

# **Book of Vaadin**

**Vaadin 7 Edition - 4th Revision**



Marko Grönroos

2014  
Vaadin Ltd

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## **Book of Vaadin: Vaadin 7 Edition - 4th Revision**

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Marko Grönroos

Vaadin 7 Edition - 4th Revision Edition

Vaadin Framework 7.0.0

Published: 2014-12-05

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### **Abstract**

Vaadin is an AJAX web application development framework that enables developers to build high-quality user interfaces with Java, both on the server- and client-side. It provides a set of libraries of ready-to-use user interface components and a clean framework for creating your own components. The focus is on ease-of-use, re-usability, extensibility, and meeting the requirements of large enterprise applications.

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# Preface

This book provides an overview of the Vaadin Framework and covers the most important topics that you might encounter while developing applications with it. A more detailed documentation of the individual classes, interfaces, and methods is given in the Vaadin API Reference.

The book has grown greatly after its first edition, until it became too thick to fit any standard pocket. To accommodate all the content also in the printed edition, it has now been split into two volumes, the first one including the topics that you need to get started with Vaadin.

This edition mostly covers Vaadin 7.3 released in 2014. The most notable feature in the release is the new and highly customizable Valo theme.

In addition to the changes in the core framework, this edition features documentation for the TestBench 4 and TouchKit 4 add-ons, which are not yet released at the time of writing. The updated chapters are based on prerelease versions of the add-ons, so the final releases may include some changes.

Writing this manual is an ongoing work and it is rarely completely up-to-date with the quick-evolving product. Some features may not be included in this book yet. For the most current version, please see the on-line edition available at <http://vaadin.com/book>. You can also find PDF and EPUB versions of the book there. You may find the other versions more easily searchable than the printed book. The index in the book is incomplete and will be expanded later. The web edition also has some additional technical content, such as some example code and additional sections that you may need when actually doing development. The purpose of the slightly abridged print edition is more to be an introductory textbook to Vaadin, and still fit in your pocket.

Also, many Vaadin 7 features are showcased as mini-tutorials, which are available in the Vaadin Wiki at <https://vaadin.com/wiki/-/wiki/Main/Vaadin+7>.

## Who is This Book For?

This book is intended for software developers who use, or are considering to use, Vaadin to develop web applications.

The book assumes that you have some experience with programming in Java, but if not, it is at least as easy to begin learning Java with Vaadin as with any other UI framework. No knowledge of AJAX is needed as it is well hidden from the developer.

You may have used some desktop-oriented user interface frameworks for Java, such as AWT, Swing, or SWT, or a library such as Qt for C++. Such knowledge is useful for understanding the scope of Vaadin, the event-driven programming model, and other common concepts of UI frameworks, but not necessary.

If you do not have a web graphics designer at hand, knowing the basics of HTML and CSS can help so that you can develop presentation themes for your application. A brief introduction to CSS is provided. Knowledge of Google Web Toolkit (GWT) may be useful if you develop or integrate new client-side components.

## Organization of This Book

The Book of Vaadin gives an introduction to what Vaadin is and how you use it to develop web applications.

## Volume 1

### **Chapter 1, *Introduction***

The chapter gives an introduction to the application architecture supported by Vaadin, the core design ideas behind the framework, and some historical background.

### **Chapter 2, *Getting Started with Vaadin***

This chapter gives practical instructions for installing Vaadin and the reference toolchain, including the Vaadin Plugin for Eclipse, how to run and debug the demos, and how to create your own application project in the Eclipse IDE.

### **Chapter 3, *Architecture***

This chapter gives an introduction to the architecture of Vaadin and its major technologies, including AJAX, Google Web Toolkit, and event-driven programming.

### **Chapter 4, *Writing a Server-Side Web Application***

This chapter gives all the practical knowledge required for creating applications with Vaadin, such as window management, application lifecycle, deployment in a servlet container, and handling events, errors, and resources.

### **Chapter 5, *User Interface Components***

This chapter gives the basic usage documentation for all the (non-layout) user interface components in Vaadin and their most significant features. The component sections include examples for using each component, as well as for styling with CSS/Sass.

### **Chapter 6, *Managing Layout***

This chapter describes the layout components, which are used for managing the layout of the user interface, just like in any desktop application frameworks.

## Volume 2:

### **Chapter 7, *Themes***

This chapter gives an introduction to Cascading Style Sheets (CSS) and Sass and explains how you can use them to build custom visual themes for your application.

### **Chapter 8, *Binding Components to Data***

This chapter gives an overview of the built-in data model of Vaadin, consisting of properties, items, and containers.

### **Chapter 9, *Vaadin SQLContainer***

This chapter gives documentation for the SQLContainer, which allows binding Vaadin components to SQL queries.

### **Chapter 10, *Visual User Interface Design with Eclipse***

This chapter gives instructions for using the visual editor for Eclipse, which is included in the Vaadin Plugin for the Eclipse IDE.

### **Chapter 11, *Advanced Web Application Topics***

This chapter provides many special topics that are commonly needed in applications, such as opening new browser windows, embedding applications in regular web pages, low-level management of resources, shortcut keys, debugging, etc.

### **Chapter 12, *Portal Integration***

This chapter describes the development of Vaadin applications as portlets which you can deploy to any portal supporting Java Portlet API 2.0 (JSR-286). The chapter also

describes the special support for Liferay and the Control Panel, IPC, and WSRP add-ons.

**Chapter 13, *Client-Side Vaadin Development***

This chapter gives an introduction to creating and developing client-side applications and widgets, including installation, compilation, and debugging.

**Chapter 14, *Client-Side Applications***

This chapter describes how to develop client-side applications and how to integrate them with a back-end service.

**Chapter 15, *Client-Side Widgets***

This chapter describes the built-in widgets (client-side components) available for client-side development. The built-in widgets include Google Web Toolkit widgets as well as Vaadin widgets.

**Chapter 16, *Integrating with the Server-Side***

This chapter describes how to integrate client-side widgets with their server-side counterparts for the purpose of creating new server-side components. The chapter also covers integrating JavaScript components.

**Chapter 17, *Using Vaadin Add-ons***

This chapter gives instructions for downloading and installing add-on components from the Vaadin Directory.

**Chapter 18, *Vaadin Charts***

This chapter documents the use of the Vaadin Charts add-on component for interactive charting with many diagram types. The add-on includes the Chart and Timeline components.

**Chapter 19, *Vaadin JPAContainer***

This chapter gives documentation of the JPAContainer add-on, which allows binding Vaadin components directly to relational and other databases using Java Persistence API (JPA).

**Chapter 20, *Mobile Applications with TouchKit***

This chapter gives examples and reference documentation for using the Vaadin TouchKit add-on for developing mobile applications.

**Chapter 21, *Vaadin TestBench***

This chapter gives the complete documentation of using the Vaadin TestBench tool for recording and executing user interface regression tests of Vaadin applications.

## Supplementary Material

The Vaadin websites offer plenty of material that can help you understand what Vaadin is, what you can do with it, and how you can do it.

**Demo Applications**

The most important demo application for Vaadin is the Sampler, which demonstrates the use of all basic components and features. You can run it on-line at <http://demo.vaadin.com/> or download it as a WAR from the Vaadin download page.

Most of the code examples in this book and many others can be found online at <http://demo.vaadin.com/book-examples-vadin7/book/>.

### Cheat Sheet

The two-page cheat sheet illustrates the basic relationship hierarchy of the user interface and data binding classes and interfaces. You can download it at <http://vaadin.com/book>.

### Refcard

The six-page DZone Refcard gives an overview to application development with Vaadin. It includes a diagram of the user interface and data binding classes and interfaces. You can find more information about it at <https://vaadin.com/refcard>.

### Address Book Tutorial

The Address Book is a sample application accompanied with a tutorial that gives detailed step-by-step instructions for creating a real-life web application with Vaadin. You can find the tutorial from the product website.

### Developer's Website

Vaadin Developer's Site at <http://dev.vaadin.com/> provides various online resources, such as the ticket system, a development wiki, source repositories, activity timeline, development milestones, and so on.

The wiki provides instructions for developers, especially for those who wish to check-out and compile Vaadin itself from the source repository. The technical articles deal with integration of Vaadin applications with various systems, such as JSP, Maven, Spring, Hibernate, and portals. The wiki also provides answers to Frequently Asked Questions.

### Online Documentation

You can read this book online at <http://vaadin.com/book>. Lots of additional material, including technical HOWTOs, answers to Frequently Asked Questions and other documentation is also available on Vaadin web-site.

## Support

Stuck with a problem? No need to lose your hair over it, the Vaadin Framework developer community and the Vaadin company offer support to all of your needs.

### Community Support Forum

You can find the user and developer community forum at <http://vaadin.com/forum>. Please use the forum to discuss any problems you might encounter, wishes for features, and so on. The answer to your problems may already lie in the forum archives, so searching the discussions is always the best way to begin.

### Report Bugs

If you have found a possible bug in Vaadin, the demo applications, or the documentation, please report it by filing a ticket at the Vaadin developer's site at <http://dev.vaadin.com/>. You may want to check the existing tickets before filing a new one. You can make a ticket to make a request for a new feature as well, or to suggest modifications to an existing feature.

### Commercial Support

Vaadin offers full commercial support and training services for the Vaadin Framework and related products. Read more about the commercial products at <http://vaadin.com/pro> for details.

## About the Author

Marko Grönroos is a professional writer and software developer working at Vaadin Ltd in Turku, Finland. He has been involved in web application development since 1994 and has worked on several application development frameworks in C, C++, and Java. He has been active in many open source software projects and holds an M.Sc. degree in Computer Science from the University of Turku.

## Acknowledgements

Much of the book is the result of close work within the development team at Vaadin Ltd. Joonas Lehtinen, CEO of Vaadin Ltd, wrote the first outline of the book, which became the basis for the first two chapters. Since then, Marko Grönroos has become the primary author and editor. The development team has contributed several passages, answered numerous technical questions, reviewed the manual, and made many corrections.

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Petter Holmström (JPAContainer)  
Leif Åstrand

## About Vaadin Ltd

Vaadin Ltd is a Finnish software company specializing in the design and development of Rich Internet Applications. The company offers planning, implementation, and support services for the software projects of its customers, as well as sub-contract software development. Vaadin Framework, previously known as IT Mill Toolkit, is the flagship open source product of the company, for which it provides commercial development and support services.



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# Chapter 1

# Introduction

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This chapter gives a brief introduction to software development with Vaadin. We also try to give some insight about the design philosophy behind Vaadin and its history.

## 1.1. Overview

Vaadin Framework is a Java web application development framework that is designed to make creation and maintenance of high quality web-based user interfaces easy. Vaadin supports two different programming models: server-side and client-side. The server-driven programming model is the more powerful one. It lets you forget the web and program user interfaces much like you would program a desktop application with conventional Java toolkits such as AWT, Swing, or SWT. But easier.

While traditional web programming is a fun way to spend your time learning new web technologies, you probably want to be productive and concentrate on the application logic. The server-side Vaadin framework takes care of managing the user interface in the browser and the AJAX communications between the browser and the server. With the Vaadin approach, you do not need to learn and deal directly with browser technologies, such as HTML or JavaScript.

## Figure 1.1. Vaadin Application Architecture

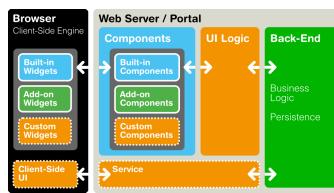


Figure 1.1, “Vaadin Application Architecture” illustrates the basic architectures of web applications made with Vaadin. The server-side application architecture consists of the *server-side framework* and a *client-side engine*. The engine runs in the browser as JavaScript code, rendering the user interface, and delivering user interaction to the server. The UI logic of an application runs as a Java Servlet in a Java application server.

As the client-side engine is executed as JavaScript in the browser, no browser plugins are needed for using applications made with Vaadin. This gives it an edge over frameworks based on Flash, Java Applets, or other plugins. Vaadin relies on the support of Google Web Toolkit for a wide range of browsers, so that the developer does not need to worry about browser support.

Because HTML, JavaScript, and other browser technologies are essentially invisible to the application logic, you can think of the web browser as only a thin client platform. A thin client displays the user interface and communicates user events to the server at a low level. The control logic of the user interface runs on a Java-based web server, together with your business logic. By contrast, a normal client-server architecture with a dedicated client application would include a lot of application specific communications between the client and the server. Essentially removing the user interface tier from the application architecture makes our approach a very effective one.

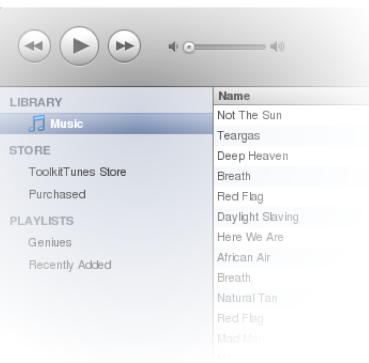
Behind the server-driven development model, Vaadin makes the best use of AJAX (*Asynchronous JavaScript and XML*, see Section 3.2.3, “AJAX” for a description) techniques that make it possible to create Rich Internet Applications (RIA) that are as responsive and interactive as desktop applications.

In addition to the server-side Java application development, you can develop on the client-side by making new widgets in Java, and even pure client-side applications that run solely in the browser. The Vaadin client-side framework includes Google Web Toolkit (GWT), which provides a compiler from Java to the JavaScript that runs in the browser, as well a full-featured user interface framework. With this approach, Vaadin is pure Java on both sides.

Vaadin uses a client-side engine for rendering the user interface of a server-side application in the browser. All the client-server communications are hidden well under the hood. Vaadin is designed to be extensible, and you can indeed use any 3rd-party widgets easily, in addition to the component repertoire offered in Vaadin. In fact, you can find hundreds of add-ons in the Vaadin Directory.

Vaadin Framework defines a clear separation between the structure of the user interface and its appearance and allows you to develop them separately. Our approach to this is *themes*, which control the appearance by CSS and (optional) HTML page templates. As Vaadin provides excellent default themes, you do not usually need to make much customization, but you can if you need to. For more about themes, see Chapter 7, *Themes*.

We hope that this is enough about the basic architecture and features of Vaadin for now. You can read more about it later in Chapter 3, *Architecture*, or jump straight to more practical things in Chapter 4, *Writing a Server-Side Web Application*.



## 1.2. Example Application Walkthrough

Let us follow the long tradition of first saying "Hello World!" when learning a new programming framework. First, using the primary server-side API.

```
import com.vaadin.server.VaadinRequest;
import com.vaadin.ui.Label;
import com.vaadin.ui.UI;

@Title("My UI")
@Theme("valo")
public class HelloWorld extends UI {
    @Override
    protected void init(VaadinRequest request) {
        // Create the content root layout for the UI
        VerticalLayout content = new VerticalLayout();
        setContent(content);

        // Display the greeting
        content.addComponent(new Label("Hello World!"));

        // Have a clickable button
        content.addComponent(new Button("Push Me!",
            new ClickListener() {
                @Override
                public void buttonClick(ClickEvent e) {
                    Notification.show("Pushed!");
                }
            }));
    }
}
```

A Vaadin application has one or more *UIs* that extend the `com.vaadin.ui.UI` class. A UI is a part of the web page in which the Vaadin application runs. An application can have multiple UIs in the same page, especially in portals, or in different windows or tabs. A UI is associated with a user session, and a session is created for each user who uses the application. In the context of our Hello World UI, it is sufficient to know that the underlying session is created when the user first accesses the application by opening the page, and the `init()` method is invoked at that time.

The page title, which is shown in the caption of the browser window or tab, is defined with an annotation. The example uses a layout component as the root content of the UI, as that is the case with most Vaadin applications, which normally have more than one component. It then

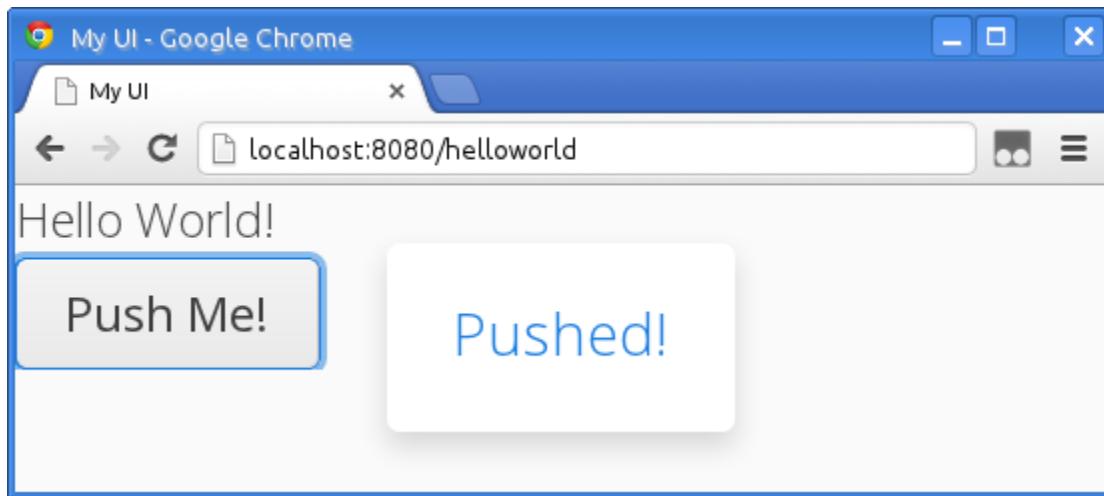
creates a new **Label** user interface component, which displays simple text, and sets the text to "Hello World!". The label is added to the layout.

The example also shows how to create a button and handle button click events. Event handling is described in Section 3.4, "Events and Listeners" and on the practical side in Section 4.3, "Handling Events with Listeners". In addition to listeners, in Java 8 you can handle events with lambda expressions, which simplifies the handler code significantly.

```
content.addComponent(new Button("Push Me!",
    event -> Notification.show("Pushed!")));
```

The result of the Hello World application, when opened in a browser, is shown in Figure 1.2, "Hello World Application".

**Figure 1.2. Hello World Application**



To run a program, you need to package it as a web application WAR package and deploy it to a server, as explained in Section 4.8, "Deploying an Application". During development, you typically deploy to an application server integrated with the IDE.

Developing a pure client-side application, you could write a Hello World just as easily, and also in Java:

```
public class HelloWorld implements EntryPoint {
    @Override
    public void onModuleLoad() {
        RootPanel.get().add(new Label("Hello, world!"));
    }
}
```

We do not set the title here, because it is usually defined in the HTML page in which the code is executed. The application would be compiled into JavaScript with the Vaadin Client Compiler (or GWT Compiler). It is more typical, however, to write client-side widgets, which you can then use from a server-side Vaadin application. For more information regarding client-side development, see Chapter 13, *Client-Side Vaadin Development*.

## 1.3. Support for the Eclipse IDE

While Vaadin is not bound to any specific IDE, and you can in fact easily use it without any IDE altogether, we provide special support for the Eclipse IDE, which has become the most used environment for Java development. The support is provided in the Vaadin Plugin for Eclipse, which helps you in:

- Creating new Vaadin projects
- Creating custom themes
- Creating custom widgets
- Creating composite components with a visual editor
- Easily upgrading to a newer version of the Vaadin library

Using the Vaadin Plugin for Eclipse is the recommended way of installing Vaadin for development. Downloading the installation package that contains the JARs or defining Vaadin as a Maven dependency is also possible.

Installing and updating the Eclipse plugin is covered in Section 2.4, “Installing Vaadin Plugin for Eclipse” and the creation of a new Vaadin project using the plugin in Section 2.5.1, “Creating the Project”. See Section 7.5, “Creating a Theme in Eclipse”, Section 16.2, “Starting It Simple With Eclipse”, and Chapter 10, *Visual User Interface Design with Eclipse* for instructions on using the different features of the plugin.

## 1.4. Goals and Philosophy

Simply put, Vaadin's ambition is to be the best possible tool when it comes to creating web user interfaces for business applications. It is easy to adopt, as it is designed to support both entry-level and advanced programmers, as well as usability experts and graphic designers.

When designing Vaadin, we have followed the philosophy inscribed in the following rules.

### Right tool for the right purpose

Because our goals are high, the focus must be clear. Vaadin is designed for creating web applications. It is not designed for creating websites or advertisement demos. You may find, for example, JSP/JSF or Flash more suitable for such purposes.

### Simplicity and maintainability

We have chosen to emphasize robustness, simplicity, and maintainability. This involves following the well-established best practices in user interface frameworks and ensuring that our implementation represents an ideal solution for its purpose without clutter or bloat.

### XML is not designed for programming

The Web is inherently document-centered and very much bound to the declarative presentation of user interfaces. The Vaadin framework frees the programmer from these limitations. It is far more natural to create user interfaces by programming them than by defining them in declarative templates, which are not flexible enough for complex and dynamic user interaction.

## Tools should not limit your work

There should not be any limits on what you can do with the framework: if for some reason the user interface components do not support what you need to achieve, it must be easy to add new ones to your application. When you need to create new components, the role of the framework is critical: it makes it easy to create re-usable components that are easy to maintain.

## 1.5. Background

The Vaadin Framework was not written overnight. After working with web user interfaces since the beginning of the Web, a group of developers got together in 2000 to form IT Mill. The team had a desire to develop a new programming paradigm that would support the creation of real user interfaces for real applications using a real programming language.

The library was originally called Millstone Library. The first version was used in a large production application that IT Mill designed and implemented for an international pharmaceutical company. IT Mill made the application already in the year 2001 and it is still in use. Since then, the company has produced dozens of large business applications with the library and it has proven its ability to solve hard problems easily.

The next generation of the library, IT Mill Toolkit Release 4, was released in 2006. It introduced an entirely new AJAX-based presentation engine. This allowed the development of AJAX applications without the need to worry about communications between the client and the server.

## Release 5 Into the Open

IT Mill Toolkit 5, released initially at the end of 2007, took a significant step further into AJAX. The client-side rendering of the user interface was completely rewritten using GWT, the Google Web Toolkit.

