candidates

Spring Boot checks for the presence of a META-INF/spring.factories file within your published jar. The file should list your configuration classes under the EnableAutoConfiguration key.

```
org.springframework.boot.autoconfigure.EnableAutoConfiguration=\
com.mycorp.libx.autoconfigure.LibXAutoConfiguration,\
com.mycorp.libx.autoconfigure.LibXWebAutoConfiguration
```

You can use the @AutoConfigureAfter or @AutoConfigureBefore annotations if your configuration needs to be applied in a specific order. For example, if you provide web-specific configuration, your class may need to be applied after WebMvcAutoConfiguration.

32.3 Condition annotations

You almost always want to include one or more @Condition annotations on your auto-configuration class. The @ConditionalOnMissingBean is one common example that is used to allow developers to ‘override’ auto-configuration if they are not happy with your defaults.

Spring Boot includes a number of @Conditional annotations that you can reuse in your own code by annotating @Configuration classes or individual @Bean methods.

Class conditions

The @ConditionalOnClass and @ConditionalOnMissingClass annotations allows configuration to be skipped based on the presence or absence of specific classes. Due to the fact that annotation metadata is parsed using ASM you can actually use the value attribute to refer to the real class, even though that class might not actually appear on the running application classpath. You can also use the name attribute if you prefer to specify the class name using a String value.

Bean conditions

The @ConditionalOnBean and @ConditionalOnMissingBean annotations allow configurations to be skipped based on the presence or absence of specific beans. You can use the value attribute to
specify beans by type, or name to specify beans by name. The search attribute allows you to limit the ApplicationContext hierarchy that should be considered when searching for beans.

**Note**

@Conditional annotations are processed when @Configuration classes are parsed. Auto-configure @Configuration is always parsed last (after any user defined beans), however, if you are using these annotations on regular @Configuration classes, care must be taken not to refer to bean definitions that have not yet been created.

**Resource conditions**

The @ConditionalOnResource annotation allows configuration to be included only when a specific resource is present. Resources can be specified using the usual Spring conventions, for example, file:/home/user/test.dat.

**Web Application Conditions**

The @ConditionalOnWebApplication and @ConditionalOnNotWebApplication annotations allow configuration to be skipped depending on whether the application is a 'web application'. A web application is any application that is using a Spring WebApplicationContext, defines a session scope or has a StandardServletEnvironment.

**SpEL expression conditions**

The @ConditionalOnExpression annotation allows configuration to be skipped based on the result of a SpEL expression.
33. What to read next

If you want to learn more about any of the classes discussed in this section you can check out the Spring Boot API documentation or you can browse the source code directly. If you have specific questions, take a look at the how-to section.

If you are comfortable with Spring Boot's core features, you can carry on and read about production-ready features.
Part V. Spring Boot Actuator: Production-ready features

Spring Boot includes a number of additional features to help you monitor and manage your application when it’s pushed to production. You can choose to manage and monitor your application using HTTP endpoints, with JMX or even by remote shell (SSH or Telnet). Auditing, health and metrics gathering can be automatically applied to your application.
34. Enabling production-ready features.

The `spring-boot-actuator` module provides all of Spring Boot's production-ready features. The simplest way to enable the features is to add a dependency to the `spring-boot-starter-actuator` 'Starter POM'.

### Definition of Actuator

An actuator is a manufacturing term, referring to a mechanical device for moving or controlling something. Actuators can generate a large amount of motion from a small change.

To add the actuator to a Maven based project, add the following 'starter' dependency:

```xml
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-actuator</artifactId>
  </dependency>
</dependencies>
```

For Gradle, use the declaration:

```groovy
dependencies {
    compile("org.springframework.boot:spring-boot-starter-actuator")
}
```
## 35. Endpoints

Actuator endpoints allow you to monitor and interact with your application. Spring Boot includes a number of built-in endpoints and you can also add your own. For example the `health` endpoint provides basic application health information.

The way that endpoints are exposed will depend on the type of technology that you choose. Most applications choose HTTP monitoring, where the ID of the endpoint is mapped to a URL. For example, by default, the `health` endpoint will be mapped to `/health`.

The following endpoints are available:

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>autoconfig</td>
<td>Displays an auto-configuration report showing all auto-configuration candidates and the reason why they ‘were’ or ‘were not’ applied.</td>
<td>true</td>
</tr>
<tr>
<td>beans</td>
<td>Displays a complete list of all the Spring Beans in your application.</td>
<td>true</td>
</tr>
<tr>
<td>configprops</td>
<td>Displays a collated list of all <code>@ConfigurationProperties</code>.</td>
<td>true</td>
</tr>
<tr>
<td>dump</td>
<td>Performs a thread dump.</td>
<td>true</td>
</tr>
<tr>
<td>env</td>
<td>Exposes properties from Spring’s <code>ConfigurableEnvironment</code>.</td>
<td>true</td>
</tr>
<tr>
<td>health</td>
<td>Shows application health information (defaulting to a simple ‘OK’ message).</td>
<td>false</td>
</tr>
<tr>
<td>info</td>
<td>Displays arbitrary application info.</td>
<td>false</td>
</tr>
<tr>
<td>metrics</td>
<td>Shows ‘metrics’ information for the current application.</td>
<td>true</td>
</tr>
<tr>
<td>mappings</td>
<td>Displays a collated list of all <code>@RequestMapping</code> paths.</td>
<td>true</td>
</tr>
<tr>
<td>shutdown</td>
<td>Allows the application to be gracefully shutdown (not enabled by default).</td>
<td>true</td>
</tr>
<tr>
<td>trace</td>
<td>Displays trace information (by default the last few HTTP requests).</td>
<td>true</td>
</tr>
</tbody>
</table>

**Note**

Depending on how an endpoint is exposed, the `sensitive` parameter may be used as a security hint. For example, sensitive endpoints will require a username/password when they are accessed over HTTP (or simply disabled if web security is not enabled).

### 35.1 Customizing endpoints

Endpoints can be customized using Spring properties. You can change if an endpoint is enabled, if it is considered sensitive and even its id.
1.1.9.RELEASE

For example, here is an application.properties that changes the sensitivity and id of the beans endpoint and also enables shutdown.

```
endpoints.beans.id=springbeans
endpoints.beans.sensitive=false
endpoints.shutdown.enabled=true
```

**Note**

The prefix `#endpoints + . + name` is used to uniquely identify the endpoint that is being configured.

### 35.2 Custom health information

The default information exposed by the health endpoint is a simple ‘OK’ message. It is often useful to perform some additional health checks, for example you might check that a database connection works, or that a remote REST endpoint is functioning.

To provide custom health information you can register a Spring bean that implements the `HealthIndicator` interface.

```java
import org.springframework.boot.actuate.health.HealthIndicator;
import org.springframework.stereotype.Component;

@Component
public class MyHealth implements HealthIndicator {
    @Override
    public Health health() {
        // perform some specific health check
        return ...
    }
}
```

Spring Boot provides a `DataSourceHealthIndicator` implementation that attempts a simple database test as well as implementations for Redis, MongoDB and RabbitMQ.

Spring Boot adds the `HealthIndicator` instances automatically if beans of type `DataSource, MongoTemplate, RedisConnectionFactory, RabbitTemplate` are present in the `ApplicationContext`.

Besides implementing custom a `HealthIndicator` type and using out-of-box `Status` types, it is also possible to introduce custom `Status` types for different or more complex system states. In that case a custom implementation of the `HealthAggregator` interface needs to be provided or the default implementation has to be configured using the `health.status.order` configuration property.

Assuming a new `Status` with code `FATAL` is being used in one of your `HealthIndicator` implementations. To configure the severity or order add the following to your application properties:

```
health.status.order: FATAL, DOWN, UNKNOWN, UP
```

### 35.3 Custom application info information

You can customize the data exposed by the info endpoint by setting info.* Spring properties. All `Environment` properties under the info key will be automatically exposed. For example, you could add the following to your application.properties:
**Automatically expand info properties at build time**

Rather than hardcoding some properties that are also specified in your project’s build configuration, you can automatically expand info properties using the existing build configuration instead. This is possible in both Maven and Gradle.

### Automatic property expansion using Maven

You can automatically expand info properties from the Maven project using resource filtering. In your `pom.xml` you have (inside the `<build/>` element):

```xml
<resources>
  <resource>
    <directory>src/main/resources</directory>
    <filtering>true</filtering>
  </resource>
</resources>
```

You can then refer to your Maven ‘project properties’ via placeholders, e.g.

- `project.artifactId=myproject`
- `project.name=Demo`
- `project.version=X.X.X.X`
- `project.description=Demo project for info endpoint`
- `info.build.artifact=${project.artifactId}`
- `info.build.name=${project.name}`
- `info.build.description=${project.description}`
- `info.build.version=${project.version}`

**Note**

In the above example we used `project.*` to set some values to be used as fallbacks if the Maven resource filtering has not been switched on for some reason.

### Automatic property expansion using Gradle

You can automatically expand info properties from the Gradle project by configuring the Java plugin’s `processResources` task to do so:

```gradle
processResources {
    expand(project.properties)
}
```

You can then refer to your Gradle project’s properties via placeholders, e.g.

- `info.build.name=${name}`
- `info.build.description=${description}`
- `info.build.version=${version}`

### Git commit information

Another useful feature of the `info` endpoint is its ability to publish information about the state of your git source code repository when the project was built. If a `git.properties` file is contained in your jar the `git.branch` and `git.commit` properties will be loaded.
For Maven users the spring-boot-starter-parent POM includes a pre-configured plugin to generate a git.properties file. Simply add the following declaration to your POM:

```xml
<build>
  <plugins>
    <plugin>
      <groupId>pl.project13.maven</groupId>
      <artifactId>git-commit-id-plugin</artifactId>
    </plugin>
  </plugins>
</build>
```

A similar gradle-git plugin is also available for Gradle users, although a little more work is required to generate the properties file.
36. Monitoring and management over HTTP

If you are developing a Spring MVC application, Spring Boot Actuator will auto-configure all non-sensitive endpoints to be exposed over HTTP. The default convention is to use the id of the endpoint as the URL path. For example, health is exposed as /health.

36.1 Exposing sensitive endpoints

If you use ‘Spring Security’ sensitive endpoints will be exposed over HTTP, but also protected. By default ‘basic’ authentication will be used with the username user and a generated password (which is printed on the console when the application starts).

Tip

Generated passwords are logged as the application starts. Search for ‘Using default security password’.

You can use Spring properties to change the username and password and to change the security role required to access the endpoints. For example, you might set the following in your application.properties:

```properties
security.user.name=admin
security.user.password=secret
management.security.role=SUPERUSER
```

36.2 Customizing the management server context path

Sometimes it is useful to group all management endpoints under a single path. For example, your application might already use /info for another purpose. You can use the management.contextPath property to set a prefix for your management endpoint:

```properties
management.context-path=/manage
```

The application.properties example above will change the endpoint from /{id} to /manage/{id} (e.g. /manage/info).

36.3 Customizing the management server port

Exposing management endpoints using the default HTTP port is a sensible choice for cloud based deployments. If, however, your application runs inside your own data center you may prefer to expose endpoints using a different HTTP port.

The management.port property can be used to change the HTTP port.

```properties
management.port=8081
```

Since your management port is often protected by a firewall, and not exposed to the public you might not need security on the management endpoints, even if your main application is secure. In that case you will have Spring Security on the classpath, and you can disable management security like this:

```properties
management.security.enabled=false
```

(If you don’t have Spring Security on the classpath then there is no need to explicitly disable the management security in this way, and it might even break the application.)
36.4 Customizing the management server address

You can customize the address that the management endpoints are available on by setting the `management.address` property. This can be useful if you want to listen only on an internal or ops-facing network, or to only listen for connections from `localhost`.

**Note**

You can only listen on a different address if the port is different to the main server port.

Here is an example `application.properties` that will not allow remote management connections:

```properties
management.port=8081
management.address=127.0.0.1
```

36.5 Disabling HTTP endpoints

If you don’t want to expose endpoints over HTTP you can set the management port to `-1`:

```properties
management.port=-1
```
37. Monitoring and management over JMX

Java Management Extensions (JMX) provide a standard mechanism to monitor and manage applications. By default Spring Boot will expose management endpoints as JMX MBeans under the org.springframework.boot domain.

37.1 Customizing MBean names

The name of the MBean is usually generated from the id of the endpoint. For example the health endpoint is exposed as org.springframework.boot/Endpoint/HealthEndpoint.

If your application contains more than one Spring ApplicationContext you may find that names clash. To solve this problem you can set the endpoints.jmx.uniqueNames property to true so that MBean names are always unique.

You can also customize the JMX domain under which endpoints are exposed. Here is an example application.properties:

```
endpoints.jmx.domain=myapp
endpoints.jmx.uniqueNames=true
```

37.2 Disabling JMX endpoints

If you don’t want to expose endpoints over JMX you can set the spring.jmx.enabled property to false:

```
spring.jmx.enabled=false
```

37.3 Using Jolokia for JMX over HTTP

Jolokia is a JMX-HTTP bridge giving an alternative method of accessing JMX beans. To use Jolokia, simply include a dependency to org.jolokia:jolokia-core. For example, using Maven you would add the following:

```
<dependency>
  <groupId>org.jolokia</groupId>
  <artifactId>jolokia-core</artifactId>
</dependency>
```

Jolokia can then be accessed using /jolokia on your management HTTP server.

Customizing Jolokia

Jolokia has a number of settings that you would traditionally configure using servlet parameters. With Spring Boot you can use your application.properties, simply prefix the parameter with jolokia.config.:

```
jolokia.config.debug=true
```

Disabling Jolokia

If you are using Jolokia but you don’t want Spring Boot to configure it, simply set the endpoints.jolokia.enabled property to false:
| endpoints.jolokia.enabled | false |
38. Monitoring and management using a remote shell

Spring Boot supports an integrated Java shell called ‘CRaSH’. You can use CRaSH to `ssh` or `telnet` into your running application. To enable remote shell support add a dependency to `spring-boot-starter-remote-shell`:

```xml
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-remote-shell</artifactId>
</dependency>
```

**Tip**

If you want to also enable telnet access your will additionally need a dependency on `org.crsh:crsh.shell.telnet`.

38.1 Connecting to the remote shell

By default the remote shell will listen for connections on port 2000. The default user is `user` and the default password will be randomly generated and displayed in the log output. If your application is using Spring Security, the shell will use the *same configuration* by default. If not, a simple authentication will be applied and you should see a message like this:

```plaintext
Using default password for shell access: ec03e16c-4cf4-49ee-b745-7c8255c1dd7e
```

Linux and OSX users can use `ssh` to connect to the remote shell, Windows users can download and install PuTTY.

```bash
$ ssh -p 2000 user@localhost
user@localhost's password:

Password: |

(\\____\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\___\_
Remote shell commands

You can write additional shell commands using Groovy or Java (see the CRaSH documentation for details). By default Spring Boot will search for commands in the following locations:

- `classpath*:commands/**`
- `classpath*:crash/commands/**`

**Tip**

You can change the search path by setting a `shell.commandPathPatterns` property.

Here is a simple 'hello world' command that could be loaded from `src/main/resources/commands/hello.groovy`

```groovy
package commands

import org.crsh.cli.Usage
import org.crsh.cli.Command

class hello {

    @Usage("Say Hello")
    @Command
    def main(InvocationContext context) {
        return "Hello"
    }
}
```

Spring Boot adds some additional attributes to `InvocationContext` that you can access from your command:

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spring.boot.version</td>
<td>The version of Spring Boot</td>
</tr>
<tr>
<td>spring.version</td>
<td>The version of the core Spring Framework</td>
</tr>
<tr>
<td>spring.beanfactory</td>
<td>Access to the Spring BeanFactory</td>
</tr>
<tr>
<td>spring.environment</td>
<td>Access to the Spring Environment</td>
</tr>
</tbody>
</table>

Remote shell plugins

In addition to new commands, it is also possible to extend other CRaSH shell features. All Spring Beans that extend `org.crsh.plugin.CRaSHPlugin` will be automatically registered with the shell.

For more information please refer to the [CRaSH reference documentation](#).
39. Metrics

Spring Boot Actuator includes a metrics service with ‘gauge’ and ‘counter’ support. A ‘gauge’ records a single value; and a ‘counter’ records a delta (an increment or decrement). Metrics for all HTTP requests are automatically recorded, so if you hit the metrics endpoint should should see a response similar to this:

```json
{
    "counter.status.200.root": 20,
    "counter.status.200.metrics": 3,
    "counter.status.200.star-star": 5,
    "counter.status.401.root": 4,
    "gauge.response.star-star": 6,
    "gauge.response_root": 2,
    "gauge.response.metrics": 3,
    "classes": 5808,
    "classes.loaded": 5808,
    "classes.unloaded": 0,
    "heap": 3728384,
    "heap.committed": 986624,
    "heap.init": 262144,
    "heap.used": 52765,
    "mem": 986624,
    "mem.free": 933858,
    "processors": 8,
    "threads": 15,
    "threads.daemon": 11,
    "threads.peak": 15,
    "uptime": 494836
}
```

Here we can see basic memory, heap, class loading, processor and thread pool information along with some HTTP metrics. In this instance the root (‘/’) and /metrics URLs have returned HTTP 200 responses 20 and 3 times respectively. It also appears that the root URL returned HTTP 401 (unauthorized) 4 times. The double asterix (star-star) comes from a request matched by Spring MVC as /** (normally a static resource).

The gauge shows the last response time for a request. So the last request to root took 2ms to respond and the last to /metrics took 3ms.

**Note**

In this example we are actually accessing the endpoint over HTTP using the /metrics URL, this explains why metrics appears in the response.

39.1 Recording your own metrics

To record your own metrics inject a CounterService and/or GaugeService into your bean.
The CounterService exposes increment, decrement and reset methods; the GaugeService provides a submit method.

Here is a simple example that counts the number of times that a method is invoked:

```java
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.boot.actuate.metrics.CounterService;
import org.springframework.stereotype.Service;

@Service
public class MyService {
```

```java
```
```java
private final CounterService counterService;

@Autowired
public MyService(CounterService counterService) {
    this.counterService = counterService;
}

public void exampleMethod() {
    this.counterService.increment("services.system.myservice.invoked");
}
```

### Tip

You can use any string as a metric name but you should follow guidelines of your chosen store/graphing technology. Some good guidelines for Graphite are available on [Matt Aimonetti’s Blog](https://www.mattaimonetti.com/blog).

## 39.2 Metric repositories

Metric service implementations are usually bound to a `MetricRepository`. A `MetricRepository` is responsible for storing and retrieving metric information. Spring Boot provides an `InMemoryMetricRepository` and a `RedisMetricRepository` out of the box (the in-memory repository is the default) but you can also write your own. The `MetricRepository` interface is actually composed of higher level `MetricReader` and `MetricWriter` interfaces. For full details refer to the [Javadoc](https://docs.spring.io/spring-boot/docs/current/api/org/springframework/metric/MetricRepository.html).

There’s nothing to stop you hooking a `MetricRepository` with back-end storage directly into your app, but we recommend using the default `InMemoryMetricRepository` (possibly with a custom `Map` instance if you are worried about heap usage) and populating a back-end repository through a scheduled export job. In that way you get some buffering in memory of the metric values and you can reduce the network chatter by exporting less frequently or in batches. Spring Boot provides an `Exporter` interface and a few basic implementations for you to get started with that.

### 39.3 Coda Hale Metrics

User of the [Coda Hale Metrics library](https://metrics.codahale.com) will automatically find that Spring Boot metrics are published to `com.codahale.metrics.MetricRegistry`. A default `com.codahale.metrics.MetricRegistry` Spring bean will be created when you declare a dependency to the `com.codahale.metrics:metrics-core` library; you can also register you own `@Bean` instance if you need customizations.

Users can create Coda Hale metrics by prefixing their metric names with the appropriate type (e.g. `histogram.*`, `meter.*`).

### 39.4 Message channel integration

If the ‘Spring Messaging’ jar is on your classpath a `MessageChannel` called `metricsChannel` is automatically created (unless one already exists). All metric update events are additionally published as ‘messages’ on that channel. Additional analysis or actions can be taken by clients subscribing to that channel.
40. Auditing

Spring Boot Actuator has a flexible audit framework that will publish events once Spring Security is in play (‘authentication success’, ‘failure’ and ‘access denied’ exceptions by default). This can be very useful for reporting, and also to implement a lock-out policy based on authentication failures.

You can also choose to use the audit services for your own business events. To do that you can either inject the existing AuditEventRepository into your own components and use that directly, or you can simply publish AuditApplicationEvent via the Spring ApplicationEventPublisher (using ApplicationEventPublisherAware).
41. Tracing

Tracing is automatically enabled for all HTTP requests. You can view the trace endpoint and obtain basic information about the last few requests:

```json
[[
   "timestamp": 1394343677415,
   "info": {
      "method": "GET",
      "path": "/trace",
      "headers": {
         "request": {
            "Accept": "text/html,application/xhtml+xml,application/xml;q=0.9, */*;q=0.8",
            "Connection": "keep-alive",
            "Accept-Encoding": "gzip, deflate",
            "User-Agent": "Mozilla/5.0 Gecko/Firefox",
            "Accept-Language": "en-US,en;q=0.5",
            "Cookie": "_ga=GA1.1.827067509.1390890128; ...",
            "Authorization": "Basic ...",
            "Host": "localhost:8080"
         }
      },
      "response": {
         "Strict-Transport-Security": "max-age=31536000; includeSubDomains",
         "X-Application-Context": "application:8080",
         "Content-Type": "application/json;charset=UTF-8",
         "status": "200"
      }
   }
},
[,{
   "timestamp": 1394343684465,
   ...
}]
```

41.1 Custom tracing

If you need to trace additional events you can inject a `TraceRepository` into your Spring Beans. The `add` method accepts a single `Map` structure that will be converted to JSON and logged.

By default an `InMemoryTraceRepository` will be used that stores the last 100 events. You can define your own instance of the `InMemoryTraceRepository` bean if you need to expand the capacity. You can also create your own alternative `TraceRepository` implementation if needed.
42. Process monitoring

In Spring Boot Actuator you can find ApplicationPidListener which creates file containing application PID (by default in application directory and file name is application.pid). It's not activated by default, but you can do it in two simple ways described below.

42.1 Extend configuration

In META-INF/spring.factories file you have to activate the listener:

```bash
org.springframework.context.ApplicationListener=
org.springframework.boot.actuate.system.ApplicationPidListener
```

42.2 Programmatically

You can also activate this listener by invoking SpringApplication.addListeners(...) method and passing ApplicationPidListener object. You can also customize the file name and path through its constructor.
43. What to read next

If you want to explore some of the concepts discussed in this chapter, you can take a look at the actuator sample applications. You also might want to read about graphing tools such as Graphite.

Otherwise, you can continue on, to read about 'cloud deployment options' or jump ahead for some in-depth information about Spring Boot's build tool plugins.
Spring Boot’s executable jars are ready-made for most popular cloud PaaS (platform-as-a-service) providers. These providers tend to require that you “bring your own container”; they manage application processes (not Java applications specifically), so they need some intermediary layer that adapts your application to the cloud’s notion of a running process.

Two popular cloud providers, Heroku and Cloud Foundry, employ a “buildpack” approach. The buildpack wraps your deployed code in whatever is needed to start your application: it might be a JDK and a call to java, it might be an embedded webserver, or it might be a full-fledged application server. A buildpack is pluggable, but ideally you should be able to get by with as few customizations to it as possible. This reduces the footprint of functionality that is not under your control. It minimizes divergence between deployment and production environments.

Ideally, your application, like a Spring Boot executable jar, has everything that it needs to run packaged within it.

In this section we’ll look at what it takes to get the simple application that we developed in the “Getting Started” section up and running in the Cloud.
44. Cloud Foundry

Cloud Foundry provides default buildpacks that come into play if no other buildpack is specified. The Cloud Foundry [Java buildpack](https://docs.cloudfoundry.org/guides/buildpacks/java-buildpack.html) has excellent support for Spring applications, including Spring Boot. You can deploy stand-alone executable jar applications, as well as traditional .war packaged applications.

Once you've built your application (using, for example, `mvn clean package`) and installed the `cf` command line tool, simply deploy your application using the `cf push` command as follows, substituting the path to your compiled `.jar`. Be sure to have `logged in with your cf command line client` before pushing an application.

```
$ cf push acloudyspringtime -p target/demo-0.0.1-SNAPSHOT.jar
```

See the [cf push documentation](https://docs.cloudfoundry.org/cli/commands/cf_push.html) for more options. If there is a Cloud Foundry [manifest.yml](https://docs.cloudfoundry.org/guides/scoring/manifest.html) file present in the same directory, it will be consulted.

**Note**

Here we are substituting `acloudyspringtime` for whatever value you give `cf` as the name of your application.

At this point `cf` will start uploading your application:

```
Uploading acloudyspringtime... OK
Preparing to start acloudyspringtime... OK
-----> Downloaded app package (8.9M)
-----> Java Buildpack source: system
-----> Downloading Open JDK 1.7.0_51 from .../x86_64/openjdk-1.7.0_51.tar.gz (1.8s)
     Expanding Open JDK to .java-buildpack/open_jdk (1.2s)
-----> Downloading Spring Auto Reconfiguration from 0.8.7 .../auto-reconfiguration-0.8.7.jar (0.1s)
-----> Uploading droplet (44M)
Checking status of app 'acloudyspringtime'...
   0 of 1 instances running (1 starting)
    ...
   0 of 1 instances running (1 down)
    ...
   0 of 1 instances running (1 starting)
    ...
  1 of 1 instances running (1 running)
App started
```

Congratulations! The application is now live!

It's easy to then verify the status of the deployed application:

```
$ cf apps
Getting applications in ...
OK
name                 requested state   instances   memory   disk   urls
    ...
  acloudyspringtime    started           1/1          512M     1G     acloudyspringtime.cfapps.io
    ...
```

Once Cloud Foundry acknowledges that your application has been deployed, you should be able to hit the application at the URI given, in this case `acloudyspringtime.cfapps.io/`. 
44.1 Binding to services

By default, metadata about the running application as well as service connection information is exposed to the application as environment variables (for example: $VCAP_SERVICES). This architecture decision is due to Cloud Foundry’s polyglot (any language and platform can be supported as a buildpack) nature; process-scoped environment variables are language agnostic.

Environment variables don’t always make for the easiest API so Spring Boot automatically extracts them and flattens the data into properties that can be accessed through Spring’s `Environment` abstraction:

```java
@Component
class MyBean implements EnvironmentAware {
    private String instanceId;

    @Override
    public void setEnvironment(Environment environment) {
        this.instanceId = environment.getProperty("vcap.application.instance_id");
    }

    // ...
}
```

All Cloud Foundry properties are prefixed with `vcap`. You can use vcap properties to access application information (such as the public URL of the application) and service information (such as database credentials). See `VcapApplicationListener` Javadoc for complete details.

**Tip**

The [Spring Cloud](https://spring.io/projects/spring-cloud) project is a better fit for tasks such as configuring a DataSource; it also lets you use Spring Cloud with Heroku.
45. Heroku

Heroku is another popular PaaS platform. To customize Heroku builds, you provide a Procfile, which provides the incantation required to deploy an application. Heroku assigns a port for the Java application to use and then ensures that routing to the external URI works.

You must configure your application to listen on the correct port. Here’s the Procfile for our starter REST application:

```bash
web: java -Dserver.port=$PORT $JAVA_OPTS -jar target/demo-0.0.1-SNAPSHOT.jar
```

Spring Boot makes `-D` arguments available as properties accessible from a Spring Environment instance. The `server.port` configuration property is fed to the embedded Tomcat or Jetty instance which then uses it when it starts up. The `$PORT` environment variable is assigned to us by the Heroku PaaS.

Heroku by default will use Java 1.6. This is fine as long as your Maven or Gradle build is set to use the same version (Maven users can use the `java.version` property). If you want to use JDK 1.7, create a new file adjacent to your `pom.xml` and `Procfile`, called `system.properties`. In this file add the following:

```properties
java.runtime.version=1.7
```

This should be everything you need. The most common workflow for Heroku deployments is to `git push` the code to production.

```bash
$ git push heroku master

Initializing repository, done.
Counting objects: 95, done.
Delta compression using up to 8 threads.
Compressing objects: 100% (78/78), done.
Writing objects: 100% (95/95), 8.66 MiB | 606.00 KiB/s, done.
Total 95 (delta 31), reused 0 (delta 0)
-----> Java app detected
-----> Installing OpenJDK 1.7... done
-----> Installing Maven 3.0.3... done
-----> Installing settings.xml... done
-----> executing /app/tmp/cache/.maven/bin/mvn -B
-Duser.home=/tmp/build_0c35a5d2-a067-4abc-a232-14b1f7a8229
-Dmaven.repo.local=/app/tmp/cache/.m2/repository
-s /app/tmp/cache/.m2/settings.xml -DskipTests=true clean install

[INFO] Scanning for projects...
Downloaded: http://repo.spring.io/... (818 B at 1.8 KB/sec)
....
Downloaded: http://s3pository.heroku.com/jvm/... (152 KB at 595.3 KB/sec)

[INFO] Installing /tmp/build_0c35a5d2-a067-4abc-a232-14b1f7a8229/target/...
[INFO] Installing /tmp/build_0c35a5d2-a067-4abc-a232-14b1f7a8229/pom.xml ...

[INFO] BUILD SUCCESS
[INFO] WARNING: Preparing your server instance (...)

[INFO] Total time: 59.358s
[INFO] Final Memory: 20M/493M

-----> Discovering process types
Procfile declares types -> web
Your application should now be up and running on Heroku.
46. CloudBees

CloudBees provides cloud-based “continuous integration” and “continuous delivery” services as well as Java PaaS hosting. Sean Gilligan has contributed an excellent Spring Boot sample application to the CloudBees community GitHub repository. The project includes an extensive README that covers the steps that you need to follow when deploying to CloudBees.
47. Openshift

Openshift is the RedHat public (and enterprise) PaaS solution. Like Heroku, it works by running scripts triggered by git commits, so you can script the launching of a Spring Boot application in pretty much any way you like as long as the Java runtime is available (which is a standard feature you can ask for at Openshift). To do this you can use the DIY Cartridge and hooks in your repository under .openshift/action_scripts:

The basic model is to:

1. Ensure Java and your build tool are installed remotely, e.g. using a pre_build hook (Java and Maven are installed by default, Gradle is not)

2. Use a build hook to build your jar (using Maven or Gradle), e.g.

```bash
#!/bin/bash
cd $OPENSHIFT_REPO_DIR
mvn package -s .openshift/settings.xml -DskipTests=true
```

3. Add a start hook that calls java -jar ...

```bash
#!/bin/bash
cd $OPENSHIFT_REPO_DIR
nohup java -jar target/*.jar --server.port=${OPENSHIFT_DIY_PORT} --server.address=${OPENSHIFT_DIY_IP} &
```

4. Use a stop hook (since the start is supposed to return cleanly), e.g.

```bash
#!/bin/bash
source $OPENSHIFT_CARTRIDGE_SDK_BASH
PID=$(ps -ef | grep java.*\.jar | grep -v grep | awk '{ print $2 }')
if [ -z "$PID" ]
then
  client_result "Application is already stopped"
else
  kill $PID
fi
```

5. Embed service bindings from environment variables provided by the platform in your application.properties, e.g.

```
spring.datasource.url: jdbc:mysql://$OPENSHIFT_MYSQL_DB_HOST:$OPENSHIFT_MYSQL_DB_PORT/$OPENSHIFT_APP_NAME
spring.datasource.username: $OPENSHIFT_MYSQL_DB_USERNAME
spring.datasource.password: $OPENSHIFT_MYSQL_DB_PASSWORD
```

There's a blog on running Gradle in Openshift on their website that will get you started with a gradle build to run the app. A bug in Gradle currently prevents you from using Gradle newer than 1.6.
48. What to read next

Check out the Cloud Foundry, Heroku and CloudBees web sites for more information about the kinds of features that a PaaS can offer. These are just three of the most popular Java PaaS providers, since Spring Boot is so amenable to cloud-based deployment you’re free to consider other providers as well.

The next section goes on to cover the Spring Boot CLI; or you can jump ahead to read about build tool plugins.
Part VII. Spring Boot CLI

The Spring Boot CLI is a command line tool that can be used if you want to quickly prototype with Spring. It allows you to run Groovy scripts, which means that you have a familiar Java-like syntax, without so much boilerplate code.
49. Installing the CLI

The Spring Boot CLI can be installed manually; using GVM (the Groovy Environment Manually) or using Homebrew if you are an OSX user. See Section 9.2, “Installing the Spring Boot CLI” in the “Getting started” section for comprehensive installation instructions.
50. Using the CLI

Once you have installed the CLI you can run it by typing spring. If you run spring without any arguments, a simple help screen is displayed:

```
$ spring
usage: spring [--help] [--version]
         [command] [args]
Available commands are:

run [options] <files> [--] [args]
  Run a spring groovy script

... more command help is shown here
```

You can use help to get more details about any of the supported commands. For example:

```
$ spring help run
spring run - Run a spring groovy script

usage: spring run [options] <files> [--] [args]

Option                     Description
------                     -----------
--autoconfigure [Boolean]  Add autoconfigure compiler
                         transformations (default: true)
--classpath, -cp           Additional classpath entries
-e, --edit                 Open the file with the default system
                         editor
--no-guess-dependencies   Do not attempt to guess dependencies
--no-guess-imports        Do not attempt to guess imports
-q, --quiet                Quiet logging
-v, --verbose              Verbose logging of dependency
                         resolution
--watch                    Watch the specified file for changes
```

The version command provides a quick way to check which version of Spring Boot you are using.

```
$ spring version
Spring CLI v1.1.9.RELEASE
```

50.1 Running applications using the CLI

You can compile and run Groovy source code using the run command. The Spring Boot CLI is completely self-contained so you don’t need any external Groovy installation.

Here is an example “hello world” web application written in Groovy:

```groovy
@RestController
class WebApplication {

    @RequestMapping("/")
    String home() {
        "Hello World!"
    }
}
```
Deduced “grab” dependencies

Standard Groovy includes a `@Grab` annotation which allows you to declare dependencies on a third-party libraries. This useful technique allows Groovy to download jars in the same way as Maven or Gradle would; but without requiring you to use a build tool.

Spring Boot extends this technique further, and will attempt to deduce which libraries to “grab” based on your code. For example, since the `WebApplication` code above uses `@RestController` annotations, “Tomcat” and “Spring MVC” will be grabbed.

The following items are used as “grab hints”:

<table>
<thead>
<tr>
<th>Items</th>
<th>Grabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>JdbcTemplate,</td>
<td>JDBC Application.</td>
</tr>
<tr>
<td>NamedParameterJdbcTemplate,</td>
<td></td>
</tr>
<tr>
<td>DataSource</td>
<td></td>
</tr>
<tr>
<td>@EnableJmsMessaging</td>
<td>JMS Application.</td>
</tr>
<tr>
<td>@Test</td>
<td>JUnit.</td>
</tr>
<tr>
<td>@EnableRabbitMessaging</td>
<td>RabbitMQ.</td>
</tr>
<tr>
<td>@EnableReactor</td>
<td>Project Reactor.</td>
</tr>
<tr>
<td><code>extends Specification</code></td>
<td>Spock test.</td>
</tr>
<tr>
<td>@EnableBatchProcessing</td>
<td>Spring Batch.</td>
</tr>
<tr>
<td>@MessageEndpoint</td>
<td></td>
</tr>
<tr>
<td>@EnableIntegrationPatterns</td>
<td>Spring Integration.</td>
</tr>
<tr>
<td>@EnableDeviceResolver</td>
<td>Spring Mobile.</td>
</tr>
<tr>
<td><code>@Controller @RestController</code></td>
<td>Spring MVC + Embedded Tomcat.</td>
</tr>
<tr>
<td>@EnableWebMvc</td>
<td></td>
</tr>
<tr>
<td>@EnableWebSecurity</td>
<td>Spring Security.</td>
</tr>
<tr>
<td>@EnableTransactionManagement</td>
<td>Spring Transaction Management.</td>
</tr>
</tbody>
</table>

Tip

See subclasses of `CompilerAutoConfiguration` in the Spring Boot CLI source code to understand exactly how customizations are applied.