IT Mill Toolkit 5 introduced many significant improvements both in the server-side API and in the functionality. Rewriting the Client-Side Engine with GWT allowed the use of Java both on the client and the server-side. The transition from JavaScript to GWT made the development and integration of custom components and customization of existing components much easier than before, and it also allows easy integration of existing GWT components. The adoption of GWT on the client-side did not, by itself, cause any changes in the server-side API, because GWT is a browser technology that is hidden well behind the API. Also theming was completely revised in IT Mill Toolkit 5.

The Release 5 was published under the Apache License 2, an unrestrictive open source license, to create faster expansion of the user base and to make the formation of a developer community possible.

## Birth of Vaadin Release 6

IT Mill Toolkit was renamed as *Vaadin Framework*, or Vaadin in short, in spring 2009. Later IT Mill, the company, was also renamed as Vaadin Ltd. Vaadin means an adult female semi-domesticated mountain reindeer in Finnish.

With Vaadin 6, the number of developers using the framework exploded. Together with the release, the Vaadin Plugin for Eclipse was released, helping the creation of Vaadin projects. The introduction of Vaadin Directory in early 2010 gave it a further boost, as the number of available components multiplied almost overnight. Many of the originally experimental components have since then matured and are now used by thousands of developers. In 2013, we are seeing tremendous

growth in the ecosystem around Vaadin. The size of the user community, at least if measured by forum activity, has already gone past the competing server-side frameworks and even GWT.

## The Major Revision with Vaadin 7

Vaadin 7 is a major revision that changes the Vaadin API much more than Vaadin 6 did. It is certainly more web-oriented than Vaadin 6 was. We are doing everything we can to help Vaadin rise high in the web universe. Some of this work is easy and almost routine - fixing bugs and implementing features. But going higher also requires standing firmer. That was one of the aims of Vaadin 7 - redesigning the product so that the new architecture enables Vaadin to reach over many long-standing challenges. Many of the changes required breaking API compatibility with Vaadin 6, especially in the client-side, but they are made with a strong desire to avoid carrying unnecessary legacy burden far into the future. Vaadin 7 includes a compatibility layer for making adoption of Vaadin 7 in existing applications easier.

Inclusion of the Google Web Toolkit in Vaadin 7 is a significant development, as it means that we now provide support for GWT as well. When Google opened the GWT development in summer 2012, Vaadin (the company) joined the new GWT steering committee. As a member of the committee, Vaadin can work towards the success of GWT as a foundation of the Java web development community.



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# Chapter 2

# Getting Started with Vaadin

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This chapter gives practical instructions for installing the recommended toolchain, the Vaadin libraries and its dependencies, and creating a new Vaadin project.

## 2.1. Overview

You can develop Vaadin applications in essentially any development environment that has the Java SDK and a Java Servlet container. Vaadin has special support for the Eclipse and NetBeans IDEs, but community support exists also for IntelliJ IDEA. You can use it with any Java IDE or no IDE at all.

Managing Vaadin and other Java libraries can get tedious to do manually, so using a build system that manages dependencies automatically is advised. Vaadin is distributed in the Maven central repository, and can be used with any build or dependency management system that can access Maven repository, such as Ivy or Gradle, in addition to Maven.

Vaadin has a multitude of installation options for different IDEs, dependency managers, and you can also install it from an installation package:

- With the Eclipse IDE, use the Vaadin Plugin for Eclipse, as described in Section 2.4, “[Installing Vaadin Plugin for Eclipse](#)”
- With the Vaadin plugin for NetBeans IDE (Section 2.7, “[Creating a Project with NetBeans IDE](#)”) or IntelliJ IDEA
- With Maven, Ivy, Gradle, or other Maven-compatible dependency manager, under Eclipse, NetBeans, IDEA, or using command-line, as described in Section 2.6, “[Using Vaadin with Maven](#)”
- From installation package without dependency management, as described in Section 2.9, “[Vaadin Installation Package](#)”

## 2.2. Setting up the Development Environment

This section guides you step-by-step in setting up a reference development environment. Vaadin supports a wide variety of tools, so you can use any IDE for writing the code, almost any Java web server for deploying the application, most web browsers for using it, and any operating system platform supported by Java.

In this example, we use the following toolchain:

- Windows, Linux, or Mac OS X
- Oracle Java SE 8 (Java 6 or newer is required)
- Eclipse IDE for Java EE Developers
- Apache Tomcat 8.0 (Core)
- Mozilla Firefox browser
- Firebug debug tool (optional)
- Vaadin Framework

The above reference toolchain is a good choice of tools, but you can use almost any tools you are comfortable with.

We recommend using Java 8 for Vaadin development, but you need to make sure that your entire toolchain supports it. If you intend to use server push or the Vaadin CDI add-on, you need to use a Java EE 7 compatible server with WebSocket support, such as Glassfish, Apache TomEE Web Profile, etc.

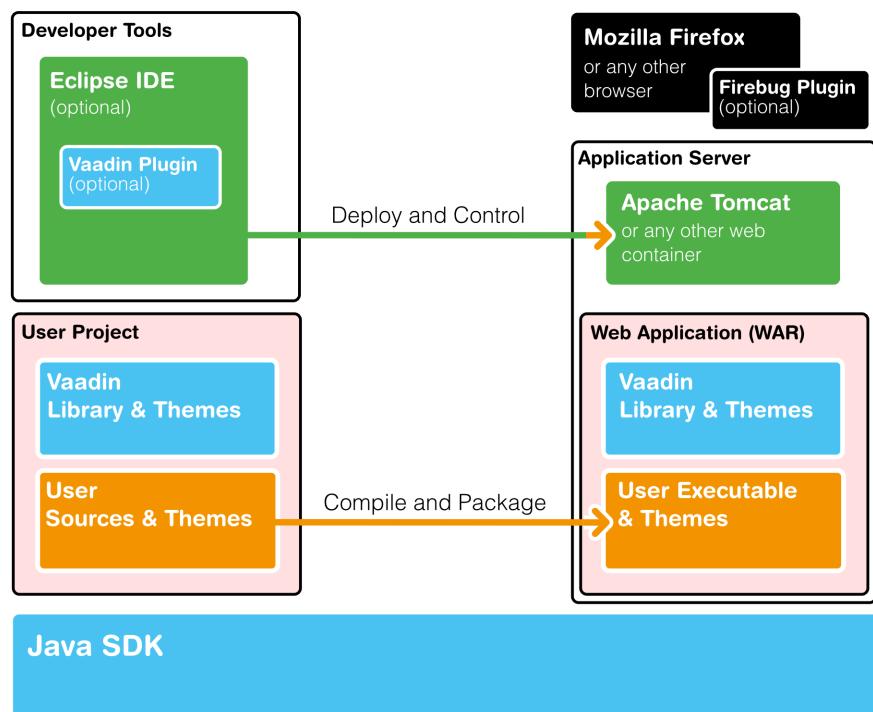
**Figure 2.1. Development Toolchain and Process**

Figure 2.1, “Development Toolchain and Process” illustrates the development toolchain. You develop your application as an Eclipse project. The project must include, in addition to your source code, the Vaadin libraries. It can also include project-specific themes.

You need to compile and deploy a project to a web container before you can use it. You can deploy a project through the Web Tools Platform (WTP) for Eclipse (included in the Eclipse EE package), which allows automatic deployment of web applications from Eclipse. You can also deploy a project manually, by creating a web application archive (WAR) and deploying it to the web container.

## 2.2.1. Installing Java SDK

Java SDK is required by Vaadin and also by the Eclipse IDE. Vaadin is compatible with Java 1.6 and later editions. Java EE 7 is required for proper server push support with WebSockets.

### Windows

1. Download Oracle Java SE 8.0 from <http://www.oracle.com/technetwork/java/javase/downloads/index.html>
2. Install the Java SDK by running the installer. The default options are fine.

### Linux / UNIX

Most Linux systems either have JDK preinstalled or allow installing it through a package management system. Notice however that they have OpenJDK as the default Java implementation. While it is known to have worked with Vaadin and possibly also with the development toolchain, we do not especially support it.

Regarding OS X, notice that JDK 1.6 or newer is included in OS X 10.6 and newer.

Otherwise:

1. Download Oracle Java SE 8.0 from <http://www.oracle.com/technetwork/java/javase/downloads/>
2. Decompress it under a suitable base directory, such as `/opt`. For example, for Java SDK, enter (either as root or with **sudo** in Linux):

```
# cd /opt  
# sh (path-to-installation-package)/jdk-8u20-linux-x64.bin
```

and follow the instructions in the installer.

3. Set up the `JAVA_HOME` environment variable to point to the Java installation directory. Also, include the `$JAVA_HOME/bin` in the `PATH`. How you do that varies by the UNIX variant. For example, in Linux and using the Bash shell, you would add lines such as the following to the `.bashrc` or `.profile` script in your home directory:

```
export JAVA_HOME=/opt/jdk1.8.0_20  
export PATH=$PATH:$HOME/bin:$JAVA_HOME/bin
```

You could also make the setting system-wide in a file such as `/etc/bash.bashrc`, `/etc/profile`, or an equivalent file. If you install Apache Ant or Maven, you may also want to set up those in the path.

Settings done in a `bashrc` file require that you open a new shell window. Settings done in a `profile` file require that you log in into the system. You can, of course, also give the commands in the current shell.

## 2.2.2. Installing Eclipse IDE

### Windows

1. Download the Eclipse IDE for Java EE Developers from <http://www.eclipse.org/downloads/>
2. Decompress the Eclipse IDE package to a suitable directory. You are free to select any directory and to use any ZIP decompressor, but in this example we decompress the ZIP file by just double-clicking it and selecting "Extract all files" task from Windows compressed folder task. In our installation example, we use `C:\dev` as the target directory.

Eclipse is now installed in `C:\dev\ eclipse` and can be started from there (by double clicking `eclipse.exe`).

### Linux / OS X / UNIX

We recommend that you install Eclipse manually in Linux and other UNIX variants as follows.

1. Download Eclipse IDE for Java EE Developers from <http://www.eclipse.org/downloads/>
2. Decompress the Eclipse package into a suitable base directory. It is important to make sure that there is no old Eclipse installation in the target directory. Installing a new version on top of an old one probably renders Eclipse unusable.

3. Eclipse should normally be installed as a regular user, as this makes installation of plugins easier. Eclipse also stores some user settings in the installation directory. To install the package, enter:

```
$ tar zxf (path-to-installation-package)/eclipse-jee-ganymede-SR2-linux-gtk.tar.gz
```

This will extract the package to a subdirectory with the name `eclipse`.

4. If you wish to enable starting Eclipse from command-line, you need to add the Eclipse installation directory to your system or user PATH, or make a symbolic link or script to point to the executable.

An alternative to the above procedure would be to use an Eclipse version available through the package management system of your operating system. It is, however, *not recommended*, because you will need write access to the Eclipse installation directory to install Eclipse plugins, and you may face incompatibility issues with Eclipse plugins installed by the package management of the operating system.

### 2.2.3. Installing Apache Tomcat

Apache Tomcat is a lightweight Java web server suitable for both development and production. There are many ways to install it, but here we simply decompress the installation package.

*Apache Tomcat should be installed with user permissions.* During development, you will be running Eclipse or some other IDE with user permissions, but deploying web applications to a Tomcat server that is installed system-wide requires administrator or root permissions.

1. Download the installation package:

Apache Tomcat 8.0 (Core Binary Distribution) from <http://tomcat.apache.org/>

2. Decompress Apache Tomcat package to a suitable target directory, such as `C:\dev` (Windows) or `/opt` (Linux or Mac OS X). The Apache Tomcat home directory will be `C:\dev\apache-tomcat-8.0.x` or `/opt/apache-tomcat-8.0.x`, respectively.

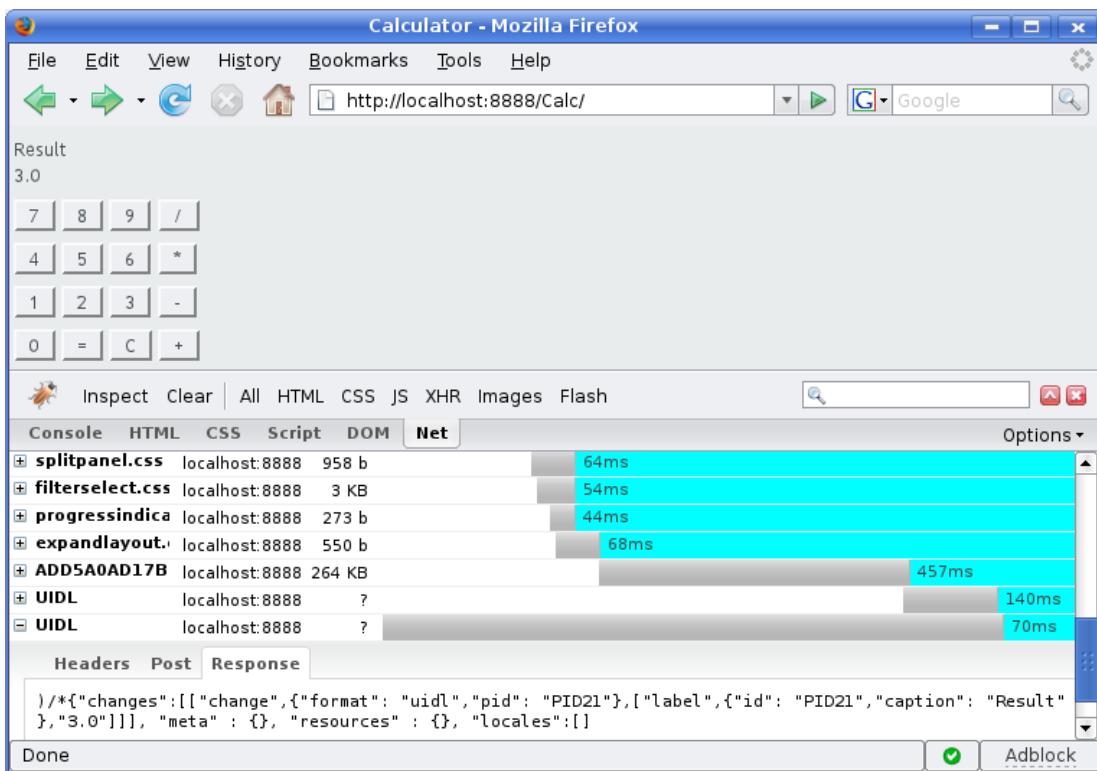
### 2.2.4. Firefox and Firebug

Vaadin supports many web browsers and you can use any of them for development. If you plan to create a custom theme, customized layouts, or create new components, we recommend that you use either Firefox together with Firebug or Google Chrome, which has built-in developer tools similar to Firebug.

#### Using Firebug with Vaadin

After installing Firefox, use it to open <http://www.getfirebug.com/>. Follow the instructions on the site to install the latest stable version of Firebug available for the browser. You may need to allow Firefox to install the plugin by clicking the yellow warning bar at the top of the browser window.

After Firebug is installed, it can be enabled at any time from the Firefox toolbar. Figure 2.2, “Firebug Debugger for Firefox” shows Firebug in action.

**Figure 2.2. Firebug Debugger for Firefox**

The most important feature in Firebug is inspecting HTML elements. Right-click on an element and select **Inspect Element with Firebug** to inspect it. In addition to HTML tree, it also shows the CSS rules matching the element, which you can use for building themes. You can even edit the CSS styles live, to experiment with styling.

## 2.3. Overview of Vaadin Libraries

Vaadin comes as a set of library JARs, of which some are optional or alternative ones, depending on whether you are developing server-side or client-side applications, whether you use add-on components, or use CSS or Sass themes.

### `vaadin-server-7.x.x.jar`

The main library for developing server-side Vaadin applications, as described in Chapter 4, *Writing a Server-Side Web Application*. It requires the `vaadin-shared` and the `vaadin-themes` libraries. You can use the prebuilt `vaadin-client-compiled` for server-side development, unless you need add-on components or custom widgets.

### `vaadin-shared-7.x.x.jar`

A shared library for server-side and client-side development. It is always needed.

### `vaadin-client-7.x.x.jar`

The client-side Vaadin framework, including the basic GWT API and Vaadin-specific widgets and other additions. It is required when using the `vaadin-client-compiler` to compile client-side modules. It is not needed if you just use the server-side framework with the precompiled Client-Side Engine. You should not deploy it with a web application.

**vaadin-client-compiler-7.x.x.jar**

The Vaadin Client Compiler is a Java-to-JavaScript compiler that allows building client-side modules, such as the Client-Side Engine (widget set) required for server-side applications. The compiler is needed, for example, for compiling add-on components to the application widget set, as described in Chapter 17, *Using Vaadin Add-ons*. For detailed information regarding the compiler, see Section 13.4, “Compiling a Client-Side Module”. Note that you should not deploy this library with a web application.

**vaadin-client-compiled-7.x.x.jar**

A precompiled Vaadin Client-Side Engine (widget set) that includes all the basic built-in widgets in Vaadin. This library is not needed if you compile the application widget set with the Vaadin Client Compiler.

**vaadin-themes-7.x.x.jar**

Vaadin built-in themes both as SCSS source files and precompiled CSS files. The library is required both for basic use with CSS themes and for compiling custom Sass themes.

**vaadin-sass-compiler-1.x.x.jar**

The Vaadin Sass Compiler compiles Sass themes to CSS, as described in Section 7.3, “Syntactically Awesome Stylesheets (Sass)”. It requires the `vaadin-themes-7.x.x.jar` library, which contains the Sass sources for the built-in themes. The library needs to be included in deployment in development mode to allow on-the-fly compilation of themes, but it is not needed in production deployment, when the themes are compiled before deployment.

Some of the libraries depend on each other as well as on the dependency libraries provided in the `lib` folder of the installation package, especially the `lib/vaadin-shared-deps.jar`.

The different ways to install the libraries are described in the subsequent sections.

Note that the `vaadin-client-compiler` and `vaadin-client` JARs should not be deployed with the web application by including them in `WEB-INF/lib`. Some other libraries, such as `vaadin-sass-compiler`, are not needed in production deployment.

## 2.4. Installing Vaadin Plugin for Eclipse

If you are using the Eclipse IDE, using the Vaadin Plugin for Eclipse helps greatly. Notice that you can also create Vaadin projects as Maven projects in Eclipse.

The plugin includes:

- *Wizards* for creating new Vaadin-based projects, themes, and client-side widgets and widget sets.
- A *visual editor* for creating composite user interface components in a WYSIWYG fashion. With full round-trip support from source code to visual model and back, the editor integrates seamlessly with your development process.

### 2.4.1. Installing the IvyDE Plugin

The Vaadin Plugin for Eclipse requires the Apache IvyDE plugin, which needs to be installed manually in Eclipse before the Vaadin plugin.

1. Select **Help Install New Software....**

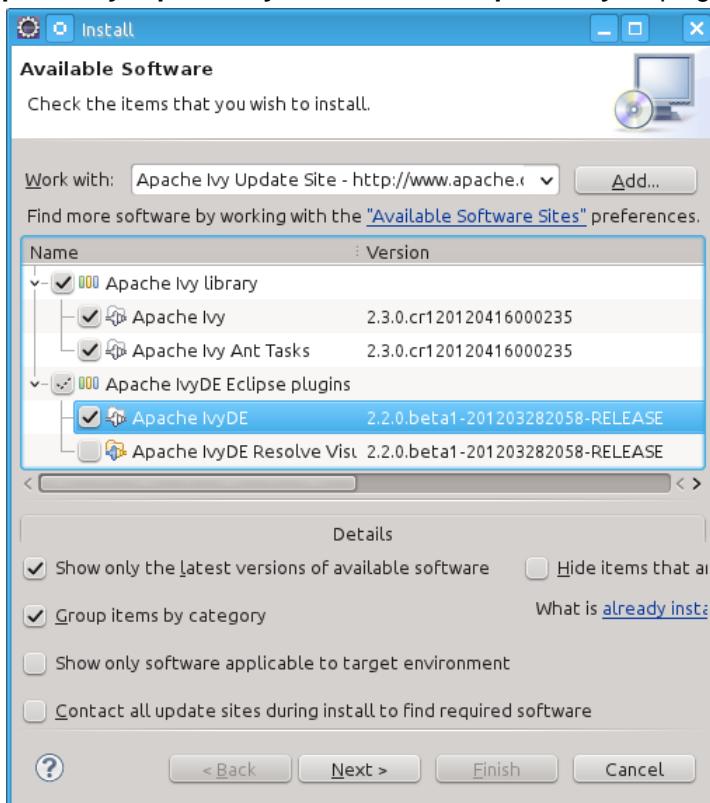
2. Add the IvyDE update site by clicking the **Add...** button.

Enter a name such as "Apache Ivy Update Site" and the URL of the update site:

`http://www.apache.org/dist/ant/ivyde/updatesite`

Then click **OK**. The update site should now appear in the **Available Software** window.

3. Select the new "Apache Ivy Update Site" from the **Work with** list.
4. Select the **Apache Ivy**, **Apache Ivy Ant Tasks**, and **Apache IvyDE** plugins.



The **Apache IvyDE Resolve Visualizer** is optional, and would require additional dependency plugins to be installed.

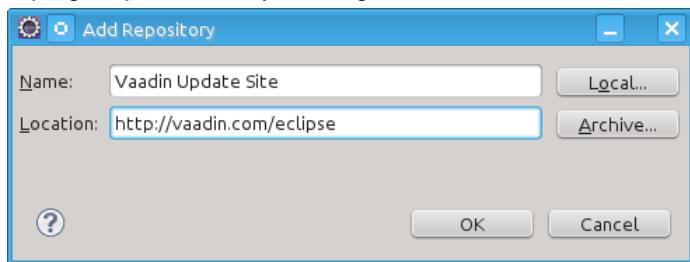
Then, click **Next**.

5. Review the installation details and click **Next**.
6. Accept or unaccept the license. Finally, click **Finish**.
7. Eclipse may warn about unsigned content. If you feel safe, click **OK**.
8. After the plugin is installed, Eclipse will ask to restart itself. You can proceed to install the Vaadin plugin before the restart, as described in the following section, so you can answer **Apply Changes Now**.

## 2.4.2. Installing the Vaadin Plugin

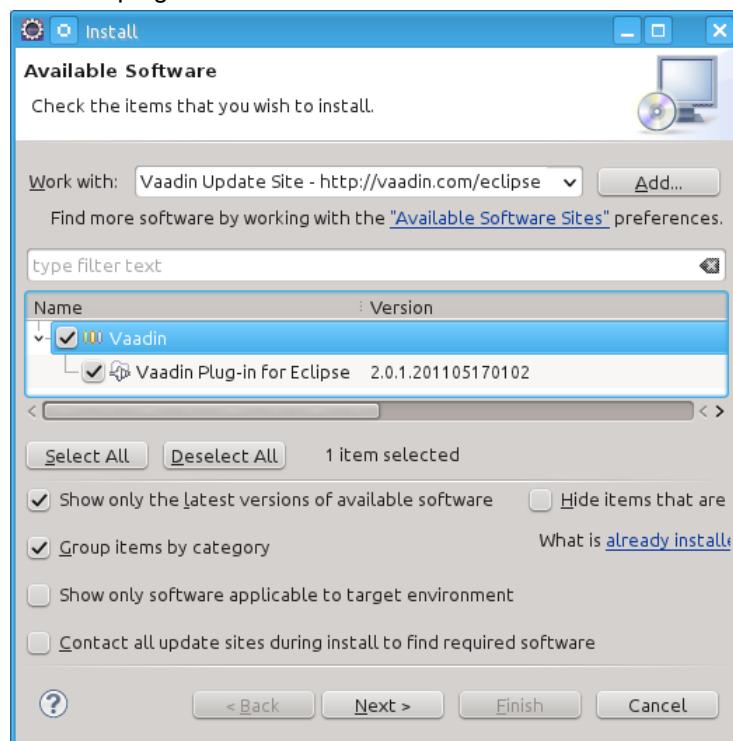
You can install the plugin as follows:

1. Select **Help Install New Software....**
2. Add the Vaadin plugin update site by clicking **Add...** button.



Enter a name such as "Vaadin Update Site" and the URL of the update site: `http://vaadin.com/eclipse`. If you want or need to use the latest unstable plugin, which is usually more compatible with development and beta releases of Vaadin, you can use `http://vaadin.com/eclipse/experimental` and give it a distinctive name such as "Vaadin Experimental Site". Then click **OK**. The Vaadin site should now appear in the **Available Software** window.

3. Currently, if using the stable plugin, the **Group items by category** should be enabled. If using the experimental plugin, it should be disabled. This may change in future.
4. Select all the Vaadin plugins in the tree.



Then, click **Next**.

5. Review the installation details and click **Next**.
6. Accept or unaccept the license. Finally, click **Finish**.
7. After the plugin is installed, Eclipse will ask to restart itself. Click **Restart**.

If you use the visual editor, Eclipse must have the internal browser enabled. Most operating system distributions include a suitable browser engine, but if not, you may need to install one as described in Chapter 10, *Visual User Interface Design with Eclipse*.

More installation instructions for the Eclipse plugin can be found at <http://vaadin.com/eclipse>.

### 2.4.3. Updating the Plugins

If you have automatic updates enabled in Eclipse (see **Window Preferences Install/Update Automatic Updates**), the Vaadin plugin will be updated automatically along with other plugins. Otherwise, you can update the Vaadin plugin manually as follows:

1. Select **Help Check for Updates**. Eclipse will contact the update sites of the installed software.
2. After the updates are installed, Eclipse will ask to restart itself. Click **Restart**.

Notice that updating the Vaadin plugin updates only the plugin and *not* the Vaadin libraries, which are project specific. See below for instructions for updating the libraries.

### 2.4.4. Updating the Vaadin Libraries

Updating the Vaadin plugin does not update Vaadin libraries. The libraries are project specific, as a different version might be required for different projects, so you have to update them separately for each project.

1. Open the `ivy.xml` in an editor Eclipse.
2. Edit the entity definition at the beginning of the file to set the Vaadin version.

```
<!ENTITY vaadin.version "7.3.1">
```

You can specify either a fixed version number, as shown in the above example, or a dynamic revision tag such as `latest.release`. You can find more information about the dependency declarations in Ivy documentation.

3. Right-click the project and select **Ivy Resolve**.

Updating the libraries can take several minutes. You can see the progress in the Eclipse status bar. You can get more details about the progress by clicking the indicator.

4. If you have compiled the widget set for your project, recompile it by clicking the **Compile Vaadin widgets** button in Eclipse toolbar.
5. Stop the integrated Tomcat (or other server) in Eclipse, clear its caches by right-clicking the server and selecting **Clean** as well as **Clean Tomcat Work Directory**, and restart it.

If you experience problems after updating the libraries, you can try clearing the Ivy resolution caches by right-clicking the project and selecting **Ivy Clean all caches**. Then, do the **Ivy Resolve** and other tasks again.

## 2.5. Creating and Running a Project with Eclipse

This section gives instructions for creating a new Eclipse project using the Vaadin Plugin. The task will include the following steps:

1. Create a new project
2. Write the source code
3. Configure and start Tomcat (or some other web server)
4. Open a web browser to use the web application

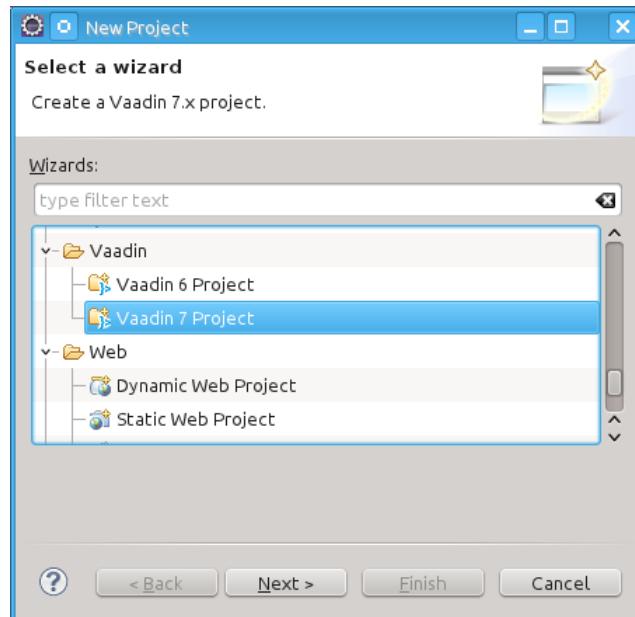
We also show how you can debug the application in the debug mode in Eclipse.

This walkthrough assumes that you have already installed the Vaadin Plugin for Eclipse and set up your development environment, as instructed in Section 2.2, “Setting up the Development Environment”.

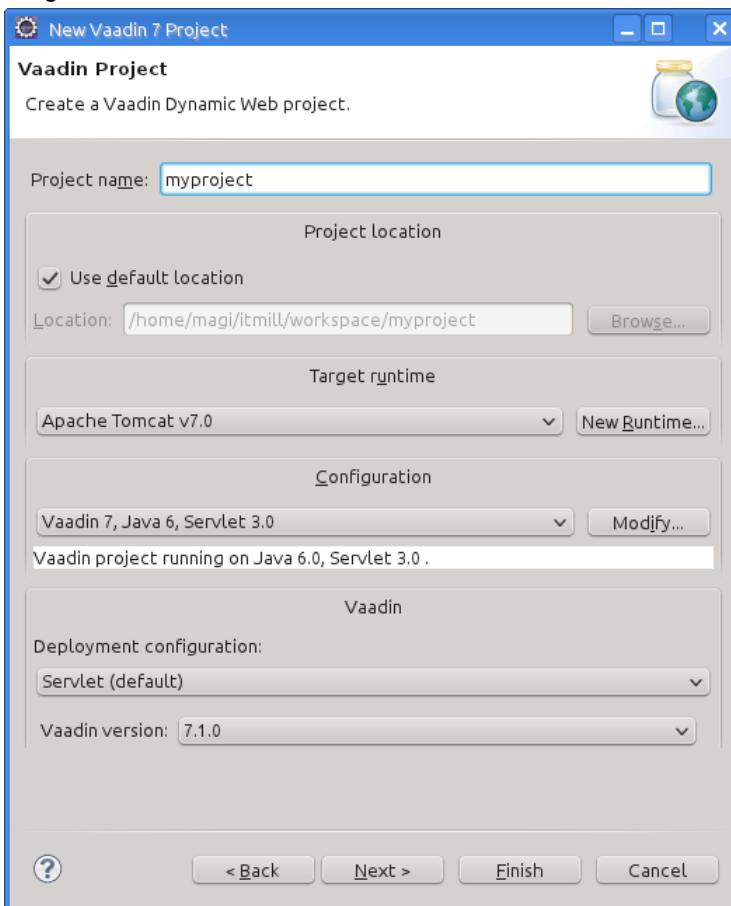
### 2.5.1. Creating the Project

Let us create the first application project with the tools installed in the previous section. First, launch Eclipse and follow the following steps:

1. Start creating a new project by selecting from the menu **File New Project...**
2. In the **New Project** window that opens, select **Web Vaadin 7 Project** and click **Next**.



3. In the **Vaadin Project** step, you need to set the basic web project settings. You need to give at least the *project name* and the runtime; the default values should be good for the other settings.



#### Project name

Give the project a name. The name should be a valid identifier usable cross-platform as a filename and inside a URL, so using only lower-case alphanumerics, underscore, and minus sign is recommended.

#### Use default location

Define the directory under which the project is created. The default is under your workspace folder, and you should normally leave it as it is. You may need to set the directory, for example, if you are creating an Eclipse project on top of a version-controlled source tree.

#### Target runtime

Define the application server to use for deploying the application. The server that you have installed, for example Apache Tomcat, should be selected automatically. If not, click **New** to configure a new server under Eclipse.

#### Configuration

Select the configuration to use; you should normally use the default configuration for the application server. If you need to modify the project facets, click **Modify**. The recommended Servlet 3.0 configuration uses the @WebServlet deployment, while Servlet 2.4 uses the old web.xml deployment.

### Deployment configuration

This setting defines the environment to which the application will be deployed, to generate the appropriate project directory layout and configuration files. The choices are:

- **Servlet** (default)
- **Google App Engine Servlet**
- **Generic Portlet (Portlet 2.0)**

The further steps in the New Project Wizard depend on the selected deployment configuration; the steps listed in this section are for the default servlet configuration. See Section 11.7, “Google App Engine Integration” and Chapter 12, *Portal Integration* for instructions regarding the use of Vaadin in the alternative environments.

### Vaadin version

Select the Vaadin version to use. The drop-down list shows, by default, the latest available version of Vaadin. The selection includes nightly **SNAPSHOT** builds, if you want to keep up with the absolutely latest unstable versions.

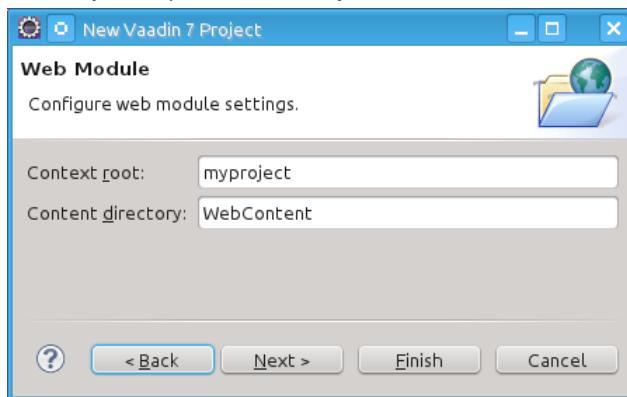
You can change the version later in the `ivy.xml`.

### Create TestBench test

When enabled, the application stub will include a test case for testing the UI with Vaadin TestBench, as described in Chapter 21, *Vaadin TestBench*. Vaadin TestBench API library will be included in `ivy.xml` as a dependency. Vaadin version 7.3 or later is required to create the stub.

You can click **Finish** here to use the defaults for the rest of the settings, or click **Next**.

4. The settings in the **Web Module** step define the basic web application (WAR) deployment settings and the structure of the web application project. All the settings are pre-filled, and you should normally accept them as they are.



### Context Root

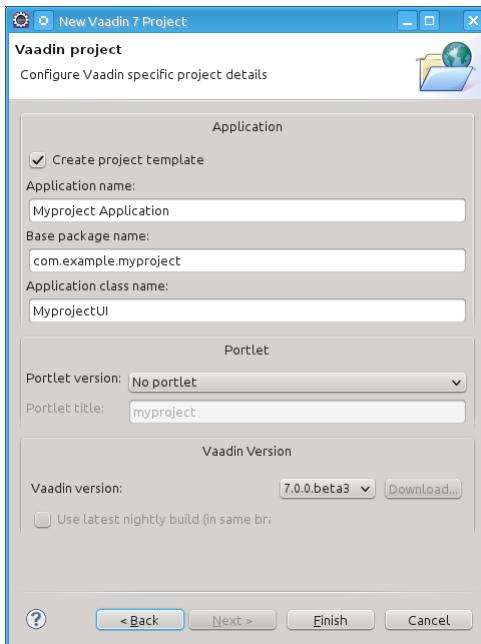
The context root (of the application) identifies the application in the URL used for accessing it. For example, if the project has a `myproject` context and a single UI at the context root, the URL would be `http://example.com/myproject`. The wizard will suggest the project name given in the first step as the context name. You can change the context root later in the Eclipse project properties.

### Content Directory

The directory containing all the content to be included in the web application (WAR) that is deployed to the web server. The directory is relative to the root directory of the project.

You can just accept the defaults and click **Next**.

5. The **Vaadin project** step page has various Vaadin-specific application settings. If you are trying out Vaadin for the first time, you should not need to change anything. You can set most of the settings afterwards, except the creation of the portlet configuration.



#### Create project template

Make the wizard create an UI class stub.

#### Application Name

A name for the application UI, shown in the title bar of the browser window.

#### Base package name

The name of the Java package under which the UI class of the application is to be placed.

#### Application/UI class name

The name of the UI class for the application, in which the user interface is developed.

#### Portlet version

When a portlet version is selected (only Portlet 2.0 is supported), the wizard will create the files needed for running the application in a portal. See Chapter 12, *Portal Integration* for more information on portlets.

Finally, click **Finish** to create the project.

## 2.5.2. Exploring the Project

After the **New Project** wizard exits, it has done all the work for you: an UI class skeleton has been written to `src` directory and the `WebContent/WEB-INF/web.xml` contains a deployment descriptor. The project hierarchy shown in the Project Explorer is shown in Figure 2.3, “A New Vaadin Project”.

The Vaadin libraries and other dependencies are managed by Ivy. Notice that the libraries are not stored under the project folder, even though they are listed in the **Java Resources Libraries ivy.xml** virtual folder.

### The UI Class

The UI class created by the plugin contains the following code:

```
package com.example.myproject;

import com.vaadin.ui.UI;
...

@SuppressWarnings("serial")
@Theme("myproject")
public class MyprojectUI extends UI {

    @WebServlet(value = "/*", asyncSupported = true)
    @VaadinServletConfiguration(
        productionMode = false,
        ui = MyprojectUI.class)
    public static class Servlet extends VaadinServlet {
    }

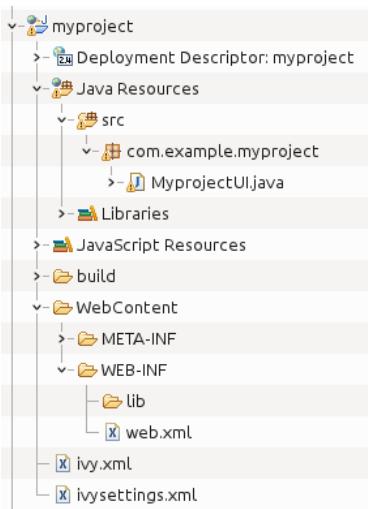
    @Override
    protected void init(VaadinRequest request) {
        final VerticalLayout layout = new VerticalLayout();
        layout.setMargin(true);
        setContent(layout);

        Button button = new Button("Click Me");
        button.addClickListener(new Button.ClickListener() {
            public void buttonClick(ClickEvent event) {
                layout.addComponent(
                    new Label("Thank you for clicking"));
            }
        });
        layout.addComponent(button);
    }
}
```

In a Servlet 3.0 project, the deployment is configured with servlet class and a `@WebServlet` annotation. The stub includes the servlet class as a static inner class. You may want to refactor it to a separate normal class.

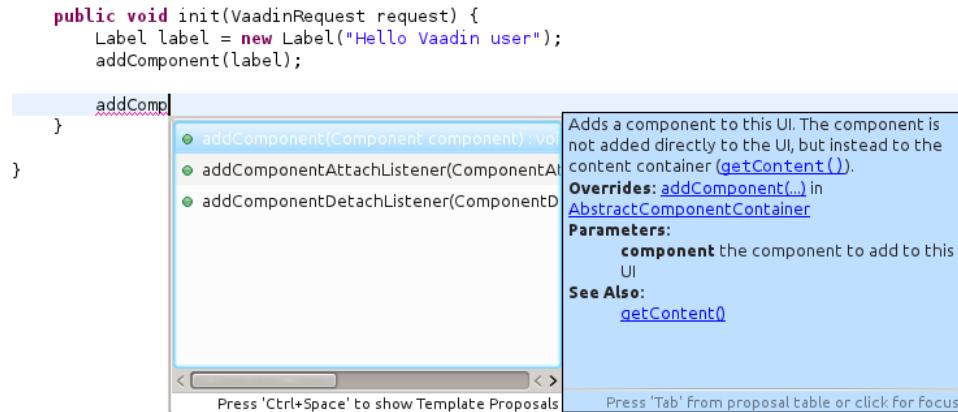
In a Servlet 2.3 project, you would have a `web.xml` deployment descriptor.

For a more detailed treatment of the deployment, see Section 4.8.4, “Using a `web.xml` Deployment Descriptor”.

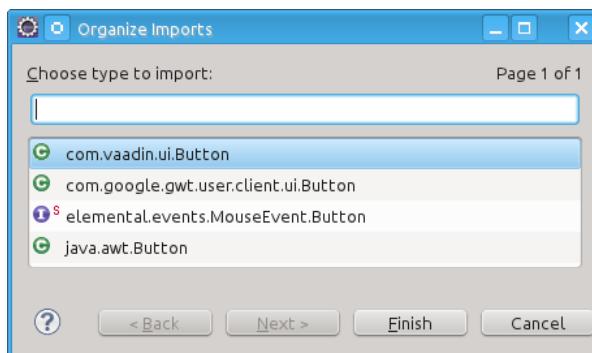
**Figure 2.3. A New Vaadin Project**

### 2.5.3. Coding Tips for Eclipse

One of the most useful features in Eclipse is *code completion*. Pressing **Ctrl+Space** in the editor will display a popup list of possible class name and method name completions, as shown in Figure 2.4, “Java Code Completion in Eclipse”, depending on the context of the cursor position.

**Figure 2.4. Java Code Completion in Eclipse**

To add an `import` statement for a class, such as `Button`, simply press **Ctrl+Shift+O** or click the red error indicator on the left side of the editor window. If the class is available in multiple packages, a list of the alternatives is displayed, as shown in Figure 2.5, “Importing Classes Automatically”. For server-side development, you should normally use the classes under the `com.vaadin.ui` or `com.vaadin.server` packages. You can not use client-side classes (under `com.vaadin.client`) or GWT classes for server-side development.

**Figure 2.5. Importing Classes Automatically**

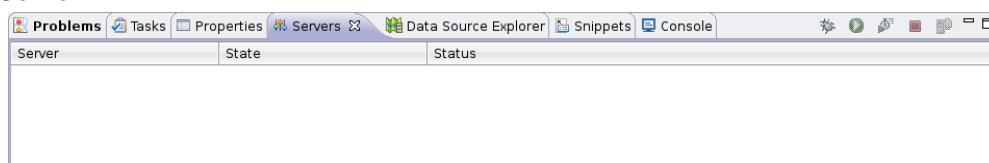
## 2.5.4. Setting Up and Starting the Web Server

Eclipse IDE for Java EE Developers has the Web Standard Tools package installed, which supports control of various web servers and automatic deployment of web content to the server when changes are made to a project.

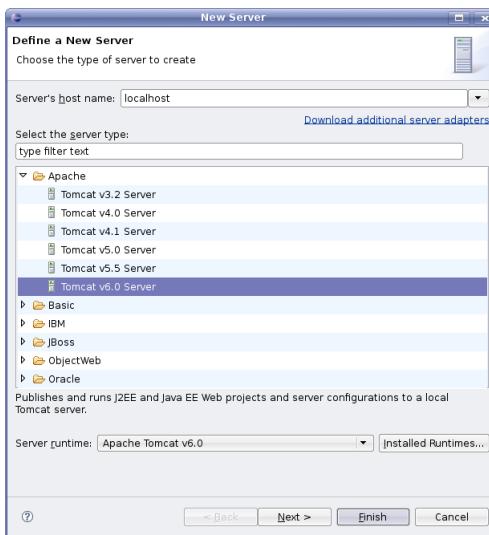
Make sure that Tomcat was installed with user permissions. Configuration of the web server in Eclipse will fail if the user does not have write permissions to the configuration and deployment directories under the Tomcat installation directory.

Follow the following steps.

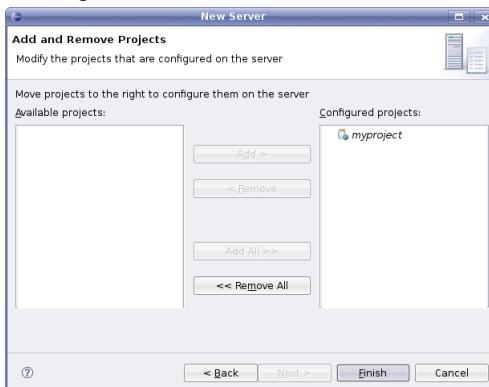
1. Switch to the **Servers** tab in the lower panel in Eclipse. List of servers should be empty after Eclipse is installed. Right-click on the empty area in the panel and select **New Server**.