Deduced “grab” coordinates

Spring Boot extends Groovy’s standard `@Grab` support by allowing you to specify a dependency without a group or version, for example `@Grab('freemarker')`. This will consult Spring Boot’s default dependency metadata to deduce the artifact’s group and version. Note that the default metadata is tied to the version of the CLI that you’re using – it will only change when you move to a new version of the CLI, putting you in control of when the versions of your dependencies may change. A table showing the dependencies and their versions that are included in the default metadata can be found in the appendix.
Custom “grab” metadata

Spring Boot provides a new annotation, `@GrabMetadata` that can be used to provide custom dependency metadata that overrides Spring Boot’s defaults. This metadata is specified by using this annotation to provide the coordinates of one or more properties files (deployed to a Maven repository with a "type" identifier: "properties"). For example `@GrabMetadata(["com.example:versions-one:1.0.0", "com.example.versions-two:1.0.0"])` will pick up files in a Maven repository in "com/example/versions-/1.0.0/versions--1.0.0.properties". The properties files are applied in the order that they’re specified. In the example above, this means that properties in `versions-two` will override properties in `versions-one`. Each entry in each properties file must be in the form `group:module=version`. You can use `@GrabMetadata` anywhere that you can use `@Grab`, however, to ensure consistent ordering of the metadata, you can only use `@GrabMetadata` at most once in your application. A useful source of dependency metadata (a superset of Spring Boot) is the Spring IO Platform, e.g. `@GrabMetadata('io.spring.platform:platform-versions:1.0.0.RELEASE')`.

Default import statements

To help reduce the size of your Groovy code, several import statements are automatically included. Notice how the example above refers to `@Component`, `@RestController` and `@RequestMapping` without needing to use fully-qualified names or import statements.

Tip

Many Spring annotations will work without using import statements. Try running your application to see what fails before adding imports.

Automatic main method

Unlike the equivalent Java application, you do not need to include a public static void main(String[] args) method with your Groovy scripts. A SpringApplication is automatically created, with your compiled code acting as the source.

50.2 Testing your code

The test command allows you to compile and run tests for your application. Typical usage looks like this:

```
$ spring test app.groovy tests.groovy
Total: 1, Success: 1, : Failures: 0
Passed? true
```

In this example, tests.groovy contains JUnit @Test methods or Spock Specification classes. All the common framework annotations and static methods should be available to you without having to import them.

Here is the tests.groovy file that we used above (with a JUnit test):

```groovy
class ApplicationTests {

    @Test
    void homeSaysHello() {
        assertEquals("Hello World!", new WebApplication().home())
    }
}
```
Tip

If you have more than one test source files, you might prefer to organize them into a test directory.

50.3 Applications with multiple source files

You can use “shell globbing” with all commands that accept file input. This allows you to easily use multiple files from a single directory, e.g.

```
$ spring run *.groovy
```

This technique can also be useful if you want to segregate your “test” or “spec” code from the main application code:

```
$ spring test app/*.groovy test/*.groovy
```

50.4 Packaging your application

You can use the `jar` command to package your application into a self-contained executable jar file. For example:

```
$ spring jar my-app.jar *.groovy
```

The resulting jar will contain the classes produced by compiling the application and all of the application’s dependencies so that it can then be run using `java -jar`. The jar file will also contain entries from the application’s classpath. You can add explicit paths to the jar using `--include` and `--exclude` (both are comma-separated, and both accept prefixes to the values “+” and “-” to signify that they should be removed from the defaults). The default includes are

```
public/**, resources/**, static/**, templates/**, META-INF/**, *
```

and the default excludes are

```
.*, repository/**, build/**, target/**, **/*.jar, **/*.groovy
```

See the output of `spring help jar` for more information.

50.5 Using the embedded shell

Spring Boot includes command-line completion scripts for BASH and zsh shells. If you don’t use either of these shells (perhaps you are a Windows user) then you can use the `shell` command to launch an integrated shell.

```
$ spring shell
Spring Boot (v1.1.9.RELEASE)
Hit TAB to complete. Type \'help\' and hit RETURN for help, and \'exit\' to quit.
```

From inside the embedded shell you can run other commands directly:

```
$ version
Spring CLI v1.1.9.RELEASE
```
The embedded shell supports ANSI color output as well as tab completion. If you need to run a native command you can use the $ prefix. Hitting ctrl-c will exit the embedded shell.
51. Developing application with the Groovy beans DSL

Spring Framework 4.0 has native support for a beans{} “DSL” (borrowed from Grails), and you can embed bean definitions in your Groovy application scripts using the same format. This is sometimes a good way to include external features like middleware declarations. For example:

```groovy
@Configuration
class Application implements CommandLineRunner {

    @Autowired
    SharedService service

    @Override
    void run(String... args) {
        println service.message
    }
}

import my.company.SharedService

beans {
    service(SharedService) {
        message = "Hello World"
    }
}
```

You can mix class declarations with beans{} in the same file as long as they stay at the top level, or you can put the beans DSL in a separate file if you prefer.
52. What to read next

There are some sample groovy scripts available from the GitHub repository that you can use to try out the Spring Boot CLI. There is also extensive javadoc throughout the source code.

If you find that you reach the limit of the CLI tool, you will probably want to look at converting your application to full Gradle or Maven built “groovy project”. The next section covers Spring Boot’s Build tool plugins that you can use with Gradle or Maven.
Part VIII. Build tool plugins

Spring Boot provides build tool plugins for Maven and Gradle. The plugins offer a variety of features, including the packaging of executable jars. This section provides more details on both plugins, as well as some help should you need to extend an unsupported build system. If you are just getting started, you might want to read “Chapter 12, Build systems” from the Part III, “Using Spring Boot” section first.
53. Spring Boot Maven plugin

The [Spring Boot Maven Plugin](https://github.com/spring-projects/spring-boot) provides Spring Boot support in Maven, allowing you to package executable jar or war archives and run an application “in-place”. To use it you must be using Maven 3 (or better).

**Note**

Refer to the [Spring Boot Maven Plugin Site](https://github.com/spring-projects/spring-boot) for complete plugin documentation.

53.1 Including the plugin

To use the Spring Boot Maven Plugin simply include the appropriate XML in the `plugins` section of your `pom.xml`

```xml
<?xml version="1.0" encoding="UTF-8"?>
  <modelVersion>4.0.0</modelVersion>
  <build>
    <plugins>
      <plugin>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-maven-plugin</artifactId>
        <version>1.1.9.RELEASE</version>
        <executions>
          <execution>
            <goals>
              <goal>repackage</goal>
            </goals>
          </execution>
        </executions>
      </plugin>
    </plugins>
  </build>
</project>
```

This configuration will repackage a jar or war that is built during the `package` phase of the Maven lifecycle. The following example shows both the repackaged jar, as well as the original jar, in the `target` directory:

```
$ mvn package
$ ls target/*.jar
  target/myproject-1.0.0.jar target/myproject-1.0.0.jar.original
```

If you don’t include the `<execution/>` configuration as above, you can run the plugin on its own (but only if the package goal is used as well). For example:

```
$ mvn package spring-boot:repackage
$ ls target/*.jar
  target/myproject-1.0.0.jar target/myproject-1.0.0.jar.original
```

If you are using a milestone or snapshot release you will also need to add appropriate `pluginRepositories` elements:

```xml
<pluginRepositories>
  <pluginRepository>
    <id>spring-snapshots</id>
    <url>http://repo.spring.io/snapshot</url>
  </pluginRepository>
</pluginRepositories>
```
53.2 Packaging executable jar and war files

Once `spring-boot-maven-plugin` has been included in your `pom.xml` it will automatically attempt to rewrite archives to make them executable using the `spring-boot:repackage` goal. You should configure your project to build a jar or war (as appropriate) using the usual `packaging` element:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/xsd/maven-4.0.0.xsd">
    <packaging>jar</packaging>
</project>
```

Your existing archive will be enhanced by Spring Boot during the package phase. The main class that you want to launch can either be specified using a configuration option, or by adding a `Main-Class` attribute to the manifest in the usual way. If you don’t specify a main class the plugin will search for a class with a `public static void main(String[] args)` method.

To build and run a project artifact, you can type the following:

```
$ mvn package
$ java -jar target/mymodule-0.0.1-SNAPSHOT.jar
```

To build a war file that is both executable and deployable into an external container you need to mark the embedded container dependencies as “provided”, e.g:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/xsd/maven-4.0.0.xsd">
    <dependencies>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-web</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-tomcat</artifactId>
            <scope>provided</scope>
        </dependency>
    </dependencies>
</project>
```

Advanced configuration options and examples are available in the plugin info page.
54. Spring Boot Gradle plugin

The Spring Boot Gradle Plugin provides Spring Boot support in Gradle, allowing you to package executable jar or war archives, run Spring Boot applications and omit version information from your build.gradle file for “blessed” dependencies.

54.1 Including the plugin

To use the Spring Boot Gradle Plugin simply include a buildscript dependency and apply the spring-boot plugin:

```groovy
buildscript {
    dependencies {
        classpath("org.springframework.boot:spring-boot-gradle-plugin:1.1.9.RELEASE")
    }
}
yapply plugin: 'spring-boot'
```

If you are using a milestone or snapshot release you will also need to add appropriate repositories reference:

```groovy
buildscript {
    repositories {  
        maven {url "http://repo.spring.io/snapshot"}
        maven {url "http://repo.spring.io/milestone"}
    }
    // ...
}
```

54.2 Declaring dependencies without versions

The spring-boot plugin will register a custom Gradle ResolutionStrategy with your build that allows you to omit version numbers when declaring dependencies to “blessed” artifacts. To make use of this functionality, simply declare dependencies in the usual way, but leave the version number empty:

```groovy
dependencies {  
    compile("org.springframework.boot:spring-boot-starter-web")
    compile("org.thymeleaf:thymeleaf-spring4")
    compile("nz.net.ultraq.thymeleaf:thymeleaf-layout-dialect")
}
```

**Note**

The version of the spring-boot gradle plugin that you declare determines the actual versions of the “blessed” dependencies (this ensures that builds are always repeatable). You should always set the version of the spring-boot gradle plugin to the actual Spring Boot version that you wish to use. Details of the versions that are provided can be found in the appendix.

The spring-boot plugin will only supply a version where one is not specified. To use a version of an artifact that differs from the one that the plugin would provide, simply specify the version when you declare the dependency as you usually would. For example:

```groovy
dependencies {  
    compile("org.thymeleaf:thymeleaf-spring4:2.1.1.RELEASE")
}
```
Custom version management

If it is possible to customize the versions used by the ResolutionStrategy if you need to deviate from Spring Boot’s “blessed” dependencies. Alternative version metadata is consulted using the versionManagement configuration. For example:

```java
dependencies {
  versionManagement("com.mycorp:mycorp-versions:1.0.0.RELEASE@properties")
  compile("org.springframework.data:spring-data-hadoop")
}
```

Version information needs to be published to a repository as a .properties file. For the above example mycorp-versions.properties file might contain the following:

```properties
org.springframework.data\:spring-data-hadoop=2.0.0.RELEASE
```

The properties file takes precedence over Spring Boot’s defaults, and can be used to override version numbers if necessary.

54.3 Default exclude rules

Gradle handles “exclude rules” in a slightly different way to Maven which can cause unexpected results when using the starter POMs. Specifically, exclusions declared on a dependency will not be applied when the dependency can be reached through a different path. For example, if a starter POM declares the following:

```xml
<dependencies>
  <dependency>
    <groupId>org.springframework</groupId>
    <artifactId>spring-core</artifactId>
    <version>4.0.5.RELEASE</version>
    <exclusions>
      <exclusion>
        <groupId>commons-logging</groupId>
        <artifactId>commons-logging</artifactId>
      </exclusion>
    </exclusions>
  </dependency>
  <dependency>
    <groupId>org.springframework</groupId>
    <artifactId>spring-context</artifactId>
    <version>4.0.5.RELEASE</version>
  </dependency>
</dependencies>
```

The commons-logging jar will not be excluded by Gradle because it is pulled in transitively via spring-context (spring-context → spring-core → commons-logging) which does not have an exclusion element.

To ensure that correct exclusions are actually applied, the Spring Boot Gradle plugin will automatically add exclusion rules. All exclusions defined in the spring-boot-dependencies POM and implicit rules for the “starter” POMs will be added.

If you don’t want exclusion rules automatically applied you can use the following configuration:

```java
springBoot {
  applyExcludeRules=false
}
```
54.4 Packaging executable jar and war files

Once the `spring-boot` plugin has been applied to your project it will automatically attempt to rewrite archives to make them executable using the `bootRepackage` task. You should configure your project to build a jar or war (as appropriate) in the usual way.

The main class that you want to launch can either be specified using a configuration option, or by adding a `Main-Class` attribute to the manifest. If you don’t specify a main class the plugin will search for a class with a `public static void main(String[] args)` method.

To build and run a project artifact, you can type the following:

```
$ gradle build
$ java -jar build/libs/mymodule-0.0.1-SNAPSHOT.jar
```

To build a war file that is both executable and deployable into an external container, you need to mark the embedded container dependencies as belonging to a configuration named “providedRuntime”, e.g:

```groovy
... apply plugin: 'war'
war {
    baseName = 'myapp'
    version = '0.5.0'
}
repositories {
    mavenCentral()
    maven { url "http://repo.spring.io/libs-snapshot" }
}
configurations {
    providedRuntime
}
dependencies {
    compile("org.springframework.boot:spring-boot-starter-web")
    providedRuntime("org.springframework.boot:spring-boot-starter-tomcat")
    ...
}
```

54.5 Running a project in-place

To run a project in place without building a jar first you can use the “bootRun” task:

```
$ gradle bootRun
```

Running this way makes your static classpath resources (i.e. in `src/main/resources` by default) reloadable in the live application, which can be helpful at development time.

**Note**

Making static classpath resources reloadable means that `bootRun` does not use the output of the `processResources` task. When invoked using `bootRun` your application will use the resources in their unprocessed form.
54.6 Spring Boot plugin configuration

The gradle plugin automatically extends your build script DSL with a `springBoot` element for global configuration of the Boot plugin. Set the appropriate properties as you would with any other Gradle extension (see below for a list of configuration options):

```gradle
springBoot {
    backupSource = false
}
```

54.7 Repackage configuration

The plugin adds a `bootRepackage` task which you can also configure directly, e.g.:

```gradle
bootRepackage {
    mainClass = 'demo.Application'
}
```

The following configuration options are available:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>enabled</td>
<td>Boolean flag to switch the repacker off (sometimes useful if you want the other Boot features but not this one)</td>
</tr>
<tr>
<td>mainClass</td>
<td>The main class that should be run. If not specified the <code>mainClassName</code> project property will be used or, if the no <code>mainClassName</code> id defined the archive will be searched for a suitable class. &quot;Suitable&quot; means a unique class with a well-formed <code>main()</code> method (if more than one is found the build will fail). You should also be able to specify the main class name via the &quot;run&quot; task (main property) and/or the &quot;startScripts&quot;(mainClassName property) as an alternative to using the &quot;springBoot&quot; configuration.</td>
</tr>
<tr>
<td>classifier</td>
<td>A file name segment (before the extension) to add to the archive, so that the original is preserved in its original location. Defaults to null in which case the archive is repackaged in place. The default is convenient for many purposes, but if you want to use the original jar as a dependency in another project, it's best to use an extension to define the executable archive.</td>
</tr>
<tr>
<td>withJarTask</td>
<td>The name or value of the Jar task (defaults to all tasks of type Jar) which is used to locate the archive to repackage.</td>
</tr>
<tr>
<td>customConfiguration</td>
<td>The name of the custom configuration which is used to populate the nested lib directory (without specifying this you get all compile and runtime dependencies).</td>
</tr>
</tbody>
</table>

54.8 Repackage with custom Gradle configuration

Sometimes it may be more appropriate to not package default dependencies resolved from compile, runtime and provided scopes. If the created executable jar file is intended to be run as it is, you need to have all dependencies nested inside it; however, if the plan is to explode a jar file and run the...
main class manually, you may already have some of the libraries available via CLASSPATH. This is a situation where you can repack your jar with a different set of dependencies.

Using a custom configuration will automatically disable dependency resolving from compile, runtime and provided scopes. Custom configuration can be either defined globally (inside the springBoot section) or per task.

```groovy
task clientJar(type: Jar) {
    appendix = 'client'
    from sourceSets.main.output
    exclude('**/*Something*')
}

task clientBoot(type: BootRepackage, dependsOn: clientJar) {
    withJarTask = clientJar
    customConfiguration = "mycustomconfiguration"
}
```

In above example, we created a new clientJar Jar task to package a customized file set from your compiled sources. Then we created a new clientBoot BootRepackage task and instructed it to work with only clientJar task and mycustomconfiguration.

```groovy
configurations {
    mycustomconfiguration.exclude group: 'log4j'
}

dependencies {
    mycustomconfiguration configurations.runtime
}
```

The configuration that we are referring to in BootRepackage is a normal Gradle configuration. In the above example we created a new configuration named mycustomconfiguration instructing it to derive from a runtime and exclude the log4j group. If the clientBoot task is executed, the repackaged boot jar will have all dependencies from runtime but no log4j jars.