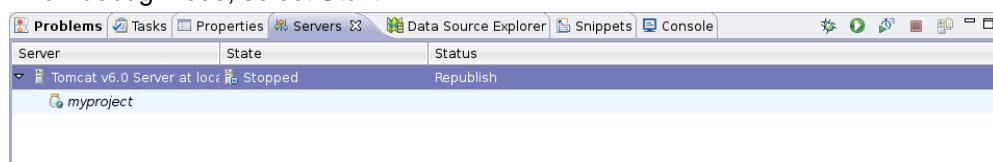
2. Select **Apache Tomcat v7.0 Server** and set **Server's host name** as **localhost**, which should be the default. If you have only one Tomcat installed, **Server runtime** has only one choice. Click **Next**.



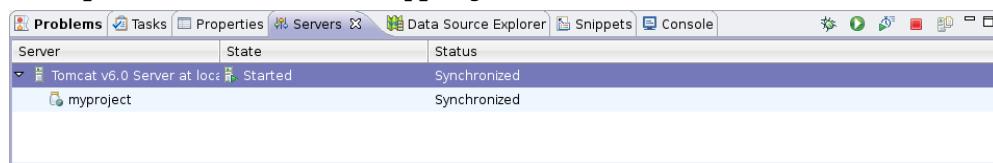
3. Add your project to the server by selecting it on the left and clicking **Add** to add it to the configured projects on the right. Click **Finish**.



4. The server and the project are now installed in Eclipse and are shown in the **Servers** tab. To start the server, right-click on the server and select **Debug**. To start the server in non-debug mode, select **Start**.



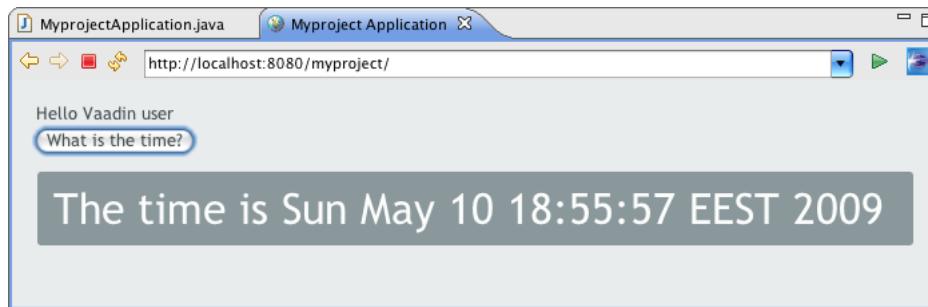
5. The server starts and the WebContent directory of the project is published to the server on <http://localhost:8080/myproject/>.



## 2.5.5. Running and Debugging

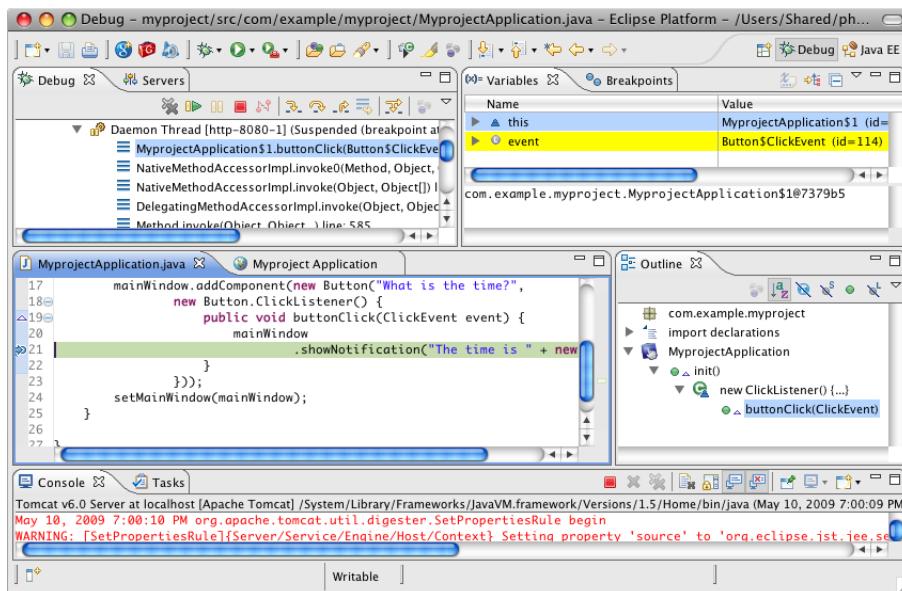
Starting your application is as easy as selecting **myproject** from the **Project Explorer** and then **Run Debug As Debug on Server**. Eclipse then opens the application in built-in web browser.

**Figure 2.6. Running a Vaadin Application**



You can insert break points in the Java code by double-clicking on the left margin bar of the source code window. For example, if you insert a breakpoint in the `buttonClick()` method and click the **What is the time?** button, Eclipse will ask to switch to the Debug perspective. Debug perspective will show where the execution stopped at the breakpoint. You can examine and change the state of the application. To continue execution, select **Resume** from **Run** menu.

**Figure 2.7. Debugging a Vaadin Application**



Above, we described how to debug a server-side application. Debugging client-side applications and widgets is described in Section 13.6, “Debugging Client-Side Code”.

## 2.6. Using Vaadin with Maven

Maven is a commonly used build and dependency management system. The Vaadin core library and all Vaadin add-ons are available through Maven. You can use a Maven with a front-end from Eclipse or NetBeans, or by using the command-line as described in this section.

In addition to regular Maven, you can use any Maven-compatible build or dependency management system, such as Ivy or Gradle. For Gradle, see the Gradle Vaadin Plugin. Vaadin Plugin for Eclipse uses Ivy for resolving dependencies in Vaadin projects, and it should provide you with the basic Ivy configuration.

## 2.6.1. Working from Command-Line

You can create a new Maven project with the following command (given in one line):

```
$ mvn archetype:generate  
  -DarchetypeGroupId=com.vaadin  
  -DarchetypeArtifactId=vaadin-archetype-application  
  -DarchetypeVersion=7.x.x  
  -DgroupId=your.company  
  -DartifactId=project-name  
  -Dversion=1.0  
  -Dpackaging=war
```

The parameters are as follows:

*archetypeGroupId*

The group ID of the archetype is com.vaadin for Vaadin archetypes.

*archetypeArtifactId*

The archetype ID. Vaadin 7 currently supports vaadin-archetype-application archetype for server-side applications and vaadin-archetype-widget for client-side widget development projects.

*archetypeVersion*

Version of the archetype to use. This should be LATEST for normal Vaadin releases. For prerelease versions it should be the exact version number, such as 7.3.1.

*groupId*

A Maven group ID for your project. It is normally your organization domain name in reverse order, such as com.example. The group ID is also used as a prefix for the Java package in the sources, so it should be Java compatible - only alphanumerics and an underscore.

*artifactId*

Identifier of the artifact, that is, your project. The identifier may contain alphanumerics, minus, and underscore. It is appended to the group ID to obtain the Java package name for the sources. For example, if the group ID is com.example and artifact ID is myproject, the project sources would be placed in com.example.myproject package.

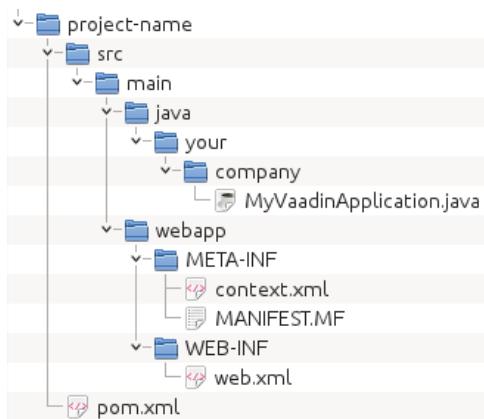
*version*

Initial version number of your application. The number must obey the Maven version numbering format.

*packaging*

How will the project be packaged. It is normally war.

Creating a project can take a while as Maven fetches all the dependencies. The created project structure is shown in Figure 2.8, “A New Vaadin Project with Maven”.

**Figure 2.8. A New Vaadin Project with Maven**

## 2.6.2. Compiling and Running the Application

Before the application can be deployed, it must be compiled and packaged as a WAR package. You can do this with the `package` goal as follows:

```
$ mvn package
```

The location of the resulting WAR package should be displayed in the command output. You can then deploy it to your favorite application server.

The easiest way to run Vaadin applications with Maven is to use the light-weight Jetty web server. After compiling the package, all you need to do is type:

```
$ mvn jetty:run
```

The special goal starts the Jetty server in port 8080 and deploys the application. You can then open it in a web browser at `http://localhost:8080/project-name`.

## 2.6.3. Using Add-ons and Custom Widget Sets

If you use Vaadin add-ons that include a widget set or make your custom widgets, you need to enable widget set compilation in the POM. The required configuration is described in Section 17.4, “Using Add-ons in a Maven Project”.

## 2.7. Creating a Project with NetBeans IDE

The easiest way to develop Vaadin application with the NetBeans IDE is to use the Vaadin Plugin for NetBeans. It allows you to create new Vaadin projects easily and provides many features for working on a project. You can download the plugin at <http://plugins.netbeans.org/plugin/50531/vaadin-plug-in-for-netbeans>. The download page contains a link to a plugin features overview in NetBeans Wiki.

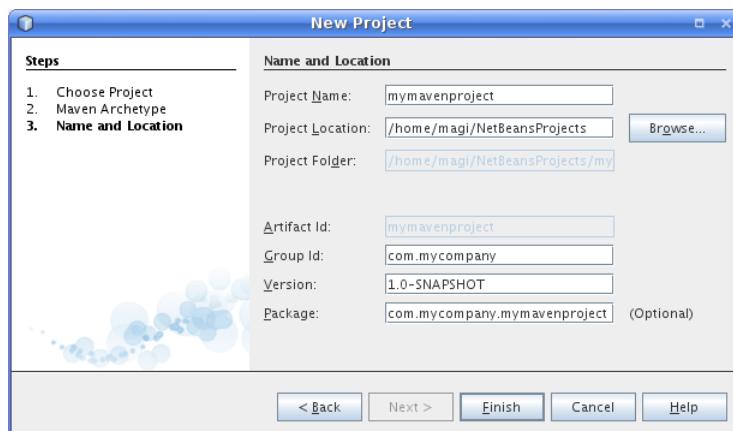
Without the plugin, you can most easily create a Vaadin project as a Maven project using a Vaadin archetype. You can also create a Vaadin project as a regular web application project, but it requires many manual steps to install all the Vaadin libraries, create the UI class, configure the servlet, create theme, and so on.

## 2.7.1. Maven Project from a Vaadin Archetype

Creating a Maven project with a Vaadin archetype creates an application skeleton with a UI class and project theme, defines the `web.xml` deployment descriptor, and also retrieves the latest Vaadin library automatically.

1. Select **File New Project**.
2. Select **Maven Project from Archetype** and click **Next**.
3. Find `vaadin-archetype-application`, select it, and click **Next**.
4. In the **Name and Location** step, enter **Project Name**, which is recommended to be only lower-case alphabets, as it is used also as a suggestion for the Java package name of the project. Modify the other parameters for your project and click **Finish**.

**Figure 2.9. Adding a New Maven Project in NetBeans**



Creating the project can take a while as Maven loads all the needed dependencies. Once created, you can run it by right-clicking on the project in the **Projects** view and selecting **Run**. In the **Select deployment server** window that opens, select **Glassfish** or **Apache Tomcat**, and click **OK**. If all goes well, NetBeans starts the server in port 8080 and, depending on your system configuration, launches the default browser to display the web application. If not, you can open it manually, for example, at `http://localhost:8080/myproject`. The project name is used by default as the context path of the application.

## 2.8. Creating a Project with IntelliJ IDEA

The Ultimate Edition of IntelliJ IDEA includes support for creating Vaadin applications and running or debugging them in an integrated application server. With the Community Edition, you can create a Vaadin application most easily with a Maven archetype and deploy it to a server with a Maven run/debug configuration.

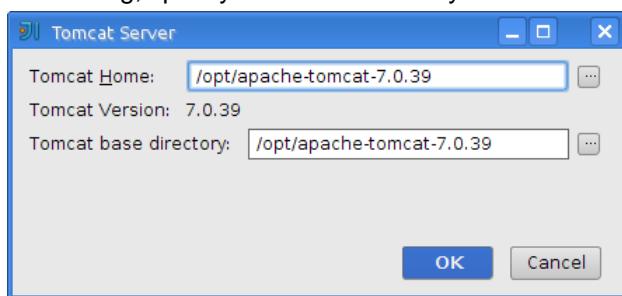
For more information, see the article "Creating a simple Web application and deploying it to Tomcat" in the IntelliJ IDEA Encyclopedia wiki.

## 2.8.1. Configuring an Application Server

To run the application during development in the Ultimate Edition of IntelliJ IDEA, you first need to install and configure an application server that is integrated with the IDE. The edition includes integration with many commonly used application servers.

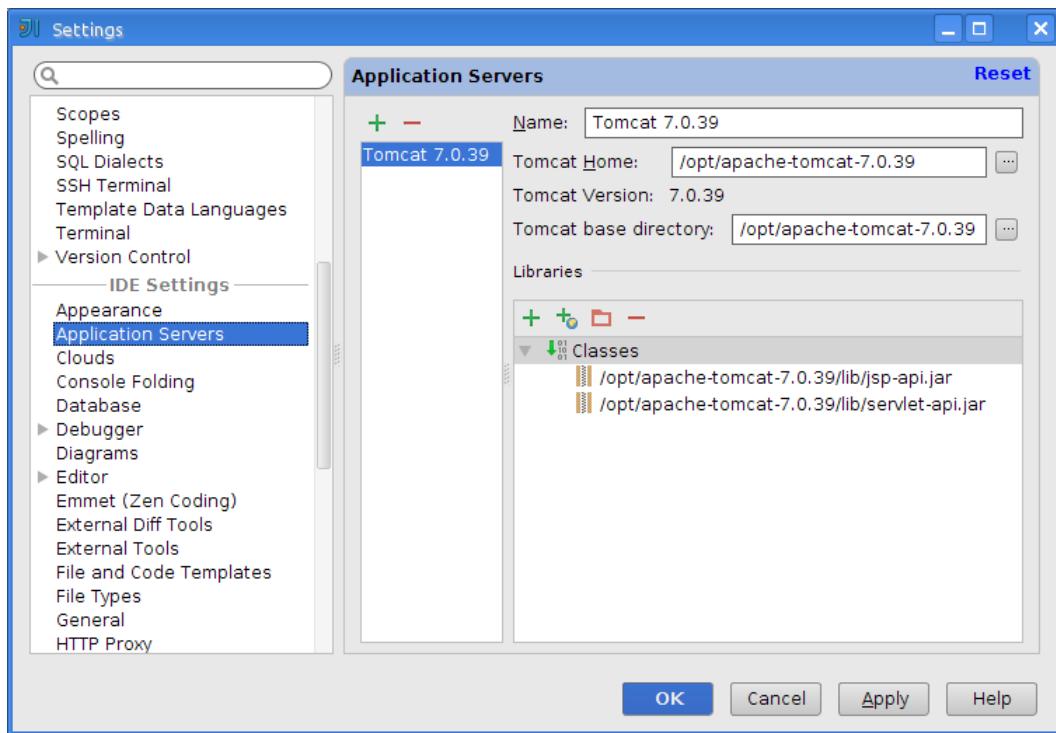
In the following, we configure Apache Tomcat:

1. Download and extract Tomcat installation package to a local directory, as instructed in Section 2.2.3, “Installing Apache Tomcat”.
2. Select **Configure Settings**.
3. Select **IDE Settings Application Servers**.
4. Select **+** **Tomcat Server** to add a Tomcat server, or any of the other supported servers. A WebSocket-enabled server, such as Glassfish or TomEE, is required for server push.
5. In the Tomcat Server dialog, specify the home directory for the server.



Click **OK**.

6. Review the application server settings page to check that it is OK.



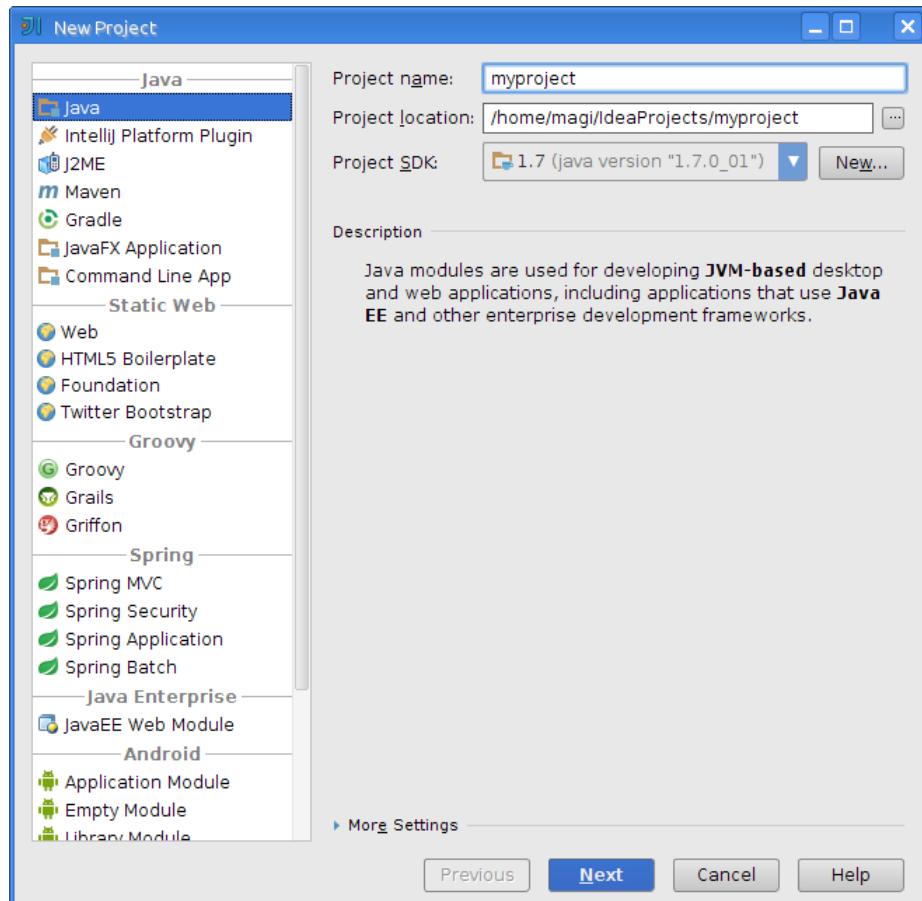
Then, click **OK**.

## 2.8.2. Creating a Vaadin Web Application Project

In the welcome page, do the following:

1. Download and extract the Vaadin installation package to a local folder, as instructed in Section 2.9, “Vaadin Installation Package”.
2. **Select New Project**
3. In the **New Project** window, select **Java**

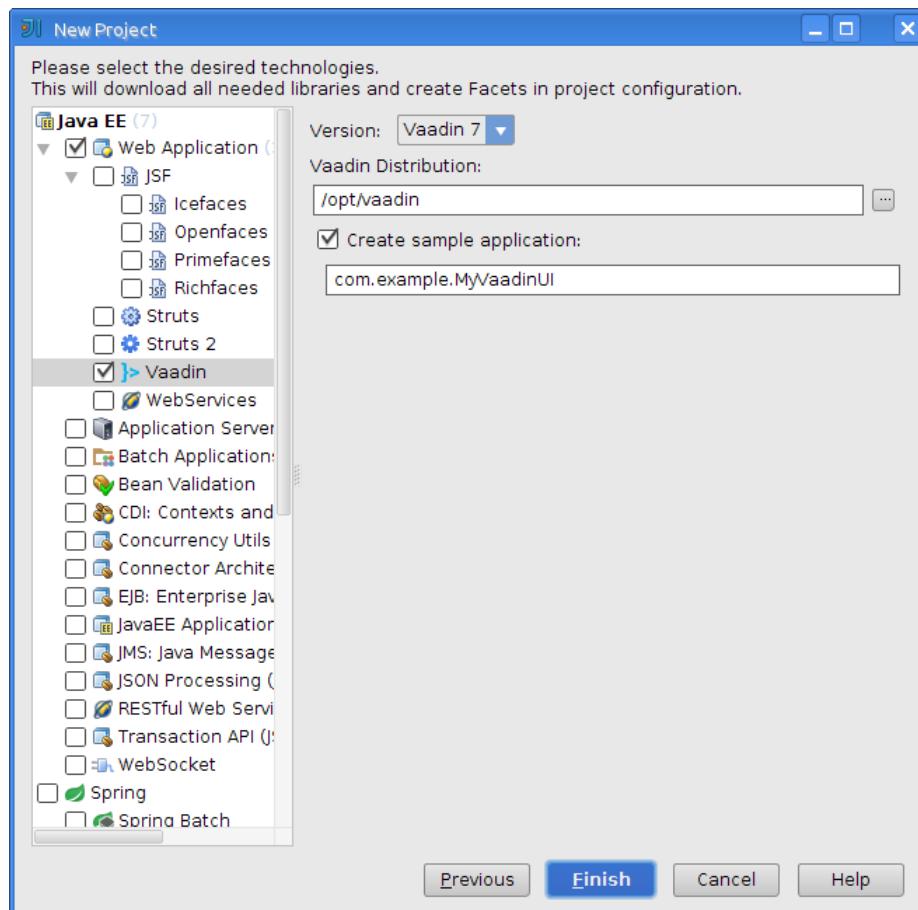
4. Enter a **Project name** and **Project location**, and select the **Java SDK** to be used for the project. Vaadin requires at least Java 6. If you have not configured a Java SDK previously, you can configure it here.



Click **Next**.

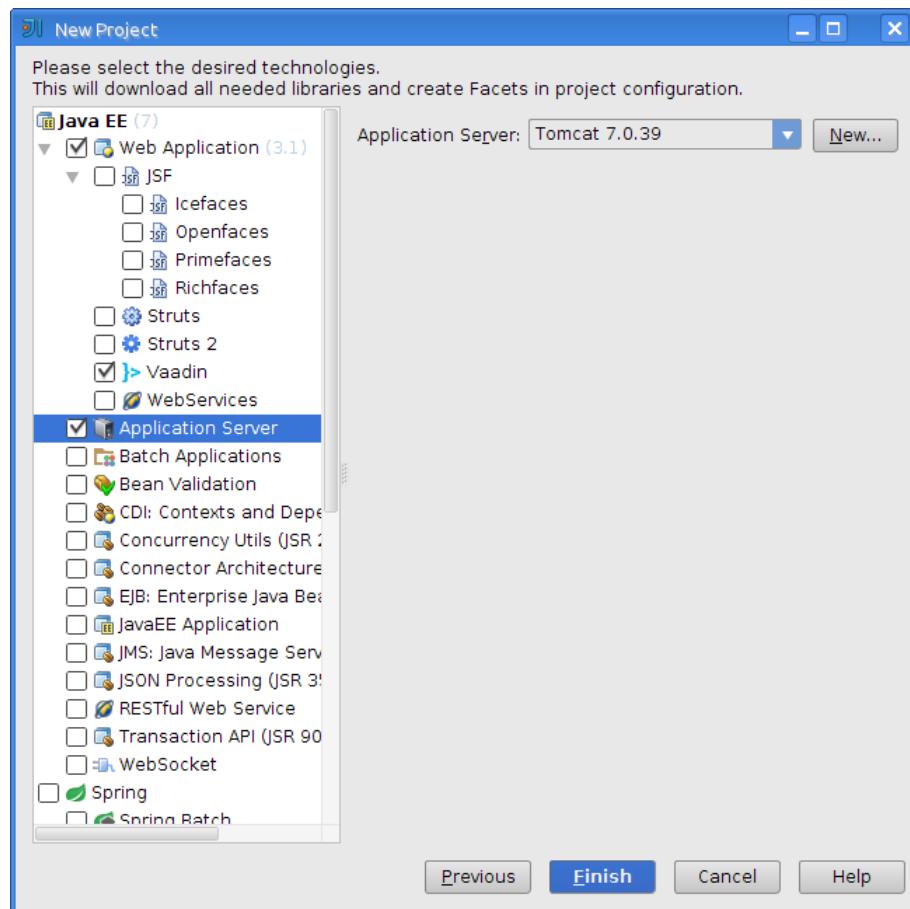
5. Select **Web Application Vaadin** to add Vaadin technology to the project.

6. Select **Vaadin Version** and **Distribution** installation path. You probably also want an application stub, so select **Create sample application** and give a name for the generated UI class.



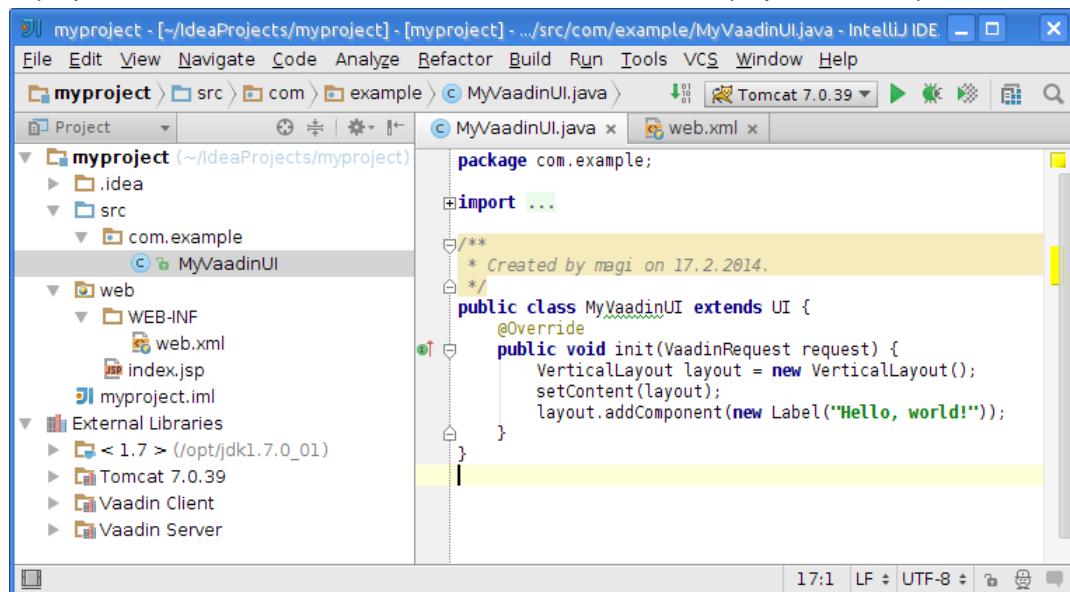
Do not click **Finish** yet.

7. Select **Application Server** in the same window. Set it as an integrated server that you have configured in IntelliJ IDEA, as described previously in Section 2.8.1, “Configuring an Application Server”.



### 8. Click **Finish**.

The project is created with the UI class stub and a `web.xml` deployment descriptor.



The wizard does not currently create a servlet class automatically, and uses Servlet 2.4 compatible deployment with a `web.xml` deployment descriptor.

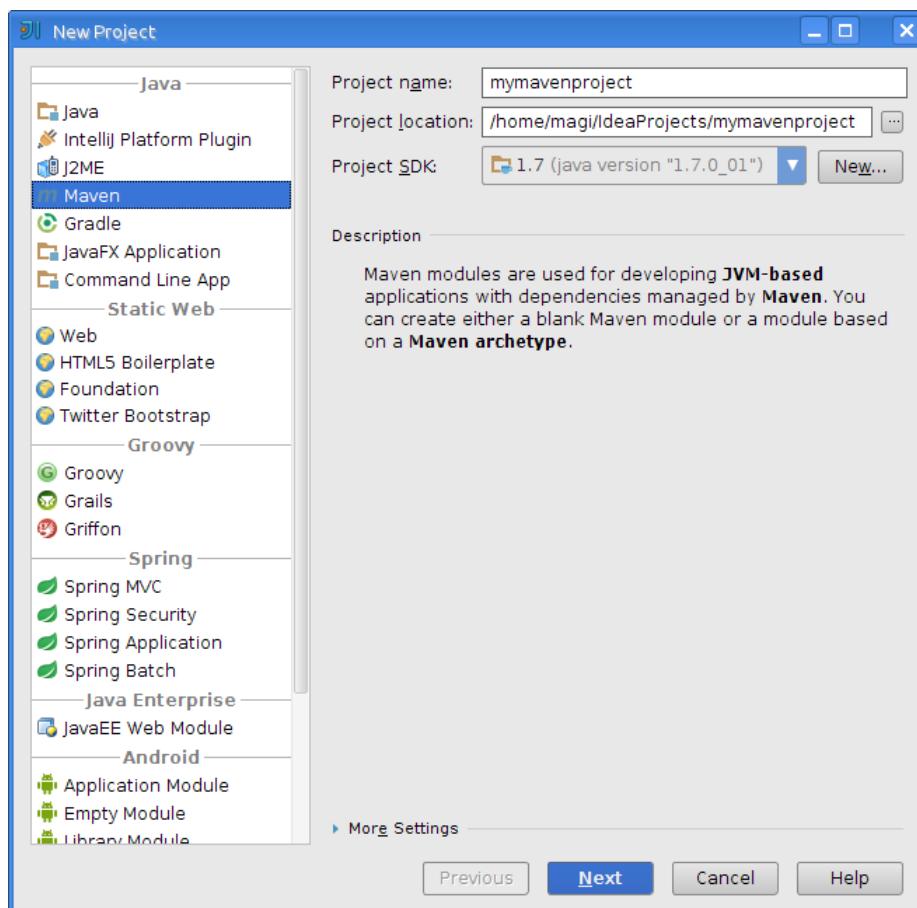
## Deploying the Project

To deploy the application to the integrated web server, right-click the `index.jsp` file in the project and select **Run 'index.jsp'**. This starts the integrated server, if it was not already running, and launches the default browser with the application page.

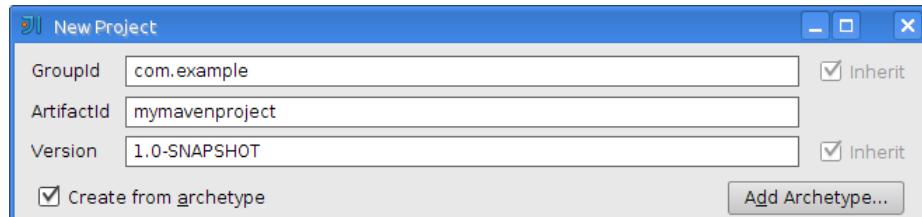
### 2.8.3. Creating a Maven Project

You can choose to create a Maven project in IntelliJ IDEA. This is the recommended way when using the Community Edition. You will not have the application server integration, but can deploy the application to an application server using a run/debug configuration.

1. Select **New Project**
2. In the **New Project** window, select **Maven**
3. Enter a project name, location, and the Java SDK to be used for the project. Vaadin requires at least Java 6. Click **Next**.

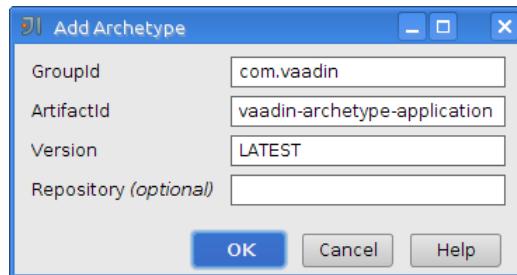


4. Give a Maven **GroupId**, **ArtifactId**, and a **Version** for the project, or use the defaults.



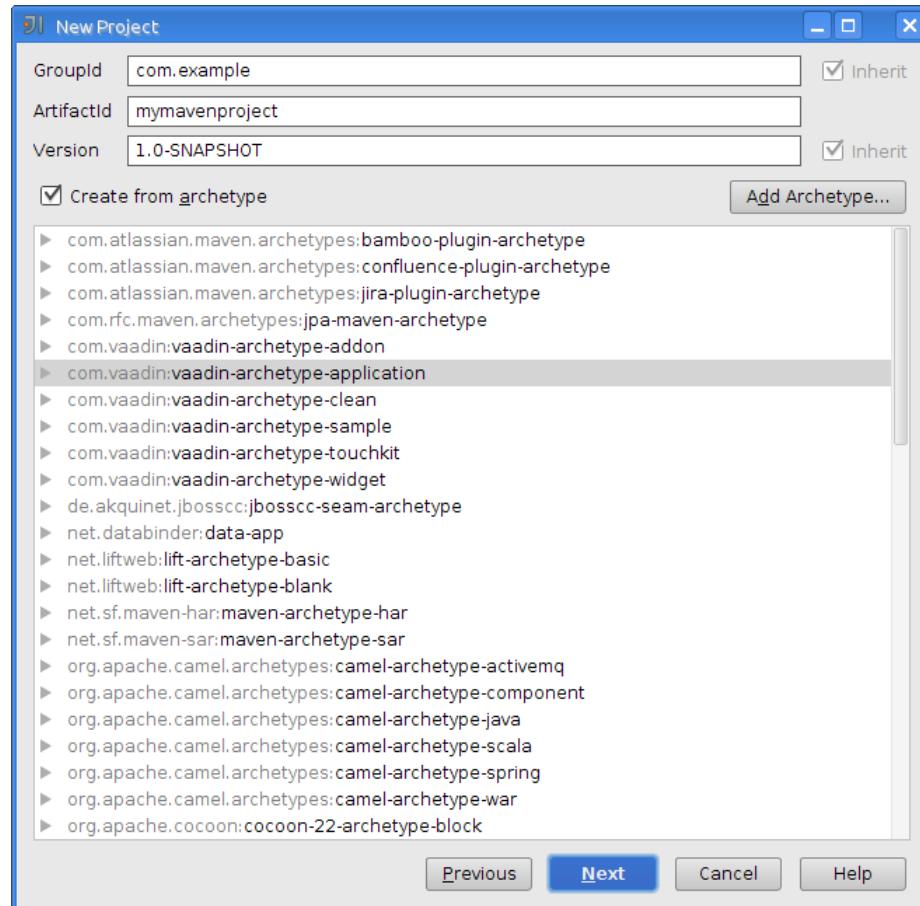
5. Check **Create from archetype**

6. If the Vaadin archetype is not in the list, click **Add archetype**, enter **GroupId** com.vaadin, **ArtifactId** vaadin-archetype-application, and **Version** LATEST (or a specific version number).



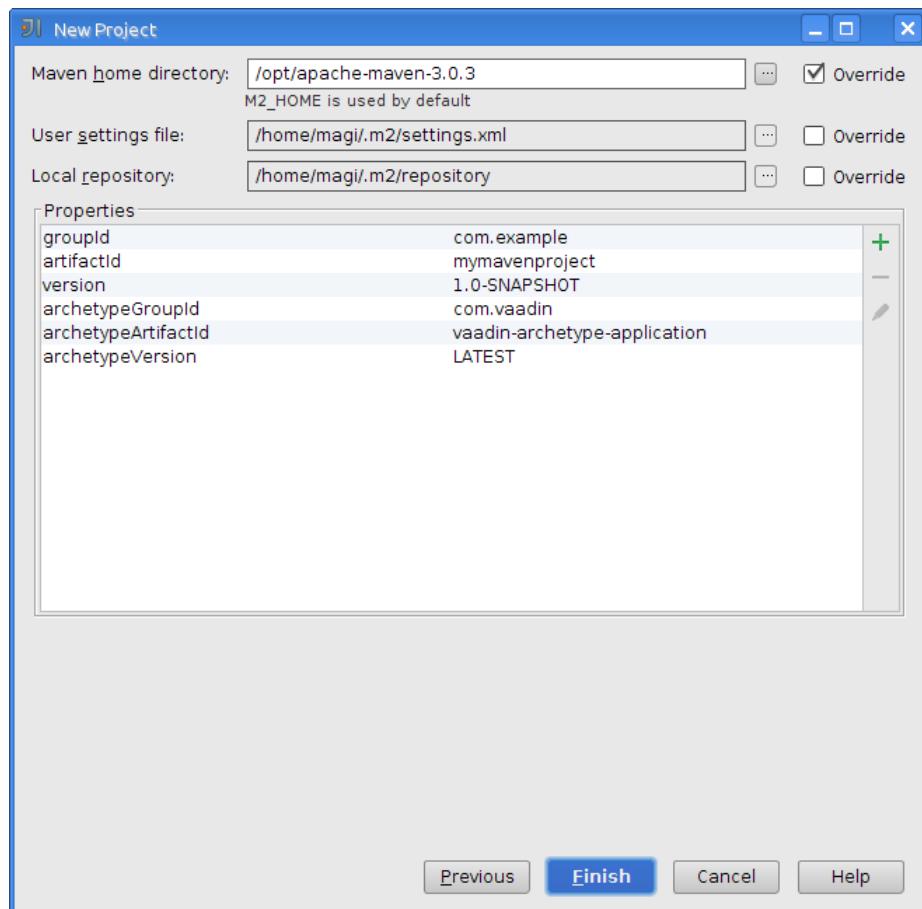
Click **OK** in the dialog.

7. Select the com.vaadin:vaadin-archetype-application.



Click **Next**.

8. Review the general Maven settings and settings for the new project. You may need to override the settings, especially if you are creating a Maven project for the first time.
- Click **Finish**.



Creating the Maven project takes some time as Maven fetches the dependencies. Once done, the project is created and the Maven POM is opened in the editor.

## Compiling the Project

To compile a Vaadin application using Maven, you can define a run/debug configuration to execute a goal such as `package` to build the deployable WAR package. It will also compile the widget set and theme, if necessary. See Section 2.6.2, “Compiling and Running the Application” for more details.

Compilation is included in the following instructions for deploying the application.

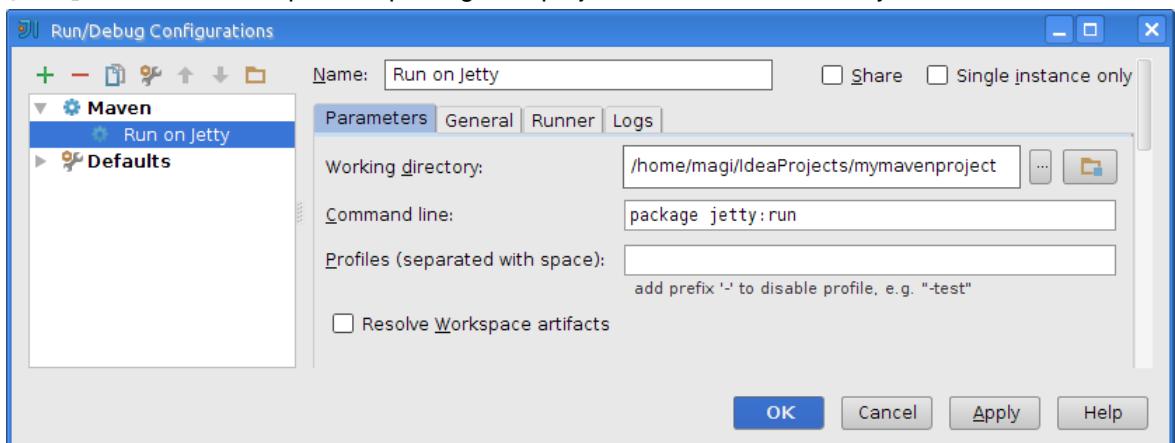
## Deploying to a Server

There exists Maven plugins for deploying to various application servers. For example, to deploy to Apache Tomcat, you can configure the `tomcat-maven-plugin` and then execute the `tomcat:deploy` goal. See the documentation of the plugin that you use for more details. If no Maven plugin exists for a particular server, you can always use some lower-level method to deploy the application, such as running an Ant task.

In the following, we create a run/debug configuration to build, deploy, and launch a Vaadin Maven application on the light-weight Jetty web server.

1. Select **Run Edit Configurations**.

2. Select **+** **Maven** to create a new Maven run/debug configuration.
3. Enter a **Name** for the run configuration. For the **Command line**, enter "package jetty:run" to first compile and package the project, and then launch Jetty to run it.



Click **OK**.

4. Select the run configuration in the toolbar and click the **Run** button beside it.



Compiling the project takes some time on the first time, as it compiles the widget set and theme. Once the run console pane informs that Jetty Server has been started, you can open the browser at the default URL `http://localhost:8080/`.

## 2.9. Vaadin Installation Package

While the recommended way to install Vaadin is to use the Eclipse plugin, one of the other IDE plugins, or a dependency management system, such as Maven, Vaadin is also available as a ZIP distribution package.

You can download the newest Vaadin installation package from the download page at <http://vaadin.com/download/>. Please use a ZIP decompression utility available in your operating system to extract the files from the ZIP package.

### 2.9.1. Package Contents

`README.TXT`

This Readme file gives simple instructions for installing Vaadin in your project.

`release-notes.html`

The Release Notes contain information about the new features in the particular release, give upgrade instructions, describe compatibility, etc. Please open the HTML file with a web browser.

`license.html`

Apache License version 2.0. Please open the HTML file with a web browser.

`lib` folder

All dependency libraries required by Vaadin are contained within the `lib` folder.

\*.jar

Vaadin libraries, as described in Section 2.3, “Overview of Vaadin Libraries”.

## 2.9.2. Installing the Libraries

You can install the Vaadin ZIP package in a few simple steps:

1. Copy the JAR files at the package root folder to the `WEB-APP/lib` web library folder in the project. Some of the libraries are optional, as explained in Section 2.3, “Overview of Vaadin Libraries”.
2. Also copy the dependency JAR files at the `lib` folder to the `WEB-APP/lib` web library folder in the project.

The location of the `WEB-APP/lib` folder depends on the project organization, which depends on the development environment.

- In Eclipse Dynamic Web Application projects: `WebContent/WEB-INF/lib`.
- In Maven projects: `src/main/webapp/WEB-INF/lib`.

## 2.10. Using Vaadin with Scala

You can use Vaadin with any JVM compatible language, such as Scala or Groovy. There are, however, some caveats related to libraries and project set-up. In the following, we give instructions for creating a Scala UI in Eclipse, with the Scala IDE for Eclipse and the Vaadin Plugin for Eclipse.

1. Install the Scala IDE for Eclipse, either from an Eclipse update site or as a bundled Eclipse distribution.
2. Open an existing Vaadin Java project or create a new one as outlined in Section 2.5, “Creating and Running a Project with Eclipse”. You can delete the UI class created by the wizard.
3. Switch to the Scala perspective by clicking the perspective in the upper-right corner of the Eclipse window.
4. Right-click on the project folder in **Project Explorer** and select **Configure Add Scala Nature**.
5. The web application needs `scala-library.jar` in its class path. If using Scala IDE, you can copy it from somewhere under your Eclipse installation to the class path of the web application, that is, either to the `WebContent/WEB-INF/lib` folder in the project or to the library path of the application server. If copying outside Eclipse to a project, refresh the project by selecting it and pressing **F5**.

You could also get it with an Ivy or Maven dependency, just make sure that the version is same as what the Scala IDE uses.

You should now be able to create a Scala UI class, such as the following:

```
@Theme( "mytheme" )
class MyScalaUI extends UI {
    override def init(request: VaadinRequest) = {
        val content: VerticalLayout = new VerticalLayout
        setContent(content)
    }
}
```

```
val label: Label = new Label("Hello, world!")
content.addComponent(label)

// Handle user interaction
content.addComponent(new Button("Click Me!",
    new ClickListener {
        override def buttonClick(event: ClickEvent) =
            Notification.show("The time is " + new Date)
    }
)
}
```

Eclipse and Scala IDE should be able to import the Vaadin classes automatically when you press **Ctrl+Shift+O**.

You need to define the Scala UI class either in a servlet class (in Servlet 3.0 project) or in a `web.xml` deployment descriptor, just like described in Section 2.5.2, “Exploring the Project” for Java UIs.

The Scaladin add-on enables a more Scala-like API for Vaadin. A Vaadin 7 compatible version is under development.