**Configuration options**

The following configuration options are available:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mainClass</td>
<td>The main class that should be run by the executable archive.</td>
</tr>
<tr>
<td>providedConfiguration</td>
<td>The name of the provided configuration (defaults to providedRuntime).</td>
</tr>
<tr>
<td>backupSource</td>
<td>If the original source archive should be backed-up before being repackaged (defaults to true).</td>
</tr>
<tr>
<td>customConfiguration</td>
<td>The name of the custom configuration.</td>
</tr>
<tr>
<td>layout</td>
<td>The type of archive, corresponding to how the dependencies are laid out inside (defaults to a guess based on the archive type).</td>
</tr>
<tr>
<td>requiresUnpack</td>
<td>A list of dependencies (in the form “groupId:artifactId” that must be unpacked from fat jars in order to run. Items are still packaged into the fat jar, but they will be automatically unpacked when it runs.</td>
</tr>
</tbody>
</table>
54.9 Understanding how the Gradle plugin works

When spring-boot is applied to your Gradle project a default task named bootRepackage is created automatically. The bootRepackage task depends on Gradle assemble task, and when executed, it tries to find all jar artifacts whose qualifier is empty (i.e. tests and sources jars are automatically skipped).

Due to the fact that bootRepackage finds 'all' created jar artifacts, the order of Gradle task execution is important. Most projects only create a single jar file, so usually this is not an issue; however, if you are planning to create a more complex project setup, with custom Jar and BootRepackage tasks, there are few tweaks to consider.

If you are 'just' creating custom jar files from your project you can simply disable default jar and bootRepackage tasks:

```groovy
ejar.enabled = false
bootRepackage.enabled = false
```

Another option is to instruct the default bootRepackage task to only work with a default jar task.

```groovy
bootRepackage.withJarTask = jar
```

If you have a default project setup where the main jar file is created and repackaged, 'and' you still want to create additional custom jars, you can combine your custom repackage tasks together and use dependsOn so that the bootJars task will run after the default bootRepackage task is executed:

```groovy
task bootJars
    bootJars.dependsOn = [clientBoot1,clientBoot2,clientBoot3]
    build.dependsOn(bootJars)
```

All the above tweaks are usually used to avoid situations where an already created boot jar is repackaged again. Repackaging an existing boot jar will not break anything, but you may find that it includes unnecessary dependencies.

54.10 Publishing artifacts to a Maven repository using Gradle

If you are declaring dependencies without versions and you want to publish artifacts to a Maven repository you will need to configure the Maven publication with details of Spring Boot’s dependency management. This can be achieved by configuring it to publish poms that inherit from spring-boot-starter-parent or that import dependency management from spring-boot-dependencies. The exact details of this configuration depend on how you’re using Gradle and how you’re trying to publish the artifacts.

Configuring Gradle to produce a pom that inherits dependency management

The following is an example of configuring Gradle to generate a pom that inherits from spring-boot-starter-parent. Please refer to the Gradle User Guide for further information.

```groovy
uploadArchives {
    repositories {
        mavenDeployer {
            pom {
                parent {
                    groupId "org.springframework.boot"
                    artifactId "spring-boot-starter-parent"
                }
            }
        }
    }
}
```
Configuring Gradle to produce a pom that imports dependency management

The following is an example of configuring Gradle to generate a pom that imports the dependency management provided by `spring-boot-dependencies`. Please refer to the Gradle User Guide for further information.

```groovy
uploadArchives {
    repositories {
        mavenDeployer {
            pom {
                project {
                    dependencyManagement {
                        dependencies {
                            dependency {
                                groupId "org.springframework.boot"
                                artifactId "spring-boot-dependencies"
                                version "1.1.9.RELEASE"
                                type "pom"
                                scope "import"
                            }
                        }
                    }
                }
            }
        }
    }
}
```
55. Supporting other build systems

If you want to use a build tool other than Maven or Gradle, you will likely need to develop your own plugin. Executable jars need to follow a specific format and certain entries need to be written in an uncompressed form (see the [executable jar format](#) section in the appendix for details).

The Spring Boot Maven and Gradle plugins both make use of `spring-boot-loader-tools` to actually generate jars. You are also free to use this library directly yourself if you need to.

55.1 Repackaging archives

To repackaging an existing archive so that it becomes a self-contained executable archive use `org.springframework.boot.loader.tools.Repackager`. The `Repackager` class takes a single constructor argument that refers to an existing jar or war archive. Use one of the two available `repackage()` methods to either replace the original file or write to a new destination. Various settings can also be configured on the repackager before it is run.

55.2 Nested libraries

When repackaging an archive you can include references to dependency files using the `org.springframework.boot.loader.tools.Libraries` interface. We don’t provide any concrete implementations of `Libraries` here as they are usually build system specific.

If your archive already includes libraries you can use `Libraries.NONE`.

55.3 Finding a main class

If you don’t use `Repackager.setMainClass()` to specify a main class, the repackager will use `ASM` to read class files and attempt to find a suitable class with a `public static void main(String[] args)` method. An exception is thrown if more than one candidate is found.

55.4 Example repackage implementation

Here is a typical example repackage:

```java
Repackager repackager = new Repackager(sourceJarFile);
repackager.setBackupSource(false);
repackager.repackage(new Libraries() {
    @Override
    public void doWithLibraries(LibraryCallback callback) throws IOException {
        // Build system specific implementation, callback for each dependency
        // callback.library(new Library(nestedFile, LibraryScope.COMPILE));
    }
});
```
56. What to read next

If you're interested in how the build tool plugins work you can look at the `spring-boot-tools` module on GitHub. More technical details of the `executable jar format` are covered in the appendix.

If you have specific build-related questions you can check out the “how-to” guides.
Part IX. ‘How-to’ guides

This section provides answers to some common ‘how do I do that…’ type of questions that often arise when using Spring Boot. This is by no means an exhaustive list, but it does cover quite a lot.

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

We’re also more than happy to extend this section; If you want to add a ‘how-to’ you can send us a pull request.
57. Spring Boot application

57.1 Troubleshoot auto-configuration

The Spring Boot auto-configuration tries its best to ‘do the right thing’, but sometimes things fail and it can be hard to tell why.

There is a really useful AutoConfigurationReport available in any Spring Boot ApplicationContext. You will see it if you enable DEBUG logging output. If you use the spring-boot-actuator there is also an autoconfig endpoint that renders the report in JSON. Use that to debug the application and see what features have been added (and which not) by Spring Boot at runtime.

Many more questions can be answered by looking at the source code and the javadoc. Some rules of thumb:

• Look for classes called *AutoConfiguration and read their sources, in particular the @Conditional* annotations to find out what features they enable and when. Add --debug to the command line or a System property -Ddebug to get a log on the console of all the autoconfiguration decisions that were made in your app. In a running Actuator app look at the autoconfig endpoint (’/autoconfig’ or the JMX equivalent) for the same information.

• Look for classes that are @ConfigurationProperties (e.g. ServerProperties) and read from there the available external configuration options. The @ConfigurationProperties has a name attribute which acts as a prefix to external properties, thus ServerProperties has prefix="server" and its configuration properties are server.port, server.address etc. In a running Actuator app look at the configprops endpoint.

• Look for use of RelaxedEnvironment to pull configuration values explicitly out of the Environment. It often is used with a prefix.

• Look for @Value annotations that bind directly to the Environment. This is less flexible than the RelaxedEnvironment approach, but does allow some relaxed binding, specifically for OS environment variables (so CAPITALS_AND_UNDERSCORES are synonyms for period.separated).

• Look for @ConditionalOnExpression annotations that switch features on and off in response to SpEL expressions, normally evaluated with place-holders resolved from the Environment.

57.2 Customize the Environment or ApplicationContext before it starts

A SpringApplication has ApplicationListeners and ApplicationContextInitializers that are used to apply customizations to the context or environment. Spring Boot loads a number of such customizations for use internally from META-INF/spring.factories. There is more than one way to register additional ones:

• Programmatically per application by calling the addListeners and addInitializers methods on SpringApplication before you run it.

• Declaratively per application by setting context.initializer.classes or context.listener.classes.

• Declaratively for all applications by adding a META-INF/spring.factories and packaging a jar file that the applications all use as a library.
The SpringApplication sends some special ApplicationEvents to the listeners (even some before the context is created), and then registers the listeners for events published by the ApplicationContext as well. See Section 20.4, “Application events and listeners” in the ‘Spring Boot features’ section for a complete list.

57.3 Build an ApplicationContext hierarchy (adding a parent or root context)

You can use the ApplicationBuilder class to create parent/child ApplicationContext hierarchies. See Section 20.3, “Fluent builder API” in the ‘Spring Boot features’ section for more information.

57.4 Create a non-web application

Not all Spring applications have to be web applications (or web services). If you want to execute some code in a main method, but also bootstrap a Spring application to set up the infrastructure to use, then it’s easy with the SpringApplication features of Spring Boot. A SpringApplication changes its ApplicationContext class depending on whether it thinks it needs a web application or not. The first thing you can do to help it is to just leave the servlet API dependencies off the classpath. If you can’t do that (e.g. you are running 2 applications from the same code base) then you can explicitly call SpringApplication.setWebEnvironment(false), or set the applicationContextClass property (through the Java API or with external properties). Application code that you want to run as your business logic can be implemented as a CommandLineRunner and dropped into the context as a @Bean definition.
58. Properties & configuration

58.1 Externalize the configuration of SpringApplication

A SpringApplication has bean properties (mainly setters) so you can use its Java API as you create the application to modify its behavior. Or you can externalize the configuration using properties in spring.main.*. E.g. in application.properties you might have:

```
spring.main.web_environment=false
spring.main.show_banner=false
```

and then the Spring Boot banner will not be printed on startup, and the application will not be a web application.

**Note**
The example above also demonstrates how flexible binding allows the use of underscores (\_) as well as dashes (\-) in property names.

58.2 Change the location of external properties of an application

By default properties from different sources are added to the Spring Environment in a defined order (see Chapter 21, Externalized Configuration in the ‘Spring Boot features’ section for the exact order).

A nice way to augment and modify this is to add @PropertySource annotations to your application sources. Classes passed to the SpringApplication static convenience methods, and those added using setSources() are inspected to see if they have @PropertySources, and if they do, those properties are added to the Environment early enough to be used in all phases of the ApplicationContext lifecycle. Properties added in this way have precedence over any added using the default locations, but have lower priority than system properties, environment variables or the command line.

You can also provide System properties (or environment variables) to change the behavior:

- `spring.config.name` (SPRING_CONFIG_NAME), defaults to `application` as the root of the file name.
- `spring.config.location` (SPRING_CONFIG_LOCATION) is the file to load (e.g. a classpath resource or a URL). A separate Environment property source is set up for this document and it can be overridden by system properties, environment variables or the command line.

No matter what you set in the environment, Spring Boot will always load application.properties as described above. If YAML is used then files with the '.yml' extension are also added to the list by default.

See ConfigFileApplicationListener for more detail.

58.3 Use ‘short’ command line arguments

Some people like to use (for example) `--port=9000` instead of `--server.port=9000` to set configuration properties on the command line. You can easily enable this by using placeholders in application.properties, e.g.
server.port=${port:8080}

Tip

If you are inheriting from the spring-boot-starter-parent POM, or if have enabled maven filtering for the application.properties directly, you may want to change the default filter token from ${*} since it conflicts with those placeholders. You can either use @*@(i.e. @maven.token@ instead of ${(maven.token)} or you can configure the maven-resources-plugin to use other delimiters.

Note

In this specific case the port binding will work in a PaaS environment like Heroku and Cloud Foundry, since in those two platforms the PORT environment variable is set automatically and Spring can bind to capitalized synonyms for Environment properties.

58.4 Use YAML for external properties

YAML is a superset of JSON and as such is a very convenient syntax for storing external properties in a hierarchical format. E.g.

```yaml
spring:
  application:
    name: cruncher
  datasource:
    driverClassName: com.mysql.jdbc.Driver
    url: jdbc:mysql://localhost/test
  server:
    port: 9000
```

Create a file called application.yml and stick it in the root of your classpath, and also add snakeyaml to your dependencies (Maven coordinates org.yaml:snakeyaml, already included if you use the spring-boot-starter). A YAML file is parsed to a Java Map<String,Object> (like a JSON object), and Spring Boot flattens the map so that it is 1-level deep and has period-separated keys, a lot like people are used to with Properties files in Java.

The example YAML above corresponds to an application.properties file

```properties
spring.application.name=cruncher
spring.datasource.driverClassName=com.mysql.jdbc.Driver
spring.datasource.url=jdbc:mysql://localhost/test
server.port=9000
```

See Section 21.5, “Using YAML instead of Properties” in the ‘Spring Boot features’ section for more information about YAML.

58.5 Set the active Spring profiles

The Spring Environment has an API for this, but normally you would set a System profile (spring.profiles.active) or an OS environment variable (SPRING_PROFILES_ACTIVE). E.g. launch your application with a -D argument (remember to put it before the main class or jar archive):

```
$ java -jar -Dspring.profiles.active=production demo-0.0.1-SNAPSHOT.jar
```

In Spring Boot you can also set the active profile in application.properties, e.g.
A value set this way is replaced by the System property or environment variable setting, but not by the `SpringApplicationBuilder.profiles()` method. Thus the latter Java API can be used to augment the profiles without changing the defaults.

See Chapter 22, Profiles in the ‘Spring Boot features’ section for more information.

58.6 Change configuration depending on the environment

A YAML file is actually a sequence of documents separated by `---` lines, and each document is parsed separately to a flattened map.

If a YAML document contains a `spring.profiles` key, then the profiles value (comma-separated list of profiles) is fed into the Spring `Environment.acceptsProfiles()` and if any of those profiles is active that document is included in the final merge (otherwise not).

Example:

```yaml
server:
  port: 9000
---

spring:
  profiles: development
server:
  port: 9001
---

spring:
  profiles: production
server:
  port: 0
```

In this example the default port is 9000, but if the Spring profile ‘development’ is active then the port is 9001, and if ‘production’ is active then it is 0.

The YAML documents are merged in the order they are encountered (so later values override earlier ones).

To do the same thing with properties files you can use `application-${profile}.properties` to specify profile-specific values.

58.7 Discover built-in options for external properties

Spring Boot binds external properties from `application.properties` (or `.yml`) (and other places) into an application at runtime. There is not (and technically cannot be) an exhaustive list of all supported properties in a single location because contributions can come from additional jar files on your classpath.

A running application with the Actuator features has a `configprops` endpoint that shows all the bound and bindable properties available through `@ConfigurationProperties`.

The appendix includes an `application.properties` example with a list of the most common properties supported by Spring Boot. The definitive list comes from searching the source code for `@ConfigurationProperties` and `@Value` annotations, as well as the occasional use of `RelaxedEnvironment`. 
59. Embedded servlet containers

59.1 Add a Servlet, Filter or ServletContextListener to an application

Servlet, Filter, ServletContextListener and the other listeners supported by the Servlet spec can be added to your application as @Bean definitions. Be very careful that they don’t cause eager initialization of too many other beans because they have to be installed in the container very early in the application lifecycle (e.g. it’s not a good idea to have them depend on your DataSource or JPA configuration). You can work around restrictions like that by initializing them lazily when first used instead of on initialization.

In the case of Filters and Servlets you can also add mappings and init parameters by adding a FilterRegistrationBean or ServletRegistrationBean instead of or as well as the underlying component.

59.2 Change the HTTP port

In a standalone application the main HTTP port defaults to 8080, but can be set with server.port (e.g. in application.properties or as a System property). Thanks to relaxed binding of Environment values you can also use SERVER_PORT (e.g. as an OS environment variable).

To switch off the HTTP endpoints completely, but still create a WebApplicationContext, use server.port=-1 (this is sometimes useful for testing).

For more details look at the section called “Customizing embedded servlet containers” in the ‘Spring Boot features’ section, or the ServerProperties source code.

59.3 Use a random unassigned HTTP port

To scan for a free port (using OS natives to prevent clashes) use server.port=0.

59.4 Discover the HTTP port at runtime

You can access the port the server is running on from log output or from the EmbeddedWebApplicationContext via its EmbeddedServletContainer. The best way to get that and be sure that it has initialized is to add a @Bean of type ApplicationListener<EmbeddedServletContainerInitializedEvent> and pull the container out of the event when it is published.

A useful practice for use with @IntegrationTests is to set server.port=0 and then inject the actual (‘local’) port as a @Value. For example:

```java
@RunWith(SpringJUnit4ClassRunner.class)
@SpringApplicationConfiguration(classes = SampleDataJpaApplication.class)
@WebAppConfiguration
@IntegrationTest("server.port:0")
public class CityRepositoryIntegrationTests {
    @Autowired
    EmbeddedWebApplicationContext server;

    @Value("${local.server.port}")
    int port;
```
59.5 Configure SSL

SSL can be configured declaratively by setting the various server.ssl.* properties, typically in application.properties or application.yml. For example:

```yaml
server.port = 8443
server.ssl.key-store = classpath:keystore.jks
server.ssl.key-store-password = secret
server.ssl.key-password = another-secret
```

See `Ssl` for details of all of the supported properties.

**Note**

Tomcat requires the key store (and trust store if you're using one) to be directly accessible on the filesystem, i.e. it cannot be read from within a jar file.

59.6 Configure Tomcat

Generally you can follow the advice from Section 58.7, “Discover built-in options for external properties” about `@ConfigurationProperties` (ServerProperties is the main one here), but also look at `EmbeddedServletContainerCustomizer` and various Tomcat-specific *Customizers that you can add in one of those. The Tomcat APIs are quite rich so once you have access to the TomcatEmbeddedServletContainerFactory you can modify it in a number of ways. Or the nuclear option is to add your own TomcatEmbeddedServletContainerFactory.