---

# Chapter 3

# Architecture

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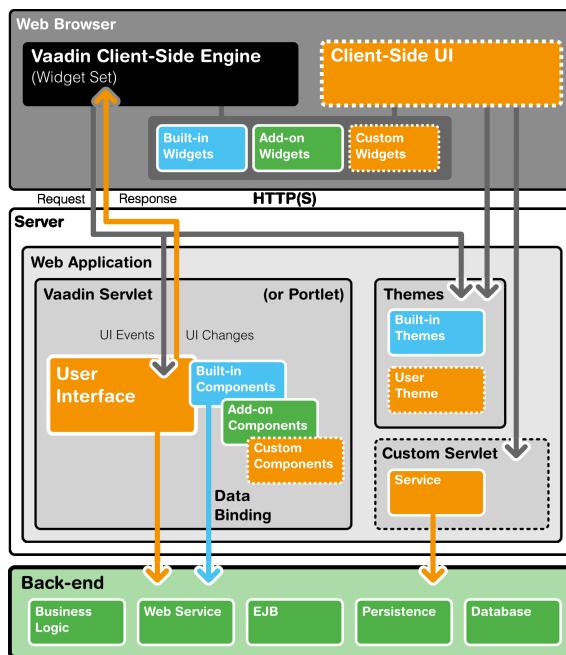
In Chapter 1, *Introduction*, we gave a short introduction to the general architecture of Vaadin. This chapter looks deeper into the architecture at a more technical level.

## 3.1. Overview

Vaadin provides two development models for web applications: for the client-side (the browser) and for the server-side. The server-driven development model is the more powerful one, allowing application development solely on the server-side, by utilizing an AJAX-based Vaadin Client-Side Engine that renders the user interface in the browser. The client-side model allows developing widgets and applications in Java, which are compiled to JavaScript and executed in the browser. The two models can share their UI widgets, themes, and back-end code and services, and can be mixed together easily.

Figure 3.1, “Vaadin Runtime Architecture” gives a basic illustration of the client-side and server-side communications, in a running situation where the page with the client-side code (engine or application) has been initially loaded in the browser.

Vaadin Framework consists of a *server-side API*, a *client-side API*, a horde of *user interface components/widgets* on the both sides, *themes* for controlling the appearance, and a *data model* that allows binding the server-side components directly to data. For client-side development, it includes the Vaadin Compiler, which allows compiling Java to JavaScript.

**Figure 3.1. Vaadin Runtime Architecture**

A server-side Vaadin application runs as a servlet in a Java web server, serving HTTP requests. The **VaadinServlet** is normally used as the servlet class. The servlet receives client requests and interprets them as events for a particular user session. Events are associated with user interface components and delivered to the event listeners defined in the application. If the UI logic makes changes to the server-side user interface components, the servlet renders them in the web browser by generating a response. The client-side engine running in the browser receives the responses and uses them to make any necessary changes to the page in the browser.

The major parts of the server-driven development architecture and their function are as follows:

#### User Interface

Vaadin applications provide a user interface for the user to interface with the business logic and data of the application. At technical level, the UI is realized as a **UI** class that extends **com.vaadin.ui.UI**. Its main task is to create the initial user interface out of UI components and set up event listeners to handle user input. The UI can then be loaded in the browser using an URL, or can be embedded to any HTML page. For detailed information about implementing a **UI**, see Chapter 4, *Writing a Server-Side Web Application*.

Please note that the term "UI" is used throughout this book to refer both to the general UI concept as well as the technical UI class concept.

#### User Interface Components/Widgets

The user interface of a Vaadin application consists of components that are created and laid out by the application. Each server-side component has a client-side counterpart, a "widget", by which it is rendered in the browser and with which the user interacts. The client-side widgets can also be used by client-side applications. The server-side components relay these events to the application logic. Field components that have a value, which the user can view or edit, can be bound to a data source (see below). For a more detailed description of the UI component architecture, see Chapter 5, *User Interface Components*.

### Client-Side Engine

The Client-Side Engine of Vaadin manages the rendering of the UI in the web browser by employing various client-side *widgets*, counterparts of the server-side components. It communicates user interaction to the server-side, and then again renders the changes in the UI. The communications are made using asynchronous HTTP or HTTPS requests. See Section 3.3, “Client-Side Engine”.

### Vaadin Servlet

Server-side Vaadin applications work on top of the Java Servlet API (see Section 3.2.5, “Java Servlets”). The Vaadin servlet, or more exactly the **VaadinServlet** class, receives requests from different clients, determines which user session they belong to by tracking the sessions with cookies, and delegates the requests to their corresponding sessions. You can customize the Vaadin servlet by extending it.

### Themes

Vaadin makes a separation between the appearance and component structure of the user interface. While the UI logic is handled as Java code, the presentation is defined in *themes* as CSS or Sass. Vaadin provides a number of default themes. User themes can, in addition to style sheets, include HTML templates that define custom layouts and other resources, such as images and fonts. Themes are discussed in detail in Chapter 7, *Themes*.

### Events

Interaction with user interface components creates events, which are first processed on the client-side by the widgets, then passed all the way through the HTTP server, Vaadin servlet, and the user interface components to the event listeners defined in the application. See Section 3.4, “Events and Listeners”.

### Server Push

In addition to the event-driven programming model, Vaadin supports server push, where the UI changes are pushed directly from the server to the client without a client request or an event. This makes it possible to update UIs immediately from other threads and other UIs, without having to wait for a request. See Section 11.16, “Server Push”.

### Data Binding

In addition to the user interface model, Vaadin provides a *data model* for binding data presented in field components, such as text fields, check boxes and selection components, to a data source. Using the data model, the user interface components can update the application data directly, often without the need for any control code. All the field components in Vaadin use this data model internally, but any of them can be bound to a separate data source as well. For example, you can bind a table component to an SQL query response. For a complete overview of the Vaadin Data Model, please refer to Chapter 8, *Binding Components to Data*.

### Client-Side Applications

In addition to server-side web applications, Vaadin supports client-side application modules, which run in the browser. Client-side modules can use the same widgets, themes, and back-end services as server-side Vaadin applications. They are useful when you have a need for highly responsive UI logic, such as for games or for serving a large number of clients with possibly stateless server-side code, and for various other purposes, such as offering an off-line mode for server-side applications. Please see Chapter 14, *Client-Side Applications* for further details.

### Back-end

Vaadin is meant for building user interfaces, and it is recommended that other application layers should be kept separate from the UI. The business logic can run in the same servlet as the UI code, usually separated at least by a Java API, possibly as EJBs, or distributed to a remote back-end service. The data storage is usually distributed to a database management system, and is typically accessed through a persistence solution, such as JPA.

## 3.2. Technological Background

This section provides an introduction to the various technologies and designs, which Vaadin is based on. This knowledge is not necessary for using Vaadin, but provides some background if you need to make low-level extensions to Vaadin.

### 3.2.1. HTML and JavaScript

The World Wide Web, with all its websites and most of the web applications, is based on the use of the Hypertext Markup Language (HTML). HTML defines the structure and formatting of web pages, and allows inclusion of graphics and other resources. It is based on a hierarchy of elements marked with start and end tags, such as `<div> ... </div>`. Vaadin uses HTML version 5, although conservatively, to the extent supported by the major browsers, and their currently most widely used versions.

JavaScript, on the other hand, is a programming language for embedding programs in HTML pages. JavaScript programs can manipulate a HTML page through the Document Object Model (DOM) of the page. They can also handle user interaction events. The Client-Side Engine of Vaadin and its client-side widgets do exactly this, although it is actually programmed in Java, which is compiled to JavaScript with the Vaadin Client Compiler.

Vaadin largely hides the use of HTML, allowing you to concentrate on the UI component structure and logic. In server-side development, the UI is developed in Java using UI components and rendered by the client-side engine as HTML, but it is possible to use HTML templates for defining the layout, as well as HTML formatting in many text elements. Also when developing client-side widgets and UIs, the built-in widgets in the framework hide most of HTML DOM manipulation.

### 3.2.2. Styling with CSS and Sass

While HTML defines the content and structure of a web page, *Cascading Style Sheet* (CSS) is a language for defining the visual style, such as colors, text sizes, and margins. CSS is based on a set of rules that are matched with the HTML structure by the browser. The properties defined in the rules determine the visual appearance of the matching HTML elements.

```
/* Define the color of labels in my view */
.myview .v-label {
    color: blue;
}
```

Sass, or *Syntactically Awesome Stylesheets*, is an extension of the CSS language, which allows the use of variables, nesting, and many other syntactic features that make the use of CSS easier and clearer. Sass has two alternative formats, SCSS, which is a superset of the syntax of CSS3, and an older indented syntax, which is more concise. The Vaadin Sass compiler supports the SCSS syntax.

Vaadin handles styling with *themes* defined with CSS or Sass, and associated images, fonts, and other resources. Vaadin themes are specifically written in Sass. In development mode, Sass files are compiled automatically to CSS. For production use, you compile the Sass files to CSS with the included compiler. The use of themes is documented in detail in Chapter 7, *Themes*, which also gives an introduction to CSS and Sass.

### 3.2.3. AJAX

AJAX, short for Asynchronous JavaScript and XML, is a technique for developing web applications with responsive user interaction, similar to traditional desktop applications. Conventional web applications, be they JavaScript-enabled or not, can get new page content from the server only by loading an entire new page. AJAX-enabled pages, on the other hand, handle the user interaction in JavaScript, send a request to the server asynchronously (without reloading the page), receive updated content in the response, and modify the page accordingly. This way, only small parts of the page data need to be loaded. This goal is achieved by the use of a certain set of technologies: HTML, CSS, DOM, JavaScript, and the XMLHttpRequest API in JavaScript. XML is just one way to serialize data between the client and the server, and in Vaadin it is serialized with the more efficient JSON.

The asynchronous requests used in AJAX are made possible by the `XMLHttpRequest` class in JavaScript. The API feature is available in all major browsers and is under way to become a W3C standard.

The communication of complex data between the browser and the server requires some sort of *serialization* (or *marshalling*) of data objects. The Vaadin servlet and the client-side engine handle the serialization of shared state objects from the server-side components to the client-side widgets, as well as serialization of RPC calls between the widgets and the server-side components.

### 3.2.4. Google Web Toolkit

The client-side framework of Vaadin is based on the Google Web Toolkit (GWT). Its purpose is to make it possible to develop web user interfaces that run in the browser easily with Java instead of JavaScript. Client-side modules are developed with Java and compiled into JavaScript with the Vaadin Compiler, which is an extension of the GWT Compiler. The client-side framework also hides much of the HTML DOM manipulation and enables handling browser events in Java.

GWT is essentially a client-side technology, normally used to develop user interface logic in the web browser. Pure client-side modules still need to communicate with a server using RPC calls and by serializing any data. The server-driven development mode in Vaadin effectively hides all the client-server communications and allows handling user interaction logic in a server-side application. This makes the architecture of an AJAX-based web application much simpler. Nevertheless, Vaadin also allows developing pure client-side applications, as described in Chapter 14, *Client-Side Applications*.

See Section 3.3, “Client-Side Engine” for a description of how the client-side framework based on GWT is used in the Client-Side Engine of Vaadin. Chapter 13, *Client-Side Vaadin Development* provides information about the client-side development, and Chapter 16, *Integrating with the Server-Side* about the integration of client-side widgets with the server-side components.

### 3.2.5. Java Servlets

A Java Servlet is a class that is executed in a Java web server (a *Servlet container*) to extend the capabilities of the server. In practice, it is normally a part of a *web application*, which can

contain HTML pages to provide static content, and JavaServer Pages (JSP) and Java Servlets to provide dynamic content. This is illustrated in Figure 3.2, “Java Web Applications and Servlets”.

Web applications are usually packaged and deployed to a server as *WAR* (*Web application ARchive*) files, which are Java JAR packages, which in turn are ZIP compressed packages. The web application is defined in a `WEB-INF/web.xml` deployment descriptor, which defines the servlet classes and also the mappings from request URL paths to the servlets. This is described in more detail in Section 4.8.4, “Using a `web.xml` Deployment Descriptor”. The class path for the servlets and their dependencies includes the `WEB-INF/classes` and `WEB-INF/lib` folders. The `WEB-INF` is a special hidden folder that can not be accessed by its URL path.

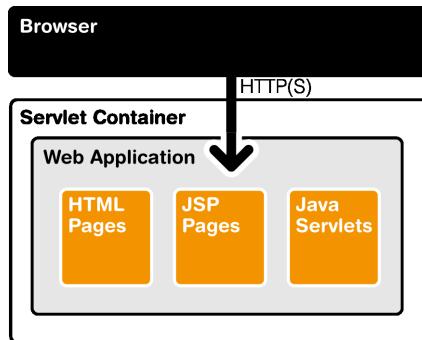
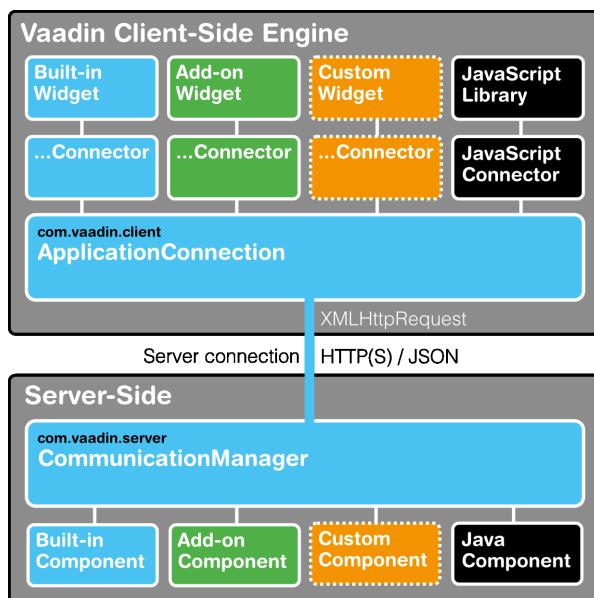
The servlets are Java classes that handle HTTP requests passed to them by the server through the *Java Servlet API*. They can generate HTML or other content as a response. JSP pages, on the other hand, are HTML pages, which allow including Java source code embedded in the pages. They are actually translated to Java source files by the container and then compiled to servlets.

The UIs of server-side Vaadin applications run as servlets. They are wrapped inside a **Vaadin-Servlet** servlet class, which handles session tracking and other tasks. On the initial request, it returns an HTML loader page and then mostly JSON responses to synchronize the widgets and their server-side counterparts. It also serves various resources, such as themes. The server-side UIs are implemented as classes extending the **UI** class, as described in Chapter 4, *Writing a Server-Side Web Application*. The class is given as a parameter to the Vaadin Servlet in the `web.xml` deployment descriptor.

The Vaadin Client-Side Engine as well as client-side Vaadin applications are loaded to the browser as static JavaScript files. The client-side engine, or widget set in technical terms, needs to be located under the `VAADIN/widgetsets` path in the web application. The precompiled default widget set is served from the `vaadin-client-compiled` JAR by the Vaadin Servlet.

### 3.3. Client-Side Engine

The user interface of a server-side Vaadin application is rendered in the browser by the Vaadin Client-Side Engine. It is loaded in the browser when the page with the Vaadin UI is opened. The server-side UI components are rendered using *widgets* (as they are called in Google Web Toolkit) on the client-side. The client-side engine is illustrated in Figure 3.3, “Vaadin Client-Side Engine”.

**Figure 3.2. Java Web Applications and Servlets****Figure 3.3. Vaadin Client-Side Engine**

The client-side framework includes two kinds of built-in widgets: GWT widgets and Vaadin-specific widgets. The two widget collections have significant overlap, where the Vaadin widgets provide a bit different features than the GWT widgets. In addition, many add-on widgets and their server-side counterparts exist, and you can easily download and install them, as described in Chapter 17, *Using Vaadin Add-ons*. You can also develop your own widgets, as described in Chapter 13, *Client-Side Vaadin Development*.

The rendering with widgets, as well as the communication to the server-side, is handled in the **ApplicationConnection**. Connecting the widgets with their server-side counterparts is done in **connectors**, and there is one for each widget that has a server-side counterpart. The framework handles serialization of component state transparently, and includes an RPC mechanism between the two sides. Integration of widgets with their server-side counterpart components is described in Chapter 16, *Integrating with the Server-Side*.

## 3.4. Events and Listeners

Vaadin offers an event-driven programming model for handling user interaction. When a user does something in the user interface, such as clicks a button or selects an item, the application

needs to know about it. Many Java-based user interface frameworks follow the *Event-Listener pattern* (also known as the Observer design pattern) to communicate user input to the application logic. So does Vaadin. The design pattern involves two kinds of elements: an object that generates ("fires" or "emits") events and a number of listeners that listen for the events. When such an event occurs, the object sends a notification about it to all the listeners. In a typical case, there is only one listener.

Events can serve many kinds of purposes. In Vaadin, the usual purpose of events is handling user interaction in a user interface. Session management can require special events, such as time-out, in which case the event would actually be the lack of user interaction. Time-out is a special case of timed or scheduled events, where an event occurs at a specific date and time or when a set time has passed.

To receive events of a particular type, an application must register a listener object with the event source. The listeners are registered in the components with an `add*Listener()` method (with a method name specific to the listener).

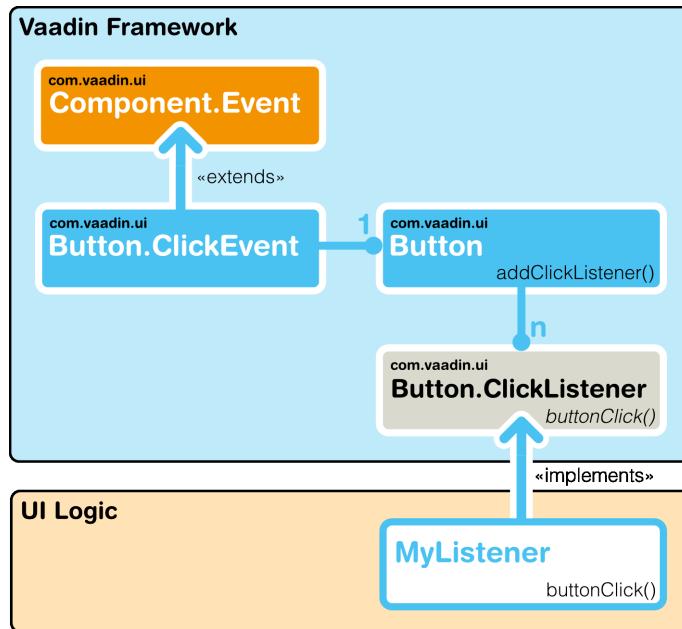
Most components that have related events define their own event class and the corresponding listener class. For example, the **Button** has **Button.ClickEvent** events, which can be listened to through the **Button.ClickListener** interface.

In the following, we handle button clicks with a listener implemented as an anonymous class:

```
final Button button = new Button("Push it!");

button.addClickListener(new Button.ClickListener() {
    public void buttonClick(ClickEvent event) {
        button.setCaption("You pushed it!");
    }
});
```

Figure 3.4, “Class Diagram of a Button Click Listener” illustrates the case where an application-specific class inherits the **Button.ClickListener** interface to be able to listen for button click events. The application must instantiate the listener class and register it with `addClickListener()`. It can be an anonymous class, such as the one above. When an event occurs, an event object is instantiated, in this case a **Button.ClickEvent**. The event object knows the related UI component, in this case the **Button**.

**Figure 3.4. Class Diagram of a Button Click Listener**

In the ancient times of C programming, *callback functions* filled largely the same need as listeners do now. In object-oriented languages, we usually only have classes and methods, not functions, so the application has to give a class interface instead of a callback function pointer to the framework.

Section 4.3, “Handling Events with Listeners” goes into details of handling events in practice.



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# Chapter 4

# Writing a Server-Side Web Application

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This chapter provides the fundamentals of server-side web application development with Vaadin, concentrating on the basic elements of an application from a practical point-of-view.

## 4.1. Overview

A server-side Vaadin application runs as a Java Servlet in a servlet container. The Java Servlet API is, however, hidden behind the framework. The user interface of the application is implemented as a *UI* class, which needs to create and manage the user interface components that make up

the user interface. User input is handled with event listeners, although it is also possible to bind the user interface components directly to data. The visual style of the application is defined in themes as CSS and SCSS files. Icons, other images, and downloadable files are handled as resources, which can be external or served by the application server or the application itself.

**Figure 4.1. Server-Side Application Architecture**

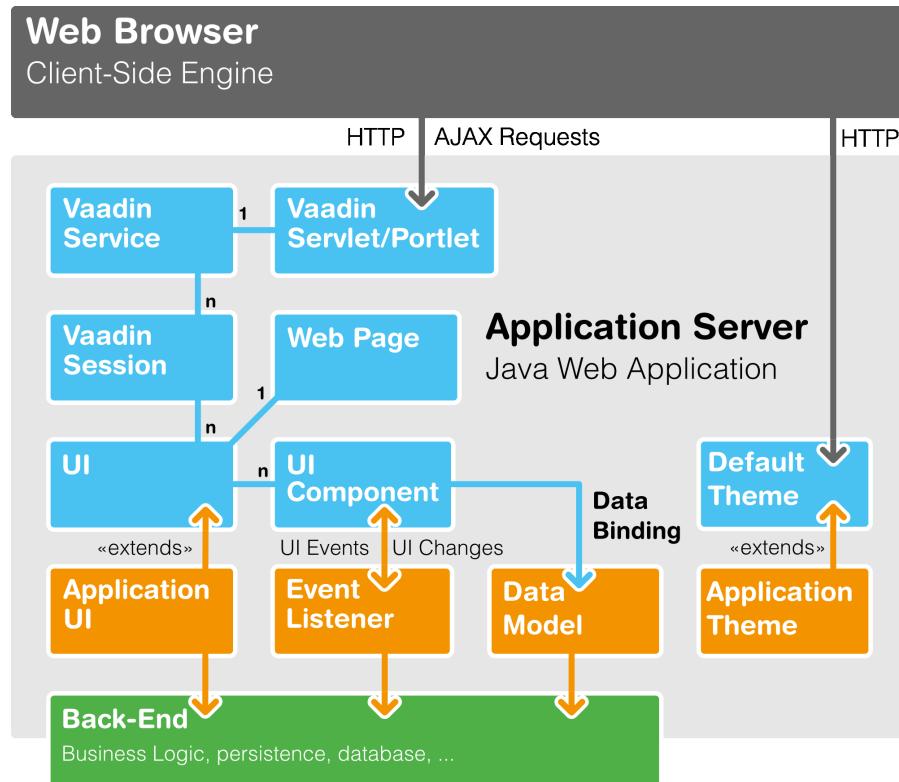


Figure 4.1, “Server-Side Application Architecture” illustrates the basic architecture of an application made with the Vaadin Framework, with all the major elements, which are introduced below and discussed in detail in this chapter.