59.7 Enable Multiple Connectors with Tomcat

Add a `org.apache.catalina.connector.Connector` to the TomcatEmbeddedServletContainerFactory which can allow multiple connectors, e.g. an HTTP and HTTPS connector:

```java
public EmbeddedServletContainerFactory servletContainer() {
    TomcatEmbeddedServletContainerFactory tomcat = new TomcatEmbeddedServletContainerFactory();
    tomcat.addAdditionalTomcatConnectors(createSslConnector());
    return tomcat;
}

private Connector createSslConnector() {
    Http11NioProtocol protocol = (Http11NioProtocol) connector.getProtocolHandler();
    try {
        File keystore = new ClassPathResource("keystore").getFile();
        File truststore = new ClassPathResource("keystore").getFile();
        connector.setScheme("https");
        connector.setSecure(true);
        connector.setPort(8443);
        protocol.setSSLEnabled(true);
        protocol.setKeystoreFile(keystore.getAbsolutePath());
        protocol.setKeystorePass("changeit");
        protocol.setTruststoreFile(truststore.getAbsolutePath());
        protocol.setTruststorePass("changeit");
        protocol.setKeyAlias("apitester");
    }
    return connector;
}
```
```java
    return connector;
}
    catch (IOException ex) {
        throw new IllegalStateException("can't access keystore: "+ "keystore" + " or truststore: "+ "keystore ", ex);
    }
```

59.8 Use Tomcat behind a front-end proxy server

Spring Boot will automatically configure Tomcat's RemoteIpValve if you enable it. This allows you to transparently use the standard `x-forwarded-for` and `x-forwarded-proto` headers that most front-end proxy servers add. The valve is switched on by setting one or both of these properties to something non-empty (these are the conventional values used by most proxies, and if you only set one the other will be set automatically):

```properties
server.tomcat.remote_ip_header=x-forwarded-for
server.tomcat.protocol_header=x-forwarded-protocol
```

If your proxy uses different headers you can customize the valve's configuration by adding some entries to `application.properties`, e.g.

```properties
server.tomcat.remote_ip_header=x-your-remote-ip-header
server.tomcat.protocol_header=x-your-protocol-header
```

The valve is also configured with a default regular expression that matches internal proxies that are to be trusted. By default, IP addresses in 10/8, 192.168/16, 169.254/16 and 127/8 are trusted. You can customize the valve's configuration by adding an entry to `application.properties`, e.g.

```properties
server.tomcat.internal_proxies=192\.168\d{1,3}\d{1,3}
```

Alternatively, you can take complete control of the configuration of the RemoteIpValve by configuring and adding it in a `TomcatEmbeddedServletContainerFactory` bean.

59.9 Use Jetty instead of Tomcat

The Spring Boot starters (`spring-boot-starter-web` in particular) use Tomcat as an embedded container by default. You need to exclude those dependencies and include the Jetty one instead. Spring Boot provides Tomcat and Jetty dependencies bundled together as separate starters to help make this process as easy as possible.

Example in Maven:

```xml
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
    <exclusions>
        <exclusion>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-tomcat</artifactId>
        </exclusion>
    </exclusions>
</dependency>
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-jetty</artifactId>
</dependency>
```

Example in Gradle:
59.10 Configure Jetty

Generally you can follow the advice from Section 58.7, “Discover built-in options for external properties” about @ConfigurationProperties (ServerProperties is the main one here), but also look at EmbeddedServletContainerCustomizer. The Jetty APIs are quite rich so once you have access to the JettyEmbeddedServletContainerFactory you can modify it in a number of ways. Or the nuclear option is to add your own JettyEmbeddedServletContainerFactory.

59.11 Use Tomcat 8

Tomcat 8 works with Spring Boot, but the default is to use Tomcat 7 (so we can support Java 1.6 out of the box). You should only need to change the classpath to use Tomcat 8 for it to work. For example, using the starter poms in Maven:

```xml
<properties>
  <tomcat.version>8.0.8</tomcat.version>
</properties>
<dependencies>
  ...
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
  </dependency>
  ...
</dependencies>
```

change the classpath to use Tomcat 8 for it to work.

59.12 Use Jetty 9

Jetty 9 works with Spring Boot, but the default is to use Jetty 8 (so we can support Java 1.6 out of the box). You should only need to change the classpath to use Jetty 9 for it to work.

If you are using the starter poms and parent you can just add the Jetty starter and change the version properties, e.g. for a simple webapp or service:

```xml
<properties>
  <java.version>1.7</java.version>
  <jetty.version>9.1.0.v20131115</jetty.version>
  <servlet-api.version>3.1.0</servlet-api.version>
</properties>
<dependencies>
  <dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
    <exclusions>
      <exclusion>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-tomcat</artifactId>
      </exclusion>
    </exclusions>
  </dependency>
</dependencies>
```
59.13 Create WebSocket endpoints using @ServerEndpoint

If you want to use @ServerEndpoint in a Spring Boot application that used an embedded container, you must declare a single ServerEndpointExporter @Bean:

```java
@Bean
public ServerEndpointExporter serverEndpointExporter() {
    return new ServerEndpointExporter();
}
```

This bean will register any @ServerEndpoint annotated beans with the underlying WebSocket container. When deployed to a standalone servlet container this role is performed by a servlet container initializer and the ServerEndpointExporter bean is not required.
60. Spring MVC

60.1 Write a JSON REST service

Any Spring @RestController in a Spring Boot application should render JSON response by default as long as Jackson2 is on the classpath. For example:

```java
@RestController
public class MyController {
    @RequestMapping("/thing")
    public MyThing thing() {
        return new MyThing();
    }
}
```

As long as MyThing can be serialized by Jackson2 (e.g. a normal POJO or Groovy object) then localhost:8080/thing will serve a JSON representation of it by default. Sometimes in a browser you might see XML responses (but by default only if MyThing was a JAXB object) because browsers tend to send accept headers that prefer XML.

60.2 Write an XML REST service

Since JAXB is in the JDK the same example as we used for JSON would work, as long as the MyThing was annotated as @XmlRootElement:

```java
@XmlRootElement
public class MyThing {
    private String name;
    // .. getters and setters
}
```

To get the server to render XML instead of JSON you might have to send an Accept: text/xml header (or use a browser).

60.3 Customize the Jackson ObjectMapper

Spring MVC (client and server side) uses HttpMessageConverters to negotiate content conversion in an HTTP exchange. If Jackson is on the classpath you already get a default converter with a vanilla ObjectMapper. Spring Boot has some features to make it easier to customize this behavior.

The smallest change that might work is to just add beans of type com.fasterxml.jackson.databind.Module to your context. They will be registered with the default ObjectMapper and then injected into the default message converter. To replace the default ObjectMapper completely, define a @Bean of that type and mark it as @Primary.

In addition, if your context contains any beans of type ObjectMapper then all of the Module beans will be registered with all of the mappers. So there is a global mechanism for contributing custom modules when you add new features to your application.

Finally, if you provide any @Beans of type MappingJackson2HttpMessageConverter then they will replace the default value in the MVC configuration. Also, a convenience bean is provided of type HttpMessageConverters (always available if you use the default MVC configuration) which has some useful methods to access the default and user-enhanced message converters.
See also the Section 60.4, “Customize the @ResponseBody rendering” section and the WebMvcAutoConfiguration source code for more details.

60.4 Customize the @ResponseBody rendering

Spring uses HttpMessageConverters to render @ResponseBody (or responses from @RestController). You can contribute additional converters by simply adding beans of that type in a Spring Boot context. If a bean you add is of a type that would have been included by default anyway (like MappingJackson2HttpMessageConverter for JSON conversions) then it will replace the default value. A convenience bean is provided of type HttpMessageConverters (always available if you use the default MVC configuration) which has some useful methods to access the default and user-enhanced message converters (useful, for example if you want to manually inject them into a custom RestTemplate).

As in normal MVC usage, any WebMvcConfigurerAdapter beans that you provide can also contribute converters by overriding the configureMessageConverters method, but unlike with normal MVC, you can supply only additional converters that you need (because Spring Boot uses the same mechanism to contribute its defaults). Finally, if you opt-out of the Spring Boot default MVC configuration by providing your own @EnableWebMvc configuration, then you can take control completely and do everything manually using getMessageConverters from WebMvcConfigurationSupport.

See the WebMvcAutoConfiguration source code for more details.

60.5 Handling Multipart File Uploads

Spring Boot embraces the Servlet 3 javax.servlet.http.Part API to support uploading files. By default Spring Boot configures Spring MVC with a maximum file of 1Mb per file and a maximum of 10Mb of file data in a single request. You may override these values, as well as the location to which intermediate data is stored (e.g., to the /tmp directory) and the threshold past which data is flushed to disk by using the properties exposed in the MultipartProperties class. If you want to specify that files be unlimited, for example, set the multipart.maxFileSize property to -1.

The multipart support is helpful when you want to receive multipart encoded file data as a @RequestParam-annotated parameter of type MultipartFile in a Spring MVC controller handler method.

See the MultipartAutoConfiguration source for more details.

60.6 Switch off the Spring MVC DispatcherServlet

Spring Boot wants to serve all content from the root of your application / down. If you would rather map your own servlet to that URL you can do it, but of course you may lose some of the other Boot MVC features. To add your own servlet and map it to the root resource just declare a @Bean of type Servlet and give it the special bean name dispatcherServlet (You can also create a bean of a different type with that name if you want to switch it off and not replace it).

60.7 Switch off the Default MVC configuration

The easiest way to take complete control over MVC configuration is to provide your own @Configuration with the @EnableWebMvc annotation. This will leave all MVC configuration in your hands.
60.8 Customize ViewResolvers

A ViewResolver is a core component of Spring MVC, translating view names in @Controller to actual View implementations. Note that ViewResolvers are mainly used in UI applications, rather than REST-style services (a View is not used to render a @ResponseBody). There are many implementations of ViewResolver to choose from, and Spring on its own is not opinionated about which ones you should use. Spring Boot, on the other hand, installs one or two for you depending on what it finds on the classpath and in the application context. The DispatcherServlet uses all the resolvers it finds in the application context, trying each one in turn until it gets a result, so if you are adding your own you have to be aware of the order and in which position your resolver is added.

WebMvcAutoConfiguration adds the following ViewResolvers to your context:

- An InternalResourceViewResolver with bean id ‘defaultViewResolver’. This one locates physical resources that can be rendered using the DefaultServlet (e.g. static resources and JSP pages if you are using those). It applies a prefix and a suffix to the view name and then looks for a physical resource with that path in the servlet context (defaults are both empty, but accessible for external configuration via spring.view.prefix and spring.view.suffix). It can be overridden by providing a bean of the same type.

- A BeanNameViewResolver with id ‘beanNameViewResolver’. This is a useful member of the view resolver chain and will pick up any beans with the same name as the View being resolved. It shouldn’t be necessary to override or replace it.

- A ContentNegotiatingViewResolver with id ‘viewResolver’ is only added if there are actually beans of type View present. This is a ‘master’ resolver, delegating to all the others and attempting to find a match to the ‘Accept’ HTTP header sent by the client. There is a useful blog about ContentNegotiatingViewResolver that you might like to study to learn more, and also look at the source code for detail. You can switch off the auto-configured ContentNegotiatingViewResolver by defining a bean named ‘viewResolver’.

- If you use Thymeleaf you will also have a ThymeleafViewResolver with id ‘thymeleafViewResolver’. It looks for resources by surrounding the view name with a prefix and suffix (externalized to spring.thymeleaf.prefix and spring.thymeleaf.suffix, defaults ‘classpath:/templates/’ and ‘.html’ respectively). It can be overridden by providing a bean of the same name.

- If you use FreeMarker you will also have a FreeMarkerViewResolver with id ‘freemarkerViewResolver’. It looks for resources in a loader path (externalized to spring.freemarker.templateLoaderPath, default ‘classpath:/templates/’) by surrounding the view name with a prefix and suffix (externalized to spring.freemarker.prefix and spring.freemarker.suffix, with empty and ‘.ftl’ defaults respectively). It can be overridden by providing a bean of the same name.

- If you use Groovy templates (actually if groovy-templates is on your classpath) you will also have a Groovy TemplateViewResolver with id ‘groovyTemplateViewResolver’. It looks for resources in a loader path by surrounding the view name with a prefix and suffix (externalized to spring.groovy.template.prefix and spring.groovy.template.suffix, defaults ‘classpath:/templates/’ and ‘.tpl’ respectively). It can be overridden by providing a bean of the same name.

- If you use Velocity you will also have a VelocityViewResolver with id ‘velocityViewResolver’. It looks for resources in a loader path (externalized to spring.velocity.resourceLoaderPath,
default `classpath:/templates/`) by surrounding the view name with a prefix and suffix (externalized to `spring.velocity.prefix` and `spring.velocity.suffix`, with empty and `.vm` defaults respectively). It can be overridden by providing a bean of the same name.

Check out [WebMvcAutoConfiguration](#), [ThymeleafAutoConfiguration](#), [FreeMarkerAutoConfiguration](#), [GroovyTemplateAutoConfiguration](#) and [VelocityAutoConfiguration](#)
61. Logging

Spring Boot has no mandatory logging dependence, except for the commons-logging API, of which there are many implementations to choose from. To use Logback you need to include it, and some bindings for commons-logging on the classpath. The simplest way to do that is through the starter poms which all depend on spring-boot-starter-logging. For a web application you only need spring-boot-starter-web since it depends transitively on the logging starter. For example, using Maven:

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-web</artifactId>
</dependency>
```

Spring Boot has a LoggingSystem abstraction that attempts to configure logging based on the content of the classpath. If Logback is available it is the first choice.

If the only change you need to make to logging is to set the levels of various loggers then you can do that in application.properties using the "logging.level" prefix, e.g.

```
logging.level.org.springframework.web: DEBUG
logging.level.org.hibernate: ERROR
```

You can also set the location of a file to log to (in addition to the console) using "logging.file".

To configure the more fine-grained settings of a logging system you need to use the native configuration format supported by the LoggingSystem in question. By default Spring Boot picks up the native configuration from its default location for the system (e.g. classpath:logback.xml for Logback), but you can set the location of the config file using the "logging.config" property.

61.1 Configure Logback for logging

If you put a logback.xml in the root of your classpath it will be picked up from there. Spring Boot provides a default base configuration that you can include if you just want to set levels, e.g.

```
<?xml version="1.0" encoding="UTF-8"?>
<configuration>
    <include resource="/org/springframework/boot/logging/logback/base.xml"/>
    <logger name="org.springframework.web" level="DEBUG"/>
</configuration>
```

If you look at the default logback.xml in the spring-boot jar you will see that it uses some useful System properties which the LoggingSystem takes care of creating for you. These are:

- `${PID}` the current process ID.
- `${LOG_FILE}` if logging.file was set in Boot’s external configuration.
- `${LOG_PATH}` if logging.path was set (representing a directory for log files to live in).

Spring Boot also provides some nice ANSI colour terminal output on a console (but not in a log file) using a custom Logback converter. See the default base.xml configuration for details.

If Groovgy is on the classpath you should be able to configure Logback with logback.groovy as well (it will be given preference if present).
61.2 Configure Log4j for logging

Spring Boot supports Log4j for logging configuration, but it has to be on the classpath. If you are using the starter poms for assembling dependencies that means you have to exclude logback and then include log4j instead. If you aren’t using the starter poms then you need to provide commons-logging (at least) in addition to Log4j.

The simplest path to using Log4j is probably through the starter poms, even though it requires some jiggling with excludes, e.g. in Maven:

```xml
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-web</artifactId>
</dependency>
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter</artifactId>
  <exclusions>
    <exclusion>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-starter-logging</artifactId>
    </exclusion>
  </exclusions>
</dependency>
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-log4j</artifactId>
</dependency>
```

**Note**

The use of the log4j starter gathers together the dependencies for common logging requirements (e.g. including having Tomcat use java.util.logging but configuring the output using Log4j). See the Actuator Log4j Sample for more detail and to see it in action.
62. Data Access

62.1 Configure a DataSource

To override the default settings just define a @Bean of your own of type DataSource. Spring Boot provides a utility builder class DataSourceBuilder that can be used to create one of the standard ones (if it is on the classpath), or you can just create your own, and bind it to a set of Environment properties e.g.

```java
@Bean
@ConfigurationProperties(prefix="datasource.mine")
public DataSource dataSource() {
    return new FancyDataSource();
}
```

ds.datasource.mine.jdbcUrl=jdbc:h2:mem:mydb
ds.datasource.mine.user=sa
ds.datasource.mine.poolSize=30

See Section 26.1, “Configure a DataSource” in the ‘Spring Boot features’ section and the DataSourceAutoConfiguration class for more details.

62.2 Configure Two DataSources

Creating more than one data source works the same as creating the first one. You might want to mark one of them as @Primary if you are using the default auto-configuration for JDBC or JPA (then that one will be picked up by any @Autowired injections).

```java
@Bean
@Primary
@ConfigurationProperties(prefix="datasource.primary")
public DataSource primaryDataSource() {
    return DataSourceBuilder.create().build();
}
```

```java
@Bean
@ConfigurationProperties(prefix="datasource.secondary")
public DataSource secondaryDataSource() {
    return DataSourceBuilder.create().build();
}
```

62.3 Use Spring Data repositories

Spring Data can create implementations for you of @Repository interfaces of various flavours. Spring Boot will handle all of that for you as long as those @Repositories are included in the same package (or a sub-package) of your @EnableAutoConfiguration class.

For many applications all you will need is to put the right Spring Data dependencies on your classpath (there is a spring-boot-starter-data-jpa for JPA and a spring-boot-starter-data-mongodb for Mongodb), create some repository interfaces to handle your @Entity objects. Examples are in the JPA sample or the Mongodb sample.

Spring Boot tries to guess the location of your @Repository definitions, based on the @EnableAutoConfiguration it finds. To get more control, use the @EnableJpaRepositories annotation (from Spring Data JPA).
62.4 Separate @Entity definitions from Spring configuration

Spring Boot tries to guess the location of your @Entity definitions, based on the @EnableAutoConfiguration it finds. To get more control, you can use the @EntityScan annotation, e.g.

```java
@Configuration
@EnableAutoConfiguration
@EntityScan(basePackageClasses=City.class)
public class Application {
    //...
}
```

62.5 Configure JPA properties

Spring Data JPA already provides some vendor-independent configuration options (e.g. for SQL logging) and Spring Boot exposes those, and a few more for hibernate as external configuration properties. The most common options to set are:

```java
spring.jpa.hibernate.ddl-auto: create-drop
spring.jpa.hibernate.naming_strategy: org.hibernate.cfg.ImprovedNamingStrategy
spring.jpa.database: H2
spring.jpa.show-sql: true
```

(Because of relaxed data binding hyphens or underscores should work equally well as property keys.) The ddl-auto setting is a special case in that it has different defaults depending on whether you are using an embedded database (create-drop) or not (none). In addition all properties in spring.jpa.properties.* are passed through as normal JPA properties (with the prefix stripped) when the local EntityManagerFactory is created.

See HibernateJpaAutoConfiguration and JpaBaseConfiguration for more details.

62.6 Use a custom EntityManagerFactory

To take full control of the configuration of the EntityManagerFactory, you need to add a @Bean named 'entityManagerFactory'. Spring Boot auto-configuration switches off its entity manager based on the presence of a bean of that type.

62.7 Use Two EntityManagers

Even if the default EntityManagerFactory works fine, you will need to define a new one because otherwise the presence of the second bean of that type will switch off the default. To make it easy to do that you can use the convenient EntityManagerBuilder provided by Spring Boot, or if you prefer you can just use the LocalContainerEntityManagerFactoryBean directly from Spring ORM.

Example:

```java
// add two data sources configured as above

@Bean
public LocalContainerEntityManagerFactoryBean customerEntityManagerFactory(
        EntityManagerFactoryBuilder builder) {
    return builder
        .dataSource(customerDataSource())
        .packages(Customer.class)
```
The configuration above almost works on its own. To complete the picture you need to configure TransactionManagers for the two EntityManagers as well. One of them could be picked up by the default JpaTransactionManager in Spring Boot if you mark it as @Primary. The other would have to be explicitly injected into a new instance. Or you might be able to use a JTA transaction manager spanning both.

### 62.8 Use a traditional persistence.xml

Spring doesn’t require the use of XML to configure the JPA provider, and Spring Boot assumes you want to take advantage of that feature. If you prefer to use persistence.xml then you need to define your own @Bean of type LocalEntityManagerFactoryBean (with id ‘entityManagerFactory’, and set the persistence unit name there.

See JpaBaseConfiguration for the default settings.

### 62.9 Use Spring Data JPA and Mongo repositories

Spring Data JPA and Spring Data Mongo can both create Repository implementations for you automatically. If they are both present on the classpath, you might have to do some extra configuration to tell Spring Boot which one (or both) you want to create repositories for you. The most explicit way to do that is to use the standard Spring Data @Enable*Repositories and tell it the location of your Repository interfaces (where ‘*’ is ‘Jpa’ or ‘Mongo’ or both).

There are also flags spring.data.*.repositories.enabled that you can use to switch the auto-configured repositories on and off in external configuration. This is useful for instance in case you want to switch off the Mongo repositories and still use the auto-configured MongoTemplate.

The same obstacle and the same features exist for other auto-configured Spring Data repository types (Elasticsearch, Solr). Just change the names of the annotations and flags respectively.
63. Database initialization

An SQL database can be initialized in different ways depending on what your stack is. Or of course you can do it manually as long as the database is a separate process.

63.1 Initialize a database using JPA

JPA has features for DDL generation, and these can be set up to run on startup against the database. This is controlled through two external properties:

- spring.jpa.generate-ddl (boolean) switches the feature on and off and is vendor independent.
- spring.jpa.hibernate.ddl-auto (enum) is a Hibernate feature that controls the behavior in a more fine-grained way. See below for more detail.

63.2 Initialize a database using Hibernate

You can set spring.jpa.hibernate.ddl-auto explicitly and the standard Hibernate property values are none, validate, update, create-drop. Spring Boot chooses a default value for you based on whether it thinks your database is embedded (default create-drop) or not (default none). An embedded database is detected by looking at the Connection type: hsqldb, h2 and derby are embedded, the rest are not. Be careful when switching from in-memory to a ‘real’ database that you don’t make assumptions about the existence of the tables and data in the new platform. You either have to set ddl-auto explicitly, or use one of the other mechanisms to initialize the database.

In addition, a file named import.sql in the root of the classpath will be executed on startup. This can be useful for demos and for testing if you are careful, but probably not something you want to be on the classpath in production. It is a Hibernate feature (nothing to do with Spring).

63.3 Initialize a database using Spring JDBC

Spring JDBC has a DataSource initializer feature. Spring Boot enables it by default and loads SQL from the standard locations schema.sql and data.sql (in the root of the classpath). In addition Spring Boot will load the schema-$\{platform}\$.sql and data-$\{platform}\$.sql files (if present), where platform is the value of spring.datasource.platform, e.g. you might choose to set it to the vendor name of the database (hsqldb, h2, oracle, mysql, postgresql etc.). Spring Boot enables the failfast feature of the Spring JDBC initializer by default, so if the scripts cause exceptions the application will fail to start. The script locations can be changed by setting spring.datasource.schema and spring.datasource.data, and neither location will be processed if spring.datasource.initialize=false.

To disable the failfast you can set spring.datasource.continueOnError=true. This can be useful once an application has matured and been deployed a few times, since the scripts can act as ‘poor man’s migrations’ — inserts that fail mean that the data is already there, so there would be no need to prevent the application from running, for instance.

If you want to use the schema.sql initialization in a JPA app (with Hibernate) then ddl-auto=create-drop will lead to errors if Hibernate tries to create the same tables. To avoid those errors set ddl-auto explicitly to "" (preferable) or "none". Whether or not you use ddl-auto=create-drop you can always use data.sql to initialize new data.
63.4 Initialize a Spring Batch database

If you are using Spring Batch then it comes pre-packaged with SQL initialization scripts for most popular database platforms. Spring Boot will detect your database type, and execute those scripts by default, and in this case will switch the fail fast setting to false (errors are logged but do not prevent the application from starting). This is because the scripts are known to be reliable and generally do not contain bugs, so errors are ignorable, and ignoring them makes the scripts idempotent. You can switch off the initialization explicitly using `spring.batch.initializer.enabled=false`.

63.5 Use a higher level database migration tool

Spring Boot works fine with higher level migration tools Flyway (SQL-based) and Liquibase (XML). In general we prefer Flyway because it is easier on the eyes, and it isn’t very common to need platform independence: usually only one or at most couple of platforms is needed.

**Execute Flyway database migrations on startup**

To automatically run Flyway database migrations on startup, add the `org.flywaydb:flyway-core` to your classpath.

The migrations are scripts in the form `V<VERSION>__<NAME>.sql` (with `<VERSION>` an underscore-separated version, e.g. ‘1’ or ‘2_1’). By default they live in a folder `classpath:db/migration` but you can modify that using `flyway.locations` (a list). See the Flyway class from flyway-core for details of available settings like schemas etc. In addition Spring Boot provides a small set of properties in `FlywayProperties` that can be used to disable the migrations, or switch off the location checking.

By default Flyway will autowire the (@Primary) `DataSource` in your context and use that for migrations. If you like to use a different `DataSource` you can create one and mark its `@Bean` as `@FlywayDataSource` - if you do that remember to create another one and mark it as `@Primary` if you want two data sources. Or you can use Flyway’s native `DataSource` by setting `flyway.[url,user,password]` in external properties.

There is a [Flyway sample](https://flywaydb.org) so you can see how to set things up.

**Execute Liquibase database migrations on startup**

To automatically run Liquibase database migrations on startup, add the `org.liquibase:liquibase-core` to your classpath.

The master change log is by default read from `db/changelog/db.changelog-master.yaml` but can be set using `liquibase.change-log`. See `LiquibaseProperties` for details of available settings like contexts, default schema etc.

There is a [Liquibase sample](http://liquibase.org) so you can see how to set things up.
64. Batch applications

64.1 Execute Spring Batch jobs on startup

Spring Batch auto configuration is enabled by adding `@EnableBatchProcessing` (from Spring Batch) somewhere in your context.

By default it executes all Jobs in the application context on startup (see `JobLauncherCommandLineRunner` for details). You can narrow down to a specific job or jobs by specifying `spring.batch.job.names` (comma-separated job name patterns).

If the application context includes a JobRegistry then the jobs in `spring.batch.job.names` are looked up in the registry instead of being autowired from the context. This is a common pattern with more complex systems where multiple jobs are defined in child contexts and registered centrally.

See `BatchAutoConfiguration` and `@EnableBatchProcessing` for more details.
65. Actuator

65.1 Change the HTTP port or address of the actuator endpoints

In a standalone application the Actuator HTTP port defaults to the same as the main HTTP port. To make the application listen on a different port set the external property `management.port`. To listen on a completely different network address (e.g. if you have an internal network for management and an external one for user applications) you can also set `management.address` to a valid IP address that the server is able to bind to.

For more detail look at the `ManagementServerProperties` source code and Section 36.3, “Customizing the management server port” in the ‘Production-ready features’ section.

65.2 Customize the ‘whitelabel’ error page

Spring Boot installs a ‘whitelabel’ error page that you will see in browser client if you encounter a server error (machine clients consuming JSON and other media types should see a sensible response with the right error code). To switch it off you can set `error.whitelabel.enabled=false`, but normally in addition or alternatively to that you will want to add your own error page replacing the whitelabel one. Exactly how you do this depends on the templating technology that you are using. For example, if you are using Thymeleaf you would add an `error.html` template and if you are using FreeMarker you would add an `error.ftl` template. In general what you need is a View that resolves with a name of `error`, and/or a `@Controller` that handles the `/error` path. Unless you replaced some of the default configuration you should find a `BeanNameViewResolver` in your `ApplicationContext` so a `@Bean` with id `error` would be a simple way of doing that. Look at `ErrorMvcAutoConfiguration` for more options.

See also the section on `Error Handling` for details of how to register handlers in the servlet container.
66. Security

66.1 Switch off the Spring Boot security configuration

If you define a `@Configuration` with `@EnableWebSecurity` anywhere in your application it will switch off the default webapp security settings in Spring Boot. To tweak the defaults try setting properties in `security.*` (see `SecurityProperties` for details of available settings) and `SECURITY` section of `Common application properties`.

66.2 Change the AuthenticationManager and add user accounts

If you provide a `@Bean` of type `AuthenticationManager` the default one will not be created, so you have the full feature set of Spring Security available (e.g. various authentication options).

Spring Security also provides a convenient `AuthenticationManagerBuilder` which can be used to build an `AuthenticationManager` with common options. The recommended way to use this in a webapp is to inject it into a callback method in a `WebSecurityConfigurerAdapter`, e.g.

```java
@Configuration
@Order(SecurityProperties.ACCESS_OVERRIDE_ORDER)
public class SecurityConfiguration extends WebSecurityConfigurerAdapter {

    @Override
    public void configure(AuthenticationManagerBuilder auth) throws Exception {
        auth.inMemoryAuthentication()
            .withUser("barry").password("password").roles("USER"); // ... etc.
    }

    // ... other stuff for application security
}
```

You will get the best results if you put this in a nested class, or a standalone class (i.e. not mixed in with a lot of other `@Beans` that might be allowed to influence the order of instantiation). The `secure web sample` is a useful template to follow.

If you experience instantiation issues (e.g. using JDBC or JPA for the user detail store) it might be worth extracting the `AuthenticationManagerBuilder` callback into a `GlobalAuthenticationConfigurerAdapter` (in the `init()` method so it happens before the authentication manager is needed elsewhere), e.g.

```java
@Configuration
public class AuthenticationManagerConfiguration extends GlobalAuthenticationConfigurerAdapter {

    @Override
    public void init(AuthenticationManagerBuilder auth) {
        auth.inMemoryAuthentication() // ... etc.
    }
}
```

66.3 Enable HTTPS when running behind a proxy server

Ensuring that all your main endpoints are only available over HTTPS is an important chore for any application. If you are using Tomcat as a servlet container, then Spring Boot will add Tomcat’s own
RemoteIpValve automatically if it detects some environment settings, and you should be able to rely on the HttpServletRequest to report whether it is secure or not (even downstream of a proxy server that handles the real SSL termination). The standard behavior is determined by the presence or absence of certain request headers (x-forwarded-for and x-forwarded-proto), whose names are conventional, so it should work with most front end proxies. You can switch on the valve by adding some entries to application.properties, e.g.

```
server.tomcat.remote_ip_header=x-forwarded-for
server.tomcat.protocol_header=x-forwarded-proto
```

(The presence of either of those properties will switch on the valve. Or you can add the RemoteIpValve yourself by adding a TomcatEmbeddedServletContainerFactory bean.)

Spring Security can also be configured to require a secure channel for all (or some requests). To switch that on in a Spring Boot application you just need to set security.require_https to true in application.properties.
67. Hot swapping

67.1 Reload static content

There are several options for hot reloading. Running in an IDE (especially with debugging on) is a good way to do development (all modern IDEs allow reloading of static resources and usually also hot-swapping of Java class changes). The [Maven and Gradle plugins](https://mvn.apache.org/) also support running from the command line with reloading of static files. You can use that with an external css/js compiler process if you are writing that code with higher level tools.

67.2 Reload Thymeleaf templates without restarting the container

If you are using Thymeleaf, then set `spring.thymeleaf.cache` to `false`. See [ThymeleafAutoConfiguration](https://docs.spring.io/spring-boot/docs/current/api/org/springframework/boot/autoconfigure/thymeleaf/ThymeleafAutoConfiguration.html) for other Thymeleaf customization options.

67.3 Reload FreeMarker templates without restarting the container

If you are using FreeMarker, then set `spring.freemarker.cache` to `false`. See [FreeMarkerAutoConfiguration](https://docs.spring.io/spring-boot/docs/current/api/org/springframework/boot/autoconfigure/freeMarker/FreeMarkerAutoConfiguration.html) for other FreeMarker customization options.

67.4 Reload Groovy templates without restarting the container

If you are using Groovy templates, then set `spring.groovy.template.cache` to `false`. See [GroovyTemplateAutoConfiguration](https://docs.spring.io/spring-boot/docs/current/api/org/springframework/boot/autoconfigure/groovy/GroovyTemplateAutoConfiguration.html) for other Groovy customization options.

67.5 Reload Velocity templates without restarting the container

If you are using Velocity, then set `spring.velocity.cache` to `false`. See [VelocityAutoConfiguration](https://docs.spring.io/spring-boot/docs/current/api/org/springframework/boot/autoconfigure/velocity/VelocityEngineAutoConfiguration.html) for other Velocity customization options.

67.6 Reload Java classes without restarting the container

Modern IDEs (Eclipse, IDEA, etc.) all support hot swapping of bytecode, so if you make a change that doesn’t affect class or method signatures it should reload cleanly with no side effects.

*Spring Loaded* goes a little further in that it can reload class definitions with changes in the method signatures. With some customization it can force an ApplicationContext to refresh itself (but there is no general mechanism to ensure that would be safe for a running application anyway, so it would only ever be a development time trick probably).

Configuring Spring Loaded for use with Gradle and IntelliJ

You need to jump through a few hoops if you want to use Spring Loaded in combination with Gradle and IntelliJ. By default, IntelliJ will compile classes into a different location than Gradle, causing Spring Loaded monitoring to fail.

To configure IntelliJ correctly you can use the `idea` Gradle plugin:
buildscript {
    repositories { mavenCentral() }
    dependencies {
        classpath "org.springframework.boot:spring-boot-gradle-plugin:1.1.9.RELEASE"
        classpath 'org.springframework:springloaded:1.2.0.RELEASE'
    }
}

apply plugin: 'idea'

idea {
    module {
        inheritOutputDirs = false
        outputDir = file("$buildDir/classes/main")
    }
}

// ...

**Note**

IntelliJ must be configured to use the same Java version as the command line Gradle task and **springloaded** must be included as a buildscript dependency.

You can also additionally enable ‘Make Project Automatically’ inside IntelliJ to automatically compile your code whenever a file is saved.
68. Build

68.1 Customize dependency versions with Maven

If you use a Maven build that inherits directly or indirectly from `spring-boot-dependencies` (for instance `spring-boot-starter-parent`) but you want to override a specific third-party dependency you can add appropriate `<properties>` elements. Browse the `spring-boot-dependencies` POM for a complete list of properties. For example, to pick a different `slf4j` version you would add the following:

```xml
<properties>
  <slf4j.version>1.7.5</slf4j.version>
</properties>
```

**Note**

This only works if your Maven project inherits (directly or indirectly) from `spring-boot-dependencies`. If you have added `spring-boot-dependencies` in your own dependencyManagement section with `<scope>import</scope>` you have to redefine the artifact yourself instead of overriding the property.

**Warning**

Each Spring Boot release is designed and tested against a specific set of third-party dependencies. Overriding versions may cause compatibility issues.

68.2 Create an executable JAR with Maven

The `spring-boot-maven-plugin` can be used to create an executable ‘fat’ JAR. If you are using the `spring-boot-starter-parent` POM you can simply declare the plugin and your jars will be repackaged:

```xml
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
    </plugin>
  </plugins>
</build>
```

If you are not using the parent POM you can still use the plugin, however, you must additionally add an `<executions>` section:

```xml
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
      <version>1.1.9.RELEASE</version>
      <executions>
        <execution>
          <goals>
            <goal>repackage</goal>
          </goals>
        </execution>
      </executions>
    </plugin>
  </plugins>
</build>
```
68.3 Create an additional executable JAR

If you want to use your project as a library jar for other projects to depend on, and in addition have an executable (e.g. demo) version of it, you will want to configure the build in a slightly different way.

For Maven the normal JAR plugin and the Spring Boot plugin both have a ‘classifier’ configuration that you can add to create an additional JAR. Example (using the Spring Boot Starter Parent to manage the plugin versions and other configuration defaults):