First of all, a Vaadin application must have one or more UI classes that extend the abstract `com.vaadin.ui.UI` class and implement the `init()` method. A custom theme can be defined as an annotation for the UI.

```
@Theme( "hellotheme" )
public class HelloWorld extends UI {
    protected void init(VaadinRequest request) {
        ... initialization code goes here ...
    }
}
```

A UI is a viewport to a Vaadin application running in a web page. A web page can actually have multiple such UIs within it. Such situation is typical especially with portlets in a portal. An application can run in multiple browser windows, each having a distinct UI instance. The UIs of an application can be the same UI class or different.

Vaadin framework handles servlet requests internally and associates the requests with user sessions and a UI state. Because of this, you can develop Vaadin applications much like you would develop desktop applications.

The most important task in the initialization is the creation of the initial user interface. This, and the deployment of a UI as a Java Servlet in the Servlet container, as described in Section 4.8, “Deploying an Application”, are the minimal requirements for an application.

Below is a short overview of the other basic elements of an application besides UI:

#### UI

A **UI** represents an HTML fragment in which a Vaadin application runs in a web page. It typically fills the entire page, but can also be just a part of a page. You normally develop a Vaadin application by extending the **UI** class and adding content to it. A UI is essentially a viewport connected to a user session of an application, and you can have many such views, especially in a multi-window application. Normally, when the user opens a new page with the URL of the Vaadin UI, a new **UI** (and the associated **Page** object) is automatically created for it. All of them share the same user session.

The current UI object can be accessed globally with `UI.getCurrent()`. The static method returns the thread-local UI instance for the currently processed request (see Section 11.15.3, “ThreadLocal Pattern”).

#### Page

A **UI** is associated with a **Page** object that represents the web page as well as the browser window in which the UI runs.

The **Page** object for the currently processed request can be accessed globally from a Vaadin application with `Page.getCurrent()`. This is equivalent to calling `UI.getCurrent().getPage()`.

#### Vaadin Session

A **VaadinSession** object represents a user session with one or more UIs open in the application. A session starts when a user first opens a UI of a Vaadin application, and closes when the session expires in the server or when it is closed explicitly.

#### User Interface Components

The user interface consists of components that are created by the application. They are laid out hierarchically using special *layout components*, with a content root layout at the top of the hierarchy. User interaction with the components causes *events* related to the component, which the application can handle. *Field components* are intended for inputting values and can be directly bound to data using the Vaadin Data Model. You can make your own user interface components through either inheritance or composition. For a thorough reference of user interface components, see Chapter 5, *User Interface Components*, for layout components, see Chapter 6, *Managing Layout*, and for compositing components, see Section 5.28, “Composition with **CustomComponent**”.

#### Events and Listeners

Vaadin follows an event-driven programming paradigm, in which events, and listeners that handle the events, are the basis of handling user interaction in an application (although also server push is possible as described in Section 11.16, “Server Push”). Section 3.4, “Events and Listeners” gave an introduction to events and listeners from an architectural point-of-view, while Section 4.3, “Handling Events with Listeners” later in this chapter takes a more practical view.

### Resources

A user interface can display images or have links to web pages or downloadable documents. These are handled as *resources*, which can be external or provided by the web server or the application itself. Section 4.4, “Images and Other Resources” gives a practical overview of the different types of resources.

### Themes

The presentation and logic of the user interface are separated. While the UI logic is handled as Java code, the presentation is defined in *themes* as CSS or SCSS. Vaadin includes some built-in themes. User-defined themes can, in addition to style sheets, include HTML templates that define custom layouts and other theme resources, such as images. Themes are discussed in detail in Chapter 7, *Themes*, custom layouts in Section 6.14, “Custom Layouts”, and theme resources in Section 4.4.4, “Theme Resources”.

### Data Binding

Field components are essentially views to data, represented in the *Vaadin Data Model*. Using the data model, the components can get their values from and update user input to the data model directly, without the need for any control code. A field component is always bound to a *property* and a group of fields to an *item* that holds the properties. Items can be collected in a *container*, which can act as a data source for some components such as tables or lists. While all the components have a default data model, they can be bound to a user-defined data source. For example, you can bind a **Table** component to an SQL query response. For a complete overview of data binding in Vaadin, please refer to Chapter 8, *Binding Components to Data*.

## 4.2. Building the UI

Vaadin user interfaces are built hierarchically from components, so that the leaf components are contained within layout components and other component containers. Building the hierarchy starts from the top (or bottom - whichever way you like to think about it), from the **UI** class of the application. You normally set a layout component as the content of the UI and fill it with other components.

```
public class MyHierarchicalUI extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        // The root of the component hierarchy  
        VerticalLayout content = new VerticalLayout();  
        content.setSizeFull(); // Use entire window  
        setContent(content); // Attach to the UI  
  
        // Add some component  
        content.addComponent(new Label("Hello!"));  
  
        // Layout inside layout  
        HorizontalLayout hor = new HorizontalLayout();  
        hor.setSizeFull(); // Use all available space  
  
        // Couple of horizontally laid out components  
        Tree tree = new Tree("My Tree",  
            TreeExample.createTreeContent());  
        hor.addComponent(tree);  
  
        Table table = new Table("My Table",  
            TableExample.generateContent());
```

```

        table.setSizeFull();
        hor.addComponent(table);
        hor.setExpandRatio(table, 1); // Expand to fill

        content.addComponent(hor);
        content.setExpandRatio(hor, 1); // Expand to fill
    }
}

```

The component hierarchy could be illustrated with a tree as follows:

```

UI
`-- VerticalLayout
  |-- Label
  '-- HorizontalLayout
    |-- Tree
    '-- Table

```

The result is shown in Figure 4.2, “Simple Hierarchical UI”.

**Figure 4.2. Simple Hierarchical UI**

The screenshot displays a user interface with two main sections. On the left, under the heading 'My Tree', there is a tree view with the following items:

- +5 Quarterstaff (blessed)
- +3 Elven Dagger (blessed)
- +5 Helmet (greased)
- ▶ Sack
- ▶ Bag of Holding
- ▶ Chest

On the right, under the heading 'My Table', there is a table with three columns: name, city, and year. The data is as follows:

name	city	year
Charles Darwin	Oxford	1 9
Charles Adams	London	1 8
Isaac Lovelace	Oxford	1 9
Charles Newton	Oxford	1 8
Charles Adams	London	1 8

The built-in components are described in Chapter 5, *User Interface Components* and the layout components in Chapter 6, *Managing Layout*.

The example application described above just is, it does not do anything. User interaction is handled with event listeners, as described a bit later in Section 4.3, “Handling Events with Listeners”.

## 4.2.1. Application Architecture

Once your application grows beyond a dozen or so lines, which is usually quite soon, you need to start considering the application architecture more closely. You are free to use any object-oriented techniques available in Java to organize your code in methods, classes, packages, and libraries. An architecture defines how these modules communicate together and what sort of dependencies they have between them. It also defines the scope of the application. The scope of this book, however, only gives a possibility to mention some of the most common architectural patterns in Vaadin applications.

The subsequent sections describe some basic application patterns. For more information about common architectures, see Section 11.10, “Advanced Application Architectures”, which discusses layered architectures, the Model-View-Presenter (MVP) pattern, and so forth. The Section 11.15, “Accessing Session-Global Data” discusses the problem of passing essentially global references around, a common problem which is also visited in Section 4.2.4, “Accessing UI, Page, Session, and Service”.

## 4.2.2. Compositing Components

User interfaces typically contain many user interface components in a layout hierarchy. Vaadin provides many layout components for laying contained components vertically, horizontally, in a grid, and in many other ways. You can extend layout components to create composite components.

```
class MyView extends VerticalLayout {
    TextField entry = new TextField("Enter this");
    Label display = new Label("See this");
    Button click = new Button("Click This");

    public MyView() {
        addComponent(entry);
        addComponent(display);
        addComponent(click);

        // Configure it a bit
        setSizeFull();
        addStyleName("myview");
    }
}

// Use it
Layout myview = new MyView();
```

This composition pattern is especially supported for creating forms, as described in Section 8.4.3, “Binding Member Fields”.

While extending layouts is an easy way to make component composition, it is a good practice to encapsulate implementation details, such as the exact layout component used. Otherwise, the users of such a composite could begin to rely on such implementation details, which would make changes harder. For this purpose, Vaadin has a special **CustomComponent** wrapper, which hides the content representation.

```
class MyView extends CustomComponent {
    TextField entry = new TextField("Enter this");
    Label display = new Label("See this");
    Button click = new Button("Click This");

    public MyView() {
```

```

        Layout layout = new VerticalLayout();

        layout.addComponent(entry);
        layout.addComponent(display);
        layout.addComponent(click);

        setCompositionRoot(layout);

        setSizeFull();
    }
}

// Use it
MyView myview = new MyView();

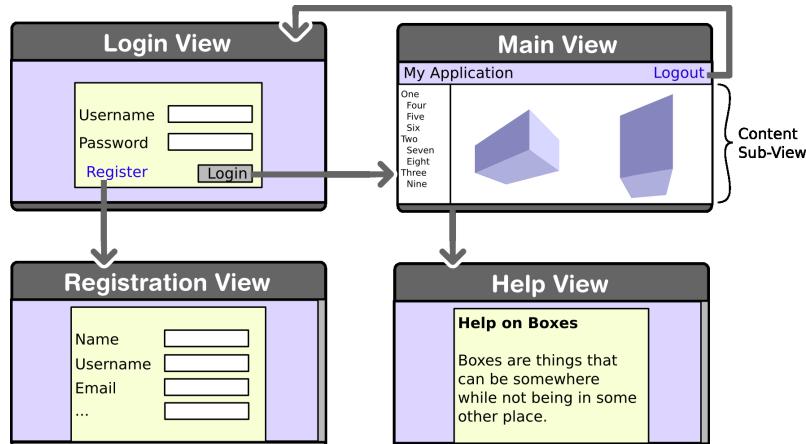
```

For a more detailed description of the **CustomComponent**, see Section 5.28, “Composition with **CustomComponent**”. The Vaadin Plugin for Eclipse also includes a visual editor for composite components, as described in Chapter 10, *Visual User Interface Design with Eclipse*.

### 4.2.3. View Navigation

While the most simple applications have just a single *view* (or *screen*), perhaps most have many. Even in a single view, you often want to have sub-views, for example to display different content. Figure 4.3, “Navigation Between Views” illustrates a typical navigation between different top-level views of an application, and a main view with sub-views.

**Figure 4.3. Navigation Between Views**



The **Navigator** described in Section 11.9, “Navigating in an Application” is a view manager that provides a flexible way to navigate between views and sub-views, while managing the URI fragment in the page URL to allow bookmarking, linking, and going back in browser history.

Often Vaadin application views are part of something bigger. In such cases, you may need to integrate the Vaadin applications with the other website. You can use the embedding techniques described in Section 11.2, “Embedding UIs in Web Pages”.

### 4.2.4. Accessing UI, Page, Session, and Service

You can get the UI and the page to which a component is attached to with `getUI()` and `getPage()`.

However, the values are `null` until the component is attached to the UI, and typically, when you need it in constructors, it is not. It is therefore preferable to access the current UI, page, session, and service objects from anywhere in the application using the static `getCurrent()` methods in the respective **UI**, **Page**, **VaadinSession**, and **VaadinService** classes.

```
// Set the default locale of the UI
UI.getCurrent().setLocale(new Locale("en"));

// Set the page title (window or tab caption)
Page.getCurrent().setTitle("My Page");

// Set a session attribute
VaadinSession.getCurrent().setAttribute("myattrib", "hello");

// Access the HTTP service parameters
File baseDir = VaadinService.getCurrent().getBaseDirectory();
```

You can get the page and the session also from a **UI** with `getPage()` and `getSession()` and the service from **VaadinSession** with `getService()`.

The static methods use the built-in `ThreadLocal` support in the classes. The pattern is described in Section 11.15.3, “`ThreadLocal` Pattern”.

## 4.3. Handling Events with Listeners

Let us put into practice what we learned of event handling in Section 3.4, “Events and Listeners”. You can implement listener interfaces in a regular class, but it brings the problem with differentiating between different event sources. Using anonymous class for listeners is recommended in most cases.

### 4.3.1. Using Anonymous Classes

By far the easiest and the most common way to handle events in Java 6 and 7 is to use anonymous local classes. It encapsulates the handling of events to where the component is defined and does not require cumbering the managing class with interface implementations. The following example defines an anonymous class that inherits the **Button.ClickListener** interface.

```
// Have a component that fires click events
final Button button = new Button("Click Me!");

// Handle the events with an anonymous class
button.addClickListener(new Button.ClickListener() {
    public void buttonClick(ClickEvent event) {
        button.setCaption("You made me click!");
    }
});
```

Local objects referenced from within an anonymous class, such as the **Button** object in the above example, must be declared `final`.

Most components allow passing a listener to the constructor, thereby losing a line or two. However, notice that if accessing the component that is constructed from an anonymous class, you must use a reference that is declared before the constructor is executed, for example as a member variable in the outer class. If it is declared in the same expression where the constructor is called, it doesn't yet exist. In such cases, you need to get a reference to the component from the event object.

```
final Button button = new Button("Click It!",
    new Button.ClickListener() {
        @Override
        public void buttonClick(ClickEvent event) {
            event.getButton().setCaption("Done!");
        }
});
```

### 4.3.2. Handling Events in Java 8

Java 8 introduced lambda expressions, which offer a replacement for listeners. You can directly use lambda expressions in place of listeners that have only one method to implement.

For example, in the following, we use a lambda expression to handle button click events in the constructor:

```
layout.addComponent(new Button("Click Me!",
    event -> event.getButton().setCaption("You made click!")));
```

Java 8 is the future that is already here, and as Vaadin API uses event listeners extensively, using lambda expressions makes UI code much more readable.

Directing events to handler methods is easy with method references:

```
public class Java8Buttons extends CustomComponent {
    public Java8Buttons() {
        setCompositionRoot(new HorizontalLayout(
            new Button("OK", this::ok),
            new Button("Cancel", this::cancel)));
    }

    public void ok(ClickEvent event) {
        event.getButton().setCaption ("OK!");
    }

    public void cancel(ClickEvent event) {
        event.getButton().setCaption ("Not OK!");
    }
}
```

### 4.3.3. Implementing a Listener in a Regular Class

The following example follows a typical pattern where you have a **Button** component and a listener that handles user interaction (clicks) communicated to the application as events. Here we define a class that listens to click events.

```
public class MyComposite extends CustomComponent
    implements Button.ClickListener {
    Button button; // Defined here for access

    public MyComposite() {
        Layout layout = new HorizontalLayout();

        // Just a single component in this composition
        button = new Button("Do not push this");
        button.addClickListener(this);
        layout.addComponent(button);
```

```
        setCompositionRoot(layout);
    }

    // The listener method implementation
    public void buttonClick(ClickEvent event) {
        button.setCaption("Do not push this again");
    }
}
```

#### 4.3.4. Differentiating Between Event Sources

If an application receives events of the same type from multiple sources, such as multiple buttons, it has to be able to distinguish between the sources. If using a regular class listener, distinguishing between the components can be done by comparing the source of the event with each of the components. The method for identifying the source depends on the event type.

```
public class TheButtons extends CustomComponent
    implements Button.ClickListener {
    Button onebutton;
    Button toobutton;

    public TheButtons() {
        onebutton = new Button("Button One", this);
        toobutton = new Button("A Button Too", this);

        // Put them in some layout
        Layout root = new HorizontalLayout();
        root.addComponent(onebutton);
        root.addComponent(toobutton);
        setCompositionRoot(root);
    }

    @Override
    public void buttonClick(ClickEvent event) {
        // Differentiate targets by event source
        if (event.getButton() == onebutton)
            onebutton.setCaption ("Pushed one");
        else if (event.getButton() == toobutton)
            toobutton.setCaption ("Pushed too");
    }
}
```

Other techniques exist for separating between event sources, such as using object properties, names, or captions to separate between them. Using captions or any other visible text is generally discouraged, as it may create problems for internationalization. Using other symbolic strings can also be dangerous, because the syntax of such strings is checked only at runtime.

### 4.4. Images and Other Resources

Web applications can display various *resources*, such as images, other embedded content, or downloadable files, that the browser has to load from the server. Image resources are typically displayed with the **Image** component or as component icons. Flash animations can be displayed with **Flash**, embedded browser frames with **BrowserFrame**, and other content with the **Embedded** component, as described in Section 5.30, “Embedded Resources”. Downloadable files are usually provided by clicking a **Link**.

There are several ways to how such resources can be provided by the web server. Static resources can be provided without having to ask for them from the application. For dynamic resources, the user application must be able to create them dynamically. The resource request interfaces in Vaadin allow applications to both refer to static resources as well as dynamically create them. The dynamic creation includes the **StreamResource** class and the **RequestHandler** described in Section 11.4, "Request Handlers".

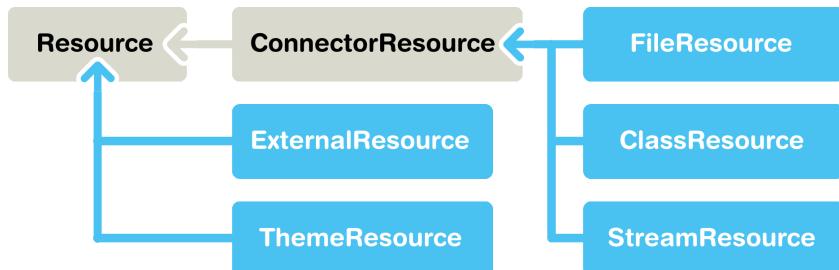
Vaadin also provides low-level facilities for retrieving the URI and other parameters of a HTTP request. We will first look into how applications can provide various kinds of resources and then look into low-level interfaces for handling URIs and parameters to provide resources and functionalities.

Notice that using request handlers to create "pages" is not normally meaningful in Vaadin or in AJAX applications generally. Please see Section 3.2.3, "AJAX" for a detailed explanation.

#### 4.4.1. Resource Interfaces and Classes

The resource classes in Vaadin are grouped under two interfaces: a generic **Resource** interface and a more specific **ConnectorResource** interface for resources provided by the servlet.

**Figure 4.4. Resource Interface and Class Diagram**



#### 4.4.2. File Resources

File resources are files stored anywhere in the file system. As such, they can not be retrieved by a regular URL from the server, but need to be requested through the Vaadin servlet. The use of file resources is typically necessary for persistent user data that is not packaged in the web application, which would not be persistent over redeployments.

A file object that can be accessed as a file resource is defined with the standard **java.io.File** class. You can create the file either with an absolute or relative path, but the base path of the relative path depends on the installation of the web server. For example, with Apache Tomcat, the default current directory would be the installation path of Tomcat.

In the following example, we provide an image resource from a file stored in the web application. Notice that the image is stored under the **WEB-INF** folder, which is a special folder that is never accessible using an URL, unlike the other folders of a web application. This is a security solution - another would be to store the resource elsewhere in the file system.

```

// Find the application directory
String basepath = VaadinService.getCurrent()
    .getBaseDirectory().getAbsolutePath();

// Image as a file resource
FileResource resource = new FileResource(new File(basepath +
  
```

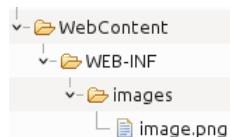
```
    "/WEB-INF/images/image.png"));

// Show the image in the application
Image image = new Image("Image from file", resource);

// Let the user view the file in browser or download it
Link link = new Link("Link to the image file", resource);
```

The result, as well as the folder structure where the file is stored under a regular Eclipse Vaadin project, is shown in Figure 4.5, “File Resource”.

### Figure 4.5. File Resource



### 4.4.3. Class Loader Resources

The **ClassResource** allows resources to be loaded from the class path using Java Class Loader. Normally, the relevant class path entry is the WEB-INF/classes folder under the web application, where the Java compilation should compile the Java classes and copy other files from the source tree.

The one-line example below loads an image resource from the application package and displays it in an **Image** component.

```
layout.addComponent(new Image(null,
    new ClassResource("smiley.jpg")));
```

### 4.4.4. Theme Resources

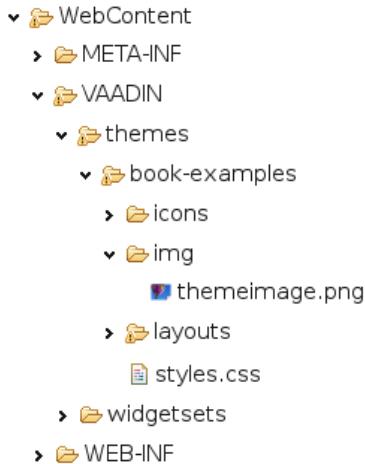
Theme resources of **ThemeResource** class are files, typically images, included in a theme. A theme is located with the path VAADIN/themes/themename in a web application. The name of a theme resource is given as the parameter for the constructor, with a path relative to the theme folder.

```
// A theme resource in the current theme ("mytheme")
// Located in: VAADIN/themes/mytheme/img/themeimage.png
ThemeResource resource = new ThemeResource("img/themeimage.png");

// Use the resource
Image image = new Image("My Theme Image", resource);
```

The result is shown in Figure 4.6, “Theme Resources”, also illustrating the folder structure for the theme resource file in an Eclipse project.

### Figure 4.6. Theme Resources



To use theme resources, you must set the theme for the UI. See Chapter 7, *Themes* for more information regarding themes.

#### 4.4.5. Stream Resources

Stream resources allow creating dynamic resource content. Charts are typical examples of dynamic images. To define a stream resource, you need to implement the **StreamResource.StreamSource** interface and its `getStream()` method. The method needs to return an **InputStream** from which the stream can be read.

The following example demonstrates the creation of a simple image in PNG image format.

```
import java.awt.image.*;  
  
public class MyImageSource  
    implements StreamResource.StreamSource {  
    ByteArrayOutputStream imagebuffer = null;  
    int reloads = 0;  
  
    /* We need to implement this method that returns  
     * the resource as a stream. */  
    public InputStream getStream () {  
        /* Create an image and draw something on it. */  
        BufferedImage image = new BufferedImage (200, 200,  
            BufferedImage.TYPE_INT_RGB);  
        Graphics drawable = image.getGraphics();  
        drawable.setColor(Color.lightGray);  
        drawable.fillRect(0,0,200,200);  
        drawable.setColor(Color.yellow);  
        drawable.fillOval(25,25,150,150);  
        drawable.setColor(Color.blue);  
        drawable.drawRect(0,0,199,199);  
        drawable.setColor(Color.black);  
        drawable.drawString("Reloads="+reloads, 75, 100);  
        reloads++;  
  
        try {  
            /* Write the image to a buffer. */  
            imagebuffer = new ByteArrayOutputStream();  
            ...  
        } catch (IOException e) {  
            ...  
        }  
        return imagebuffer.  
    }  
}
```

```
        ImageIO.write(image, "png", imagebuffer);

        /* Return a stream from the buffer. */
        return new ByteArrayInputStream(
            imagebuffer.toByteArray());
    } catch (IOException e) {
        return null;
    }
}
```

The content of the generated image is dynamic, as it updates the reloads counter with every call. The `ImageIO.write()` method writes the image to an output stream, while we had to return an input stream, so we stored the image contents to a temporary buffer.

Below we display the image with the `Image` component.

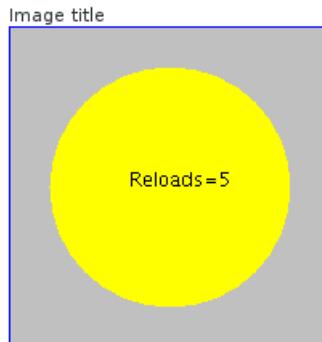
```
// Create an instance of our stream source.
StreamResource.StreamSource imagesource = new MyImageSource();

// Create a resource that uses the stream source and give it a name.
// The constructor will automatically register the resource in
// the application.
StreamResource resource =
    new StreamResource(imagesource, "myimage.png");

// Create an image component that gets its contents
// from the resource.
layout.addComponent(new Image("Image title", resource));
```

The resulting image is shown in Figure 4.7, “A Stream Resource”.

**Figure 4.7. A Stream Resource**



Another way to create dynamic content is a request handler, described in Section 11.4, “Request Handlers”.

## 4.5. Handling Errors

### 4.5.1. Error Indicator and Message

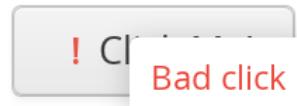
All components have a built-in error indicator that is turned on if validating the component fails, and can be set explicitly with `setComponentError()`. Usually, the error indicator is placed right of the component caption. The error indicator is part of the component caption, so its

placement is usually managed by the layout in which the component is contained, but some components handle it themselves. Hovering the mouse pointer over the field displays the error message.

```
textfield.setComponentError(new UserError("Bad value"));
button.setComponentError(new UserError("Bad click"));
```

The result is shown in Figure 4.8, “Error Indicator Active”.

**Figure 4.8. Error Indicator Active**



## 4.5.2. Customizing System Messages

System messages are notifications that indicate a major invalid state that usually requires restarting the application. Session timeout is perhaps the most typical such state.

System messages are strings managed in the **SystemMessages** class.

### sessionExpired

Application servlet session expired. A session expires if no server requests are made during the session timeout period. The session timeout can be configured with the *session-timeout* parameter in web.xml, as described in Section 4.8.4, “Using a web.xml Deployment Descriptor”.

### communicationError

An unspecified communication problem between the Vaadin Client-Side Engine and the application server. The server may be unavailable or there is some other problem.

### authenticationError

This error occurs if 401 (Unauthorized) response to a request is received from the server.

### internalError

A serious internal problem, possibly indicating a bug in Vaadin Client-Side Engine or in some custom client-side code.

### outOfSync

The client-side state is invalid with respect to server-side state.

### cookiesDisabled

Informs the user that cookies are disabled in the browser and the application does not work without them.

Each message has four properties: a short caption, the actual message, a URL to which to redirect after displaying the message, and property indicating whether the notification is enabled.

Additional details may be written (in English) to the debug console window described in Section 11.3, “Debug Mode and Window”.

You can override the default system messages by setting the `SystemMessagesProvider` in the `VaadinService`. You need to implement the `getSystemMessages()` method, which should return a `SystemMessages` object. The easiest way to customize the messages is to use a `CustomizedSystemMessages` object.

You can set the system message provider in the `servletInitialized()` method of a custom servlet class, for example as follows:

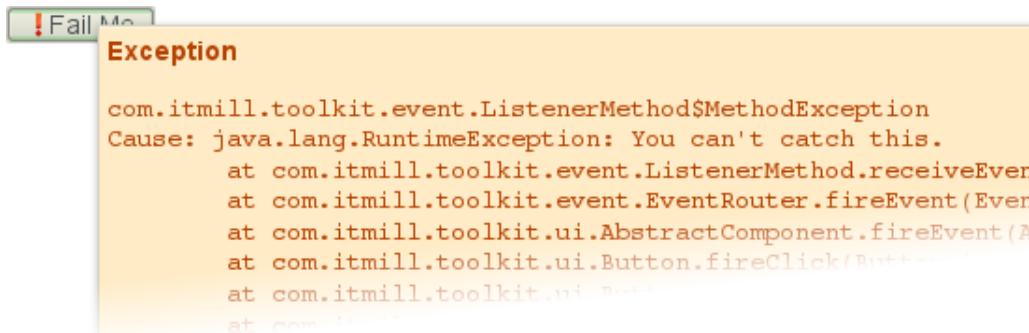
```
getService().setSystemMessagesProvider(
    new SystemMessagesProvider() {
        @Override
        public SystemMessages getSystemMessages(
            SystemMessagesInfo systemMessagesInfo) {
            CustomizedSystemMessages messages =
                new CustomizedSystemMessages();
            messages.setCommunicationErrorCaption("Comm Err");
            messages.setCommunicationErrorMessage("This is bad.");
            messages.setCommunicationErrorNotificationEnabled(true);
            messages.setCommunicationErrorURL("http://vaadin.com/");
            return messages;
        }
    });
}
```

See Section 4.7.2, “Vaadin Servlet, Portlet, and Service” for information about customizing Vaadin servlets.

### 4.5.3. Handling Uncaught Exceptions

Handling events can result in exceptions either in the application logic or in the framework itself, but some of them may not be caught properly by the application. Any such exceptions are eventually caught by the framework. It delegates the exceptions to the `DefaultErrorHandler`, which displays the error as a component error, that is, with a small red "!" -sign (depending on the theme). If the user hovers the mouse pointer over it, the entire backtrace of the exception is shown in a large tooltip box, as illustrated in Figure 4.9, “Uncaught Exception in Component Error Indicator”.

**Figure 4.9. Uncaught Exception in Component Error Indicator**



You can customize the default error handling by implementing a custom `ErrorHandler` and enabling it with `setErrorHandler()` in any of the components in the component hierarchy, including the `UI`, or in the `VaadinSession` object. You can either implement the `ErrorHandler` or extend the `DefaultErrorHandler`. In the following example, we modify the behavior of the default handler.

```
// Here's some code that produces an uncaught exception
final VerticalLayout layout = new VerticalLayout();
final Button button = new Button("Click Me!",
    new Button.ClickListener() {
        public void buttonClick(ClickEvent event) {
            ((String)null).length(); // Null-pointer exception
        }
    });
layout.addComponent(button);

// Configure the error handler for the UI
UI.getCurrent().setErrorHandler(new DefaultErrorHandler() {
    @Override
    public void error(com.vaadin.server.ErrorEvent event) {
        // Find the final cause
        String cause = "<b>The click failed because:</b><br/>";
        for (Throwable t = event.getThrowable(); t != null;
            t = t.getCause())
            if (t.getCause() == null) // We're at final cause
                cause += t.getClassName() + "<br/>";

        // Display the error message in a custom fashion
        layout.addComponent(new Label(cause, ContentMode.HTML));
    }

    // Do the default error handling (optional)
    doDefault(event);
}
});
```

The above example also demonstrates how to dig up the final cause from the cause stack.

When extending **DefaultErrorHandler**, you can call `doDefault()` as was done above to run the default error handling, such as set the component error for the component where the exception was thrown. See the source code of the implementation for more details. You can call `findAbstractComponent(event)` to find the component that caused the error. If the error is not associated with a component, it returns null.

## 4.6. Notifications

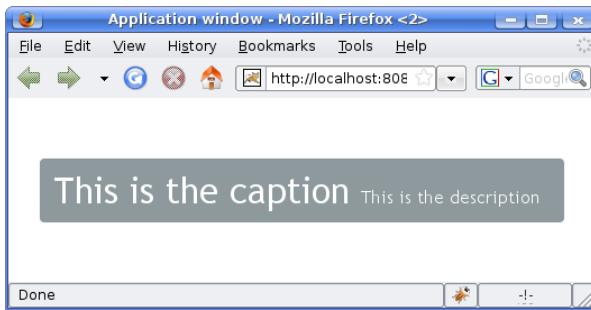
Notifications are error or information boxes that appear briefly, typically at the center of the screen. A notification box has a caption and an optional description and icon. The box stays on the screen either for a preset time or until the user clicks it. The notification type defines the default appearance and behaviour of a notification.

There are two ways to create a notification. The easiest is to use a static shorthand `Notification.show()` method, which takes the caption of the notification as a parameter, and an optional description and notification type, and displays it in the current page.

```
Notification.show("This is the caption",
    "This is the description",
    Notification.Type.WARNING_MESSAGE);
```

For more control, you can create a **Notification** object. Different constructors exist for taking just the caption, and optionally the description, notification type, and whether HTML is allowed or not. Notifications are shown in a **Page**, typically the current page.

```
new Notification("This is a warning",
    "<br/>This is the <i>last</i> warning",
```

**Figure 4.10. Notification**

```
Notification.TYPE_WARNING_MESSAGE, true)
.show(Page.getCurrent());
```

The caption and description are by default written on the same line. If you want to have a line break between them, use the HTML line break markup "<br />" if HTML is enabled, or "\n" if not. HTML is disabled by default, but can be enabled with `setHtmlContentAllowed(true)`. When enabled, you can use any HTML markup in the caption and description of a notification. If it is in any way possible to get the notification content from user input, you should either disallow HTML or sanitize the content carefully, as noted in Section 11.8.1, "Sanitizing User Input to Prevent Cross-Site Scripting".

**Figure 4.11. Notification with HTML Formatting**

#### 4.6.1. Notification Type

The notification type defines the overall default style and behaviour of a notification. If no notification type is given, the "humanized" type is used as the default. The notification types, listed below, are defined in the `Notification.Type` class.



`TYPE_HUMANIZED_MESSAGE`

A user-friendly message that does not annoy too much: it does not require confirmation by clicking and disappears quickly. It is centered and has a neutral gray color.



`TYPE_WARNING_MESSAGE`

Warnings are messages of medium importance. They are displayed with colors that are neither neutral nor too distractive. A warning is displayed for 1.5 seconds, but the user can click the message box to dismiss it. The user can continue to interact with the application while the warning is displayed.



`TYPE_ERROR_MESSAGE`

Error messages are notifications that require the highest user attention, with alert colors, and they require the user to click the message to dismiss it. The error message box does not itself include an instruction to click the message, although the close box in the upper right corner indicates it visually. Unlike with other notifications, the user can not interact with the application while the error message is displayed.

`Tray notification`

Stays up longer - but away

`TYPE_TRAY_NOTIFICATION`

Tray notifications are displayed in the "system tray" area, that is, in the lower-right corner of the browser view. As they do not usually obscure any user interface, they are displayed longer than humanized or warning messages, 3 seconds by default. The user can continue to interact with the application normally while the tray notification is displayed.

## 4.6.2. Customizing Notifications

All of the features of specific notification types can be controlled with the **Notification** properties. Once configured, you need to show it in the current page.

```
// Notification with default settings for a warning
Notification notif = new Notification(
    "Warning",
    "<br/>Area of reindeer husbandry",
    Notification.TYPE_WARNING_MESSAGE);

// Customize it
notif.setDelayMsec(20000);
notif.setPosition(Position.BOTTOM_RIGHT);
notif.setStyleName("mystyle");
notif.setIcon(new ThemeResource("img/reindeer.png"));

// Show it in the page
notif.show(Page.getCurrent());
```

The `setPosition()` method allows setting the positioning of the notification. The position can be specified by any of the constants defined in the **Position** enum.

The `setDelayMSec()` allows setting the time for how long the notification is displayed in milliseconds. Parameter value `-1` means that the message is displayed until the user clicks the message box. It also prevents interaction with other parts of the application window, which is the default behaviour for error notifications. It does not, however, add a close box that the error notification has.

## 4.6.3. Styling with CSS

```
.v-Notification {}
.popUpContent {}
.gwt-HTML {}
```

```
h1 {}  
p {}
```

The notification box is a floating `div` element under the `body` element of the page. It has an overall `v-Notification` style. The content is wrapped inside an element with `popupContent` style. The caption is enclosed within an `h1` element and the description in a `p` element.

To customize it, add a style for the **Notification** object with `setStyleName( "mystyle" )`, and make the settings in the theme, for example as follows:

```
.v-Notification.mystyle {  
    background: #FFFF00;  
    border: 10px solid #C00000;  
    color: black;  
}
```

The result is shown, with the icon set earlier in the customization example, in Figure 4.12, “A Styled Notification”.

**Figure 4.12. A Styled Notification**



## 4.7. Application Lifecycle

In this section, we look into more technical details of application deployment, user sessions, and UI instance lifecycle. These details are not generally needed for writing Vaadin applications, but may be useful for understanding how they actually work and, especially, in what circumstances their execution ends.

### 4.7.1. Deployment

Before a Vaadin application can be used, it has to be deployed to a Java web server, as described in Section 4.8, “Deploying an Application”. Deploying reads the servlet classes annotated with the `@WebServlet` annotation (Servlet 3.0) or the `web.xml` deployment descriptor (Servlet 2.4) in the application to register servlets for specific URL paths and loads the classes. Deployment does not yet normally run any code in the application, although static blocks in classes are executed when they are loaded.

### Undeploying and Redeploying

Applications are undeployed when the server shuts down, during redeployment, and when they are explicitly undeployed. Undeploying a server-side Vaadin application ends its execution, all application classes are unloaded, and the heap space allocated by the application is freed for garbage-collection.

If any user sessions are open at this point, the client-side state of the UIs is left hanging and an Out of Sync error is displayed on the next server request.

## Redeployment and Serialization

Some servers, such as Tomcat, support *hot deployment*, where the classes are reloaded while preserving the memory state of the application. This is done by serializing the application state and then deserializing it after the classes are reloaded. This is, in fact, done with the basic Eclipse setup with Tomcat and if a UI is marked as `@PreserveOnRefresh`, you may actually need to give the `?restartApplication` URL parameter to force it to restart when you reload the page. Tools such as JRebel go even further by reloading the code in place without need for serialization. The server can also serialize the application state when shutting down and restarting, thereby preserving sessions over restarts.

Serialization requires that the applications are *serializable*, that is, all classes implement the `Serializable` interface. All Vaadin classes do. If you extend them or implement interfaces, you can provide an optional serialization key, which is automatically generated by Eclipse if you use it. Serialization is also used for clustering and cloud computing, such as with Google App Engine, as described in Section 11.7, “Google App Engine Integration”.

### 4.7.2. Vaadin Servlet, Portlet, and Service

The `VaadinServlet`, or `VaadinPortlet` in a portal, receives all server requests mapped to it by its URL, as defined in the deployment configuration, and associates them with sessions. The sessions further associate the requests with particular UIs.

When servicing requests, the Vaadin servlet or portlet handles all tasks common to both servlets and portlets in a `VaadinService`. It manages sessions, gives access to the deployment configuration information, handles system messages, and does various other tasks. Any further servlet or portlet specific tasks are handled in the corresponding `VaadinServletService` or `VaadinPortletService`. The service acts as the primary low-level customization layer for processing requests.

#### Customizing Vaadin Servlet

Many common configuration tasks need to be done in the servlet class, which you already have if you are using the `@WebServlet` annotation for Servlet 3.0 to deploy the application. You can handle most customization by overriding the `servletInitialized()` method, where the `VaadinService` object is available with `getService()` (it would not be available in a constructor). You should always call `super.servletInitialized()` in the beginning.

```
public class MyServlet extends VaadinServlet {  
    @Override  
    protected void servletInitialized()  
        throws ServletException {  
        super.servletInitialized();  
  
        ...  
    }  
}
```

To add custom functionality around request handling, you can override the `service()` method.

To use the custom servlet class in a Servlet 2.4 project, you need to define it in the `web.xml` deployment descriptor instead of the regular `VaadinServlet` class, as described in Section 4.8.4, “Using a `web.xml` Deployment Descriptor”.

## Customizing Vaadin Portlet

*To Be Done*

## Customizing Vaadin Service

To customize **VaadinService**, you first need to extend the **VaadinServlet** or **-Portlet** class and override the `createServletService()` to create a custom service object.

### 4.7.3. User Session

A user session begins when a user first makes a request to a Vaadin servlet or portlet by opening the URL for a particular **UI**. All server requests belonging to a particular UI class are processed by the **VaadinServlet** or **VaadinPortlet** class. When a new client connects, it creates a new user session, represented by an instance of **VaadinSession**. Sessions are tracked using cookies stored in the browser.

You can obtain the **VaadinSession** of a **UI** with `getSession()` or globally with `VaadinSession.getCurrent()`. It also provides access to the lower-level session objects, `HttpSession` and `PortletSession`, through a **WrappedSession**. You can also access the deployment configuration through **VaadinSession**, as described in Section 4.8.7, “Deployment Configuration”.

A session ends after the last **UI** instance expires or is closed, as described later.

## Handling Session Initialization and Destruction

You can handle session initialization and destruction by implementing a `SessionInitListener` or `SessionDestroyListener`, respectively, to the **VaadinService**. You can do that best by extending **VaadinServlet** and overriding the `servletInitialized()` method, as outlined in Section 4.7.2, “Vaadin Servlet, Portlet, and Service”.

```
public class MyServlet extends VaadinServlet
    implements SessionInitListener, SessionDestroyListener {

    @Override
    protected void servletInitialized() throws ServletException {
        super.servletInitialized();
        getService().addSessionInitListener(this);
        getService().addSessionDestroyListener(this);
    }

    @Override
    public void sessionInit(SessionInitEvent event)
        throws ServiceException {
        // Do session start stuff here
    }

    @Override
    public void sessionDestroy(SessionDestroyEvent event) {
        // Do session end stuff here
    }
}
```

If using Servlet 2.4, you need to configure the custom servlet class in the `servlet-class` parameter in the `web.xml` descriptor instead of the **VaadinServlet**, as described in Section 4.8.4, “Using a `web.xml` Deployment Descriptor”.

#### 4.7.4. Loading a UI

When a browser first accesses a URL mapped to the servlet of a particular UI class, the Vaadin servlet generates a loader page. The page loads the client-side engine (widget set), which in turn loads the UI in a separate request to the Vaadin servlet.

A **UI** instance is created when the client-side engine makes its first request. The servlet creates the UIs using a **UIProvider** registered in the **VaadinSession** instance. A session has at least a **DefaultUIProvider** for managing UIs opened by the user. If the application lets the user open popup windows with a **BrowserWindowOpener**, each of them has a dedicated special UI provider.

Once a new UI is created, its `init()` method is called. The method gets the request as a **VaadinRequest**.

#### Customizing the Loader Page

The HTML content of the loader page is generated as an HTML DOM object, which can be customized by implementing a **BootstrapListener** that modifies the DOM object. To do so, you need to extend the **VaadinServlet** and add a **SessionInitListener** to the service object, as outlined in Section 4.7.3, “User Session”. You can then add the bootstrap listener to a session with `addBootstrapListener()` when the session is initialized.

Loading the widget set is handled in the loader page with functions defined in a separate `vaadinBootstrap.js` script.

You can also use entirely custom loader code, such as in a static HTML page, as described in Section 11.2, “Embedding UIs in Web Pages”.

#### Custom UI Providers

You can create UI objects dynamically according to their request parameters, such as the URL path, by defining a custom **UIProvider**. You need to add custom UI providers to the session object which calls them. The providers are chained so that they are requested starting from the one added last, until one returns a UI (otherwise they return null). You can add a UI provider to a session most conveniently by implementing a custom servlet and adding the UI provider to sessions in a **SessionInitListener**.

You can find an example of custom UI providers in Section 20.8.1, “Providing a Fallback UI”.

#### Preserving UI on Refresh

Reloading a page in the browser normally spawns a new **UI** instance and the old UI is left hanging, until cleaned up after a while. This can be undesired as it resets the UI state for the user. To preserve the UI, you can use the **@PreserveOnRefresh** annotation for the UI class. You can also use a **UIProvider** with a custom implementation of `isUiPreserved()`.

```
@PreserveOnRefresh  
public class MyUI extends UI {
```

Adding the `?restartApplication` parameter in the URL tells the Vaadin servlet to create a new **UI** instance when loading the page, thereby overriding the **@PreserveOnRefresh**. This is often necessary when developing such a UI in Eclipse, when you need to restart