```xml
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
      <configuration>
        <classifier>exec</classifier>
      </configuration>
    </plugin>
  </plugins>
</build>
```

Two jars are produced, the default one, and an executable one using the Boot plugin with classifier ‘exec’.

For Gradle users the steps are similar. Example:

```gradle
bootRepackage { 
    classifier = 'exec'
}
```

68.4 Extract specific libraries when an executable jar runs

Most nested libraries in an executable jar do not need to be unpacked in order to run, however, certain libraries can have problems. For example, JRuby includes its own nested jar support which assumes that the `jruby-complete.jar` is always directly available as a file in its own right.

To deal with any problematic libraries, you can flag that specific nested jars should be automatically unpacked to the ‘temp folder’ when the executable jar first runs.

For example, to indicate that JRuby should be flagged for unpack using the Maven Plugin you would add the following configuration:

```xml
<build>
  <plugins>
    <plugin>
      <groupId>org.springframework.boot</groupId>
      <artifactId>spring-boot-maven-plugin</artifactId>
      <configuration>
        <requiresUnpack>
          <dependency>
            <groupId>org.jruby</groupId>
            <artifactId>jruby-complete</artifactId>
          </dependency>
        </requiresUnpack>
      </configuration>
    </plugin>
  </plugins>
</build>
```
And to do that same with Gradle:

```gradle
springBoot {
    requiresUnpack = ['org.jruby:jruby-complete']
}
```

### 68.5 Create a non-executable JAR with exclusions

Often if you have an executable and a non-executable jar as build products, the executable version will have additional configuration files that are not needed in a library jar. E.g. the `application.yml` configuration file might excluded from the non-executable JAR.

Here’s how to do that in Maven:

```xml
<build>
    <plugins>
        <plugin>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-maven-plugin</artifactId>
            <configuration>
                <classifier>exec</classifier>
            </configuration>
        </plugin>
        <plugin>
            <groupId>org.apache.maven.plugins</groupId>
            <artifactId>maven-jar-plugin</artifactId>
            <executions>
                <execution>
                    <id>exec</id>
                    <phase>package</phase>
                    <goals>
                        <goal>jar</goal>
                    </goals>
                    <configuration>
                        <classifier>exec</classifier>
                    </configuration>
                </execution>
                <execution>
                    <id>package</id>
                    <phase>package</phase>
                    <goals>
                        <goal>jar</goal>
                    </goals>
                    <configuration>
                        <forceCreation>true</forceCreation>
                        <excludes>
                            <exclude>application.yml</exclude>
                        </excludes>
                    </configuration>
                </execution>
            </executions>
        </plugin>
    </plugins>
</build>
```

In Gradle you can create a new JAR archive with standard task DSL features, and then have the `bootRepackage` task depend on that one using its `withJarTask` property:

```gradle
jar {
    baseName = 'spring-boot-sample-profile'
    version = '0.0.0'
}
```
68.6 Remote debug a Spring Boot application started with Maven

To attach a remote debugger to a Spring Boot application started with Maven you can use the `jvmArguments` property of the `maven plugin`.

Check [this example](#) for more details.

68.7 Remote debug a Spring Boot application started with Gradle

To attach a remote debugger to a Spring Boot application started with Gradle you can use the `applicationDefaultJvmArgs` in `build.gradle` or `--debug-jvm` command line option.

```groovy
build.gradle:

    applicationDefaultJvmArgs = [
        "-agentlib:jdwp=transport=dt_socket,server=y,suspend=y,address=5005"
    ]
```

Command line:

```
$ gradle run --debug-jvm
```

Check [Gradle Application Plugin](#) for more details.

68.8 Build an executable archive with Ant

To build with Ant you need to grab dependencies, compile and then create a jar or war archive as normal. To make it executable:

1. Use the appropriate launcher as a `Main-Class`, e.g. `JarLauncher` for a jar file, and specify the other properties it needs as manifest entries, principally a `Start-Class`.

2. Add the runtime dependencies in a nested ‘lib’ directory (for a jar) and the `provided` (embedded container) dependencies in a nested `lib-provided` directory. Remember not to compress the entries in the archive.

3. Add the `spring-boot-loader` classes at the root of the archive (so the `Main-Class` is available).

Example:
The Actuator Sample has a `build.xml` that should work if you run it with

```
$ ant -lib <path_to>/ivy-2.2.jar
```

after which you can run the application with

```
$ java -jar target/*.jar
```
69. Traditional deployment

69.1 Create a deployable war file

Use the `SpringBootServletInitializer` base class, which is picked up by Spring’s Servlet 3.0 support on deployment. Add an extension of that to your project and build a war file as normal. For more detail, see the ‘Converting a jar Project to a war’ guide on the spring.io website and the sample below.

The war file can also be executable if you use the Spring Boot build tools. In that case the embedded container classes (to launch Tomcat for instance) have to be added to the war in a `lib-provided` directory. The tools will take care of that as long as the dependencies are marked as ‘provided’ in Maven or Gradle. Here’s a Maven example in the Boot Samples.

**69.2 Create a deployable war file for older servlet containers**

Older Servlet containers don’t have support for the `ServletContextInitializer` bootstrap process used in Servlet 3.0. You can still use Spring and Spring Boot in these containers but you are going to need to add a `web.xml` to your application and configure it to load an `ApplicationContext` via a `DispatcherServlet`.

**69.3 Convert an existing application to Spring Boot**

For a non-web application it should be easy (throw away the code that creates your `ApplicationContext` and replace it with calls to `SpringApplication` or `SpringApplicationBuilder`). Spring MVC web applications are generally amenable to first creating a deployable war application, and then migrating it later to an executable war and/or jar. Useful reading is in the Getting Started Guide on Converting a jar to a war.

Create a deployable war by extending `SpringBootServletInitializer` (e.g. in a class called `Application`), and add the Spring Boot `@EnableAutoConfiguration` annotation. Example:

```java
@Configuration
@EnableAutoConfiguration
@ComponentScan
public class Application extends SpringBootServletInitializer {

    @Override
    protected SpringApplicationBuilder configure(SpringApplicationBuilder application) {
        return application.sources(Application.class);
    }
}
```

Remember that whatever you put in the `sources` is just a Spring `ApplicationContext` and normally anything that already works should work here. There might be some beans you can remove later and let Spring Boot provide its own defaults for them, but it should be possible to get something working first.

Static resources can be moved to `/public` (or `/static` or `/resources` or `/META-INF/resources`) in the classpath root. Same for `messages.properties` (Spring Boot detects this automatically in the root of the classpath).

Vanilla usage of Spring `DispatcherServlet` and Spring Security should require no further changes. If you have other features in your application, using other servlets or filters for instance, then you may need to add some configuration to your `ApplicationContext`, replacing those elements from the `web.xml` as follows:
• A `@Bean` of type `Servlet` or `ServletRegistrationBean` installs that bean in the container as if it was a `<servlet/>` and `<servlet-mapping/>` in `web.xml`.

• A `@Bean` of type `Filter` or `FilterRegistrationBean` behaves similarly (like a `<filter/>` and `<filter-mapping/>`).

• An `ApplicationContext` in an XML file can be added to an `@Import` in your `Application`. Or simple cases where annotation configuration is heavily used already can be recreated in a few lines as `@Bean` definitions.

Once the war is working we make it executable by adding a `main` method to our `Application`, e.g.

```java
public static void main(String[] args) {
    SpringApplication.run(Application.class, args);
}
```

Applications can fall into more than one category:

• Servlet 3.0 applications with no `web.xml`.

• Applications with a `web.xml`.

• Applications with a context hierarchy.

• Applications without a context hierarchy.

All of these should be amenable to translation, but each might require slightly different tricks.

Servlet 3.0 applications might translate pretty easily if they already use the Spring Servlet 3.0 initializer support classes. Normally all the code from an existing `WebApplicationInitializer` can be moved into a `SpringBootServletInitializer`. If your existing application has more than one `ApplicationContext` (e.g. if it uses `AbstractDispatcherServletInitializer`) then you might be able to squash all your context sources into a single `SpringApplication`. The main complication you might encounter is if that doesn’t work and you need to maintain the context hierarchy. See the entry on building a hierarchy for examples. An existing parent context that contains web-specific features will usually need to be broken up so that all the `ServletContextAware` components are in the child context.

Applications that are not already Spring applications might be convertible to a Spring Boot application, and the guidance above might help, but your mileage may vary.
Part X. Appendices
Appendix A. Common application properties

Various properties can be specified inside your `application.properties/application.yml` file or as command line switches. This section provides a list of common Spring Boot properties and references to the underlying classes that consume them.

**Note**

Property contributions can come from additional jar files on your classpath so you should not consider this an exhaustive list. It is also perfectly legit to define your own properties.

**Warning**

This sample file is meant as a guide only. Do not copy/paste the entire content into your application; rather pick only the properties that you need.

```java
# COMMON SPRING BOOT PROPERTIES
# This sample file is provided as a guideline. Do NOT copy it in its entirety to your application. ^^^

# CORE PROPERTIES
spring.config.name= # config file name (default to 'application')
spring.config.location= # location of config file

# PROFILES
spring.profiles.active= # comma list of active profiles

# APPLICATION SETTINGS
spring.main.sources=
spring.main.web-environment= # detect by default
spring.main.show-banner=true
spring.main....= # see class for all properties

# LOGGING
logging.path=/var/logs
logging.file=myapp.log
logging.config= # location of config file (default classpath:logback.xml for logback)
logging.level.= # levels for loggers, e.g. "logging.level.org.springframework=DEBUG" (TRACE, DEBUG, INFO, WARN, ERROR, FATAL, OFF)

# IDENTITY
spring.application.name=
spring.application.index=

# EMBEDDED SERVER CONFIGURATION
server.port=8080
server.address= # bind to a specific NIC
server.session-timeout= # session timeout in seconds
server.context-path= # the context path, defaults to '/'
server.servlet-path= # the servlet path, defaults to '/'
server.ssl.client-auth= # want or need
server.ssl.key-alias=
server.ssl.key-password=
```
server.ssl.key-store=
server.ssl.key-store-password=
server.ssl.key-store-provider=
server.ssl.protocol-TLS
server.ssl.trust-store=
server.ssl.trust-store-password=
server.ssl.trust-store-provider=
server.ssl.trust-store-type=
server.tomcat.access-log-pattern=# log pattern of the access log
server.tomcat.access-log-enabled=false # is access logging enabled
server.tomcat.internal-proxies=10\.[d1,3]\.[d1,3]\.[d1,3]|169\.[d1,3]\.[d1,3]\.[d1,3]| 127\.[d1,3]\.[d1,3]\.[d1,3] # regular expression matching trusted IP addresses
server.tomcat.protocol-header=x-forwarded-proto # front end proxy forward header
server.tomcat.port-header=# front end proxy port header
server.tomcat.remote-ip-header=x-forwarded-for
server.tomcat.background-processor-delay=30; # in seconds
server.tomcat.max-threads=0 # number of threads in protocol handler
server.tomcat.basedir=/tmp # base dir (usually not needed, defaults to tmp)
server.tomcat.uri-encoding=UTF-8 # character encoding to use for URL decoding

# SPRING MVC (HttpMapperProperties)
http.mappers.json-pretty-print=false # pretty print JSON
http.mappers.json-sort-keys=false # sort keys
spring.mvc.locale= # set fixed locale, e.g. en_UK
spring.mvc.date-format= # set fixed date format, e.g. dd/MM/yyyy
spring.mvc.message-codes-resolver-format= # PREFIX_ERROR_CODE / POSTFIX_ERROR_CODE
spring.view.prefix= # MVC view prefix
spring.view.suffix= ... and suffix
spring.resources.cache-period=# cache timeouts in headers sent to browser
spring.resources.add-mappings=false # if default mappings should be added

# THYMELEAF (ThymeleafAutoConfiguration)
spring.thymeleaf.check-template-location=true
spring.thymeleaf.prefix=classpath:/templates/
spring.thymeleaf.suffix=.html
spring.thymeleaf.mode=HTML5
spring.thymeleaf.encoding=UTF-8
spring.thymeleaf.content-type=text/html # ;charset=<encoding> is added
spring.thymeleaf.cache=true # set to false for hot refresh

# FREEMARKER (FreemarkerAutoConfiguration)
spring.freemarker.allow-request-override=false
spring.freemarker.cache=false
spring.freemarker.check-template-location=true
spring.freemarker.charset=utf-8
spring.freemarker.content-type=text/html
spring.freemarker.exposeRequestAttributes=false
spring.freemarker.exposeSessionAttributes=false
spring.freemarker.exposeSpringMacroHelpers=false
spring.freemarker.prefix=
spring.freemarker.requestContextAttribute=
spring.freemarker.settings.*=
spring.freemarker.suffix.ftl
spring.freemarker.template-loader-path=classpath:/templates/
spring.freemarker.viewNames= # whitelist of view names that can be resolved

# GROOVY TEMPLATES (GroovyTemplateAutoConfiguration)
spring.groovy.template.cache=true
spring.groovy.template.charset=utf-8
spring.groovy.template.configuration.*= # See Groovy’s TemplateConfiguration
spring.groovy.template.content-type=text/html
spring.groovy.template.prefix=classpath:/templates/
spring.groovy.template.suffix=.tpl
spring.groovy.template.view-names= # whitelist of view names that can be resolved

# VELOCITY TEMPLATES (VelocityAutoConfiguration)
spring.velocity.allow-request-override=false
spring.velocity.cache=true
spring.velocity.check-template-location=true
spring.velocity.char-set=UTF-8
spring.velocity.content-type=text/html
spring.velocity.date-tool-attribute=
spring.velocity.expose-Request-attributes=false
spring.velocity.expose-Session-attributes=false
spring.velocity.expose-Spring-macro helpers=false
spring.velocity.number-tool-attribute=
spring.velocity.prefix=
spring.velocity.properties.*=
spring.velocity.request-context-attribute=
spring.velocity.resource-loader-path=classpath:/templates/
spring.velocity.suffix=.vm
spring.velocity.view-names= # whitelist of view names that can be resolved

# INTERNATIONALIZATION (MessageSourceAutoConfiguration)
spring.messages.basename=messages
spring.messages.cacheSeconds=-1
spring.messages.encoding=UTF-8

# SECURITY (SecurityProperties)
security.user.name=user # login username
security.user.password= # login password
security.user.role=USER # role assigned to the user
security.require-ssl=false # advanced settings ...
security.enable-csrf=false
security.basic.enabled=true
security.basic.realm=Spring
security.basic.path= /**
security.headers.xss=false
security.headers.cache=false
security.headers.frame=false
security.headers.content-type=false
security.headers.hsts=all # none / domain / all
security.sessions=stateless # always / never / if_required / stateless
security.ignored=false

# DATASOURCE (DataSourceAutoConfiguration & DataSourceProperties)
spring.datasource.name= # name of the data source
spring.datasource.initialize=true # populate using data.sql
spring.datasource.schema= # a schema (DDL) script resource reference
spring.datasource.data= # a data (DML) script resource reference
spring.datasource.sql-script-encoding= # a charset for reading SQL scripts
spring.datasource.platform= # the platform to use in the schema resource (schema-{$platform}.sql)
spring.datasource.continue-on-error=false # continue even if can't be initialized
spring.datasource.separator= ; # statement separator in SQL initialization scripts
spring.datasource.driver-class-name= # JDBC Settings...
spring.datasource.username= spring.datasource.password=
spring.datasource.max-active=100 # Advanced configuration...
spring.datasource.max-idle=
spring.datasource.min-idle=
spring.datasource.validation-query=
spring.datasource.test-on-borrow=false
spring.datasource.test-on-return=false
spring.datasource.test-while-idle=
spring.datasource.time-between-eviction-runs-millis=
spring.datasource.min-evictable-idle-time-millis=
spring.datasource.max-wait=

# MONGODB (MongoProperties)
spring.data.mongodb.host= # the db host
spring.data.mongodb.port=27017 # the connection port (default to 27107)
spring.data.mongodb.uri=mongodb://localhost/test # connection URL
spring.data.mongodb.repositories.enabled=true # if spring data repository support is enabled

# JPA (JpaBaseConfiguration, HibernateJpaAutoConfiguration)
spring.jpa.properties.*= # properties to set on the JPA connection
spring.jpa.open-in-view=true
spring.jpa.show-sql=true
spring.jpa.database-platform=
spring.jpa.database=

spring.jpa.hibernate.dialect= # ignored by Hibernate, might be useful for other vendors
spring.jpa.hibernate.dialect= # naming class name

spring.jpa.hibernate.dialect= # defaults to create-drop for embedded dbs
spring.jpa.hibernate.dialect= # if spring data repository support is enabled

# SOLR (SolrProperties)
spring.data.solr.host=http://127.0.0.1:8983/solr
spring.data.solr.zk-host=
spring.data.solr.repositories.enabled=true # if spring data repository support is enabled

# ELASTICSEARCH (ElasticsearchProperties)
spring.data.elasticsearch.cluster-name= # The cluster name (defaults to elasticsearch)
spring.data.elasticsearch.cluster-name= # The address(es) of the server node (comma-separated; if not
specified starts a client node)
spring.data.elasticsearch.repositories.enabled=true # if spring data repository support is enabled

# FLYWAY (FlywayProperties)
flyway.locations=classpath:db/migrations # locations of migrations scripts
flyway.schemas= # schemas to update
flyway.init-version=1 # version to start migration
flyway.sql-migration-prefix=V
flyway.sql-migration-suffix=.sql
flyway.enabled=true
flyway.url= # JDBC url if you want Flyway to create its own DataSource
flyway.username= # JDBC username if you want Flyway to create its own DataSource
flyway.password= # JDBC password if you want Flyway to create its own DataSource

# LIQUIBASE (LiquibaseProperties)
liquibase.change-log=classpath:/db/changelog/db.changelog-master.yaml
liquibase.contexts= # runtime contexts to use
liquibase.default-schema= # default database schema to use
liquibase.drop-first=false
liquibase.enabled=true
liquibase.url= # specific JDBC url (if not set the default datasource is used)
liquibase.user= # user name for liquibase.url
liquibase.password= # password for liquibase.url

# JMX
spring.jmx.enabled=true # Expose MBeans from Spring

# RABBIT (RabbitProperties)
spring.rabbitmq.host= # connection host
spring.rabbitmq.port= # connection port
spring.rabbitmq.addresses= # connection addresses (e.g. myhost:9999,otherhost:1111)
spring.rabbitmq.username= # login user
spring.rabbitmq.password= # login password
spring.rabbitmq.virtual-host=
spring.rabbitmq.dynamic=

# REDIS (RedisProperties)
spring.redis.host=localhost # server host
spring.redis.password= # server password
spring.redis.port=6379 # connection port
spring.redis.pool.max-idle=8 # pool settings ...
spring.redis.pool.min-idle=0
spring.redis.pool.max-active=8
spring.redis.pool.max-wait=-1

# ACTIVEMQ (ActiveMQProperties)
spring.activemq.broker-url=tcp://localhost:61616 # connection URL
spring.activemq.user=
spring.activemq.password=
spring.activemq.in-memory=true # broker kind to create if no broker-url is specified
spring.activemq.pooled=false
# HornetQ (HornetQProperties)

- `spring.hornetq.mode` # connection mode (native, embedded)
- `spring.hornetq.host` = localhost # hornetq host (native mode)
- `spring.hornetq.port` = 5445 # hornetq port (native mode)
- `spring.hornetq.embedded.enabled` = true # if the embedded server is enabled (needs hornetq-jms-server.jar)
- `spring.hornetq.embedded.server-id` # auto-generated id of the embedded server (integer)
- `spring.hornetq.embedded.persistent` = false # message persistence
- `spring.hornetq.embedded.data-directory` # location of data content (when persistence is enabled)
- `spring.hornetq.embedded.queue` = # comma-separated queues to create on startup
- `spring.hornetq.embedded.topics` = # comma-separated topics to create on startup
- `spring.hornetq.embedded.cluster-password` = # customer password (randomly generated by default)

# JMS (JmsProperties)

- `spring.jms.pub-sub-domain` # false for queue (default), true for topic

# SPRING BATCH (BatchDatabaseInitializer)

- `spring.batch.job.names` = job1, job2
- `spring.batch.job.enabled` = true
- `spring.batch.initializer.enabled` = true
- `spring.batch.schema` = # batch schema to load

# AOP

- `spring.aop.auto` =
- `spring.aop.proxy-target-class` =

# FILE ENCODING (FileEncodingApplicationListener)

- `spring.mandatory-file-encoding` = false

# SPRING SOCIAL (SocialWebAutoConfiguration)

- `spring.social.auto-connection-views` = true # set to true for default connection views or false if you provide your own

# SPRING SOCIAL FACEBOOK (FacebookAutoConfiguration)

- `spring.social.facebook.app-id` = # your application’s Facebook App ID
- `spring.social.facebook.app-secret` = # your application's Facebook App Secret

# SPRING SOCIAL LINKEDIN (LinkedInAutoConfiguration)

- `spring.social.linkedin.app-id` = # your application’s LinkedIn App ID
- `spring.social.linkedin.app-secret` = # your application's LinkedIn App Secret

# SPRING SOCIAL TWITTER (TwitterAutoConfiguration)

- `spring.social.twitter.app-id` = # your application’s Twitter App ID
- `spring.social.twitter.app-secret` = # your application’s Twitter App Secret

# SPRING MOBILE SITE PREFERENCE (SitePreferenceAutoConfiguration)

- `spring.mobile.sitepreference.enabled` = true # enabled by default

# SPRING MOBILE DEVICE VIEWS (DeviceDelegatingViewResolverAutoConfiguration)

- `spring.mobile.delegatingviewresolver.enabled` = true # disabled by default
- `spring.mobile.delegatingviewresolver.normal-prefix` =
- `spring.mobile.delegatingviewresolver.normal-suffix` =
- `spring.mobile.delegatingviewresolver.mobile-prefix` = mobile/
- `spring.mobile.delegatingviewresolver.mobile-suffix` =
- `spring.mobile.delegatingviewresolver.tablet-prefix` = tablet/
- `spring.mobile.delegatingviewresolver.tablet-suffix` =

# ACTUATOR PROPERTIES

# MANAGEMENT HTTP SERVER (ManagementServerProperties)

- `management.port` = # defaults to 'server.port'
- `management.address` = # bind to a specific NIC
- `management.context-path` = # default to '/'
- `management.add-application-context-header` = # default to true

# ENDPOINTS (AbstractEndpoint subclasses)

- `endpoints.autoconfig.id` = autoconfig
- `endpoints.autoconfig.enabled` = true
- `endpoints.autoconfig.sensitive` = true
endpoints.beans.sensitive=true
endpoints.beans.enabled=true
endpoints.configprops.id=configprops
endpoints.configprops.sensitive=true
endpoints.configprops.enabled=true
endpoints.configprops.keys-to-sanitize=password,secret
endpoints.dump.id=dump
endpoints.dump.sensitive=true
endpoints.dump.enabled=true
endpoints.env.id=env
endpoints.env.sensitive=true
endpoints.env.enabled=true
endpoints.health.id=health
endpoints.health.sensitive=false
endpoints.health.enabled=true
endpoints.info.id=info
endpoints.info.sensitive=false
endpoints.info.enabled=true
endpoints.metrics.id=metrics
endpoints.metrics.sensitive=true
endpoints.metrics.enabled=true
endpoints.shutdown.id=shutdown
endpoints.shutdown.sensitive=true
endpoints.shutdown.enabled=false
endpoints.trace.id=trace
endpoints.trace.sensitive=true
endpoints.trace.enabled=true

# MVC ONLY ENDPOINTS
endpoints.jolokia.path=jolokia
endpoints.jolokia.sensitive=true
endpoints.jolokia.enabled=true # when using Jolokia

# JMX ENDPOINT (EndpointMBeanExportProperties)
endpoints.jmx.enabled=true
endpoints.jmx.domain=# the JMX domain, defaults to 'org.springframework'
endpoints.jmx.unique-names=false
endpoints.jmx.static-names=

# JOLOKIA (JolokiaProperties)
jolokia.config.*=# See Jolokia manual

# REMOTE SHELL
shell.auth=simple # jaas, key, simple, spring
shell.command-refresh-interval=-1
shell.command-path-patterns=# classpath*/commands/**, classpath*/crash/commands/**
shell.config-path-patterns=# classpath*/crash/**
shell.disabled-plugins=false # don't expose plugins
shell.ssh.enabled=# ssh settings ...
shell.ssh.key-path=
shell.ssh.port=
shell.telnet.enabled=# telnet settings ...
shell.telnet.port=
shell.auth.jaas.domain=# authentication settings ...
shell.auth.key.path=
shell.auth.simple.user.name=
shell.auth.simple.user.password=
shell.auth.spring.roles=

# GIT INFO
spring.git.properties=# resource ref to generated git info properties file
# Appendix B. Auto-configuration classes

Here is a list of all auto configuration classes provided by Spring Boot with links to documentation and source code. Remember to also look at the autoconfig report in your application for more details of which features are switched on. (start the app with `--debug` or `-Ddebug`, or in an Actuator application use the `autoconfig` endpoint).

## B.1 From the “spring-boot-autoconfigure” module

The following auto-configuration classes are from the `spring-boot-autoconfigure` module:

<table>
<thead>
<tr>
<th>Configuration Class</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ActiveMQAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>AopAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>BatchAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>DataSourceAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>DataSourceTransactionManagerAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>DeviceDelegatingViewResolverAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>DeviceResolverAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>DispatcherServletAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>ElasticsearchAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>ElasticsearchDataAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>ElasticsearchRepositoriesAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>EmbeddedServletContainerAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>ErrorMvcAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>FacebookAutoConfiguration</code></td>
<td>javadoc</td>
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<tr>
<td><code>FallbackWebSecurityAutoConfiguration</code></td>
<td>javadoc</td>
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<tr>
<td><code>FlywayAutoConfiguration</code></td>
<td>javadoc</td>
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<tr>
<td><code>FreeMarkerAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>GroovyTemplateAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>HibernateJpaAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>HornetQAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
<tr>
<td><code>HttpMessageConvertersAutoConfiguration</code></td>
<td>javadoc</td>
</tr>
</tbody>
</table>
### Configuration Class

<table>
<thead>
<tr>
<th>Class</th>
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<tbody>
<tr>
<td>HypermediaAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>IntegrationAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>JmsAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>JmxAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>JpaRepositoriesAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>LinkedInAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>LiquibaseAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>MessageSourceAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>MongoAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>MongoDataAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>MongoRepositoriesAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>MultipartAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>PropertyPlaceholderAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>RabbitAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>ReactorAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>RedisAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>RepositoryRestMvcAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>SecurityAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>ServerPropertiesAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>SitePreferenceAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>SocialWebAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>SolrAutoConfiguration</td>
<td>javadoc</td>
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<td>SolrRepositoriesAutoConfiguration</td>
<td>javadoc</td>
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<td>ThymeleafAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>TwitterAutoConfiguration</td>
<td>javadoc</td>
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<tr>
<td>VelocityAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>WebMvcAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>WebSocketAutoConfiguration</td>
<td>javadoc</td>
</tr>
</tbody>
</table>

### B.2 From the “spring-boot-actuator” module

The following auto-configuration classes are from the `spring-boot-actuator` module:
<table>
<thead>
<tr>
<th>Configuration Class</th>
<th>Links</th>
</tr>
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<tbody>
<tr>
<td>AuditAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>CrashAutoConfiguration</td>
<td>javadoc</td>
</tr>
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<td>EndpointAutoConfiguration</td>
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</tr>
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</tr>
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<td>EndpointWebMvcAutoConfiguration</td>
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<td>javadoc</td>
</tr>
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<td>JolokiaAutoConfiguration</td>
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</tr>
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<td>javadoc</td>
</tr>
<tr>
<td>ManagementServerPropertiesAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>MetricFilterAutoConfiguration</td>
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</tr>
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<td>MetricRepositoryAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>TraceRepositoryAutoConfiguration</td>
<td>javadoc</td>
</tr>
<tr>
<td>TraceWebFilterAutoConfiguration</td>
<td>javadoc</td>
</tr>
</tbody>
</table>
Appendix C. The executable jar format

The `spring-boot-loader` modules allows Spring Boot to support executable jar and war files. If you're using the Maven or Gradle plugin, executable jars are automatically generated and you generally won't need to know the details of how they work.

If you need to create executable jars from a different build system, or if you are just curious about the underlying technology, this section provides some background.

C.1 Nested JARs

Java does not provide any standard way to load nested jar files (i.e. jar files that are themselves contained within a jar). This can be problematic if you are looking to distribute a self-contained application that you can just run from the command line without unpacking.

To solve this problem, many developers use “shaded” jars. A shaded jar simply packages all classes, from all jars, into a single ‘uber jar’. The problem with shaded jars is that it becomes hard to see which libraries you are actually using in your application. It can also be problematic if the the same filename is used (but with different content) in multiple jars. Spring Boot takes a different approach and allows you to actually nest jars directly.

The executable jar file structure

Spring Boot Loader compatible jar files should be structured in the following way:

```
example.jar
  |  
  +-META-INF
  |    +-MANIFEST.MF
  +-org
  |  +-springframework
  |    +-boot
  |       +-loader
  |          +-<spring boot loader classes>
  +-com
  |  +-mycompany
  |     +-project
  |        +-YouClasses.class
  +-lib
     +-dependency1.jar
     +-dependency2.jar
```

Dependencies should be placed in a nested `lib` directory.

The executable war file structure

Spring Boot Loader compatible war files should be structured in the following way:

```
example.jar
  |  
  +-META-INF
  |    +-MANIFEST.MF
  +-org
  |  +-springframework
  |    +-boot
```

 Dependencies should be placed in a nested `lib` directory.
Dependencies should be placed in a nested WEB-INF/lib directory. Any dependencies that are required when running embedded but are not required when deploying to a traditional web container should be placed in WEB-INF/lib-provided.

C.2 Spring Boot’s “JarFile” class

The core class used to support loading nested jars is org.springframework.boot.loader.jar.JarFile. It allows you load jar content from a standard jar file, or from nested child jar data. When first loaded, the location of each JarEntry is mapped to a physical file offset of the outer jar:

```
myapp.jar
+---------------------+
|                    |
| /lib/mylib.jar      |
| A.class             |
| B.class             |
| B.class             |
+--------------------+
```

The example above shows how A.class can be found in myapp.jar position 0063. B.class from the nested jar can actually be found in myapp.jar position 3452 and B.class is at position 3980.

Armed with this information, we can load specific nested entries by simply seeking to appropriate part if the outer jar. We don’t need to unpack the archive and we don’t need to read all entry data into memory.

Compatibility with the standard Java “JarFile”

Spring Boot Loader strives to remain compatible with existing code and libraries. org.springframework.boot.loader.jar.JarFile extends from java.util.jar.JarFile and should work as a drop-in replacement. The RandomAccessJarFile.getURL() method will return a URL that opens a java.net.JarURLConnection compatible connection. RandomAccessJarFile URLs can be used with Java’s URLClassLoader.

C.3 Launching executable jars

The org.springframework.boot.loader.Launcher class is a special bootstrap class that is used as an executable jars main entry point. It is the actual Main-Class in your jar file and it’s used to setup an appropriate URLClassLoader and ultimately call your main() method.

There are 3 launcher subclasses (JarLauncher, WarLauncher and PropertiesLauncher). Their purpose is to load resources (.class files etc.) from nested jar files or war files in directories (as opposed to explicitly on the classpath). In the case of the [Jar|War]Launcher the nested paths
are fixed (lib/*.jar and lib-provided/*.jar for the war case) so you just add extra jars in those locations if you want more. The PropertiesLauncher looks in lib/ by default, but you can add additional locations by setting an environment variable LOADER_PATH or loader.path in application.properties (comma-separated list of directories or archives).

Launcher manifest

You need to specify an appropriate Launcher as the Main-Class attribute of META-INF/MANIFEST.MF. The actual class that you want to launch (i.e. the class that you wrote that contains a main method) should be specified in the Start-Class attribute.

For example, here is a typical MANIFEST.MF for an executable jar file:

```plaintext
Main-Class: org.springframework.boot.loader.JarLauncher
Start-Class: com.mycompany.project.MyApplication
```

For a war file, it would be:

```plaintext
Main-Class: org.springframework.boot.loader.WarLauncher
Start-Class: com.mycompany.project.MyApplication
```

Note

You do not need to specify Class-Path entries in your manifest file, the classpath will be deduced from the nested jars.

Exploded archives

Certain PaaS implementations may choose to unpack archives before they run. For example, Cloud Foundry operates in this way. You can run an unpacked archive by simply starting the appropriate launcher:

```
$ unzip -q myapp.jar
$ java org.springframework.boot.loader.JarLauncher
```

C.4 PropertiesLauncher Features

PropertiesLauncher has a few special features that can be enabled with external properties (System properties, environment variables, manifest entries or application.properties).

<table>
<thead>
<tr>
<th>Key</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>loader.path</td>
<td>Comma-separated Classpath, e.g. lib:$/HOME/app/lib.</td>
</tr>
<tr>
<td>loader.home</td>
<td>Location of additional properties file, e.g. /opt/app (defaults to ${user.dir})</td>
</tr>
<tr>
<td>loader.args</td>
<td>Default arguments for the main method (space separated)</td>
</tr>
<tr>
<td>loader.main</td>
<td>Name of main class to launch, e.g. com.app.Application.</td>
</tr>
<tr>
<td>loader.config.name</td>
<td>Name of properties file, e.g. loader (defaults to application).</td>
</tr>
<tr>
<td>loader.config.location</td>
<td>Path to properties file, e.g. classpath:loader.properties (defaults to application.properties).</td>
</tr>
<tr>
<td>Key</td>
<td>Purpose</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>loader.system</td>
<td>Boolean flag to indicate that all properties should be added to System properties (defaults to false)</td>
</tr>
</tbody>
</table>

Manifest entry keys are formed by capitalizing initial letters of words and changing the separator to "-" from "." (e.g. Loader-Path). The exception is loader.main which is looked up as Start-Class in the manifest for compatibility with JarLauncher).

Environment variables can be capitalized with underscore separators instead of periods.

- loader.home is the directory location of an additional properties file (overriding the default) as long as loader.config.location is not specified.
- loader.path can contain directories (scanned recursively for jar and zip files), archive paths, or wildcard patterns (for the default JVM behavior).
- Placeholder replacement is done from System and environment variables plus the properties file itself on all values before use.

C.5 Executable jar restrictions

There are a number of restrictions that you need to consider when working with a Spring Boot Loader packaged application.

Zip entry compression

The ZipEntry for a nested jar must be saved using the ZipEntry.STORED method. This is required so that we can seek directly to individual content within the nested jar. The content of the nested jar file itself can still be compressed, as can any other entries in the outer jar.

System ClassLoader

Launched applications should use Thread.getContextClassLoader() when loading classes (most libraries and frameworks will do this by default). Trying to load nested jar classes via ClassLoader.getSystemClassLoader() will fail. Please be aware that java.util.Logging always uses the system classloader, for this reason you should consider a different logging implementation.

C.6 Alternative single jar solutions

If the above restrictions mean that you cannot use Spring Boot Loader the following alternatives could be considered:

- Maven Shade Plugin
- JarClassLoader
- OneJar
## Appendix D. Dependency versions

The table below provides details of all of the dependency versions that are provided by Spring Boot in its CLI, Maven dependency management and Gradle plugin. When you declare a dependency on one of these artifacts without declaring a version the version that is listed in the table will be used.

<table>
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<tr>
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<th>Artifact ID</th>
<th>Version</th>
</tr>
</thead>
<tbody>
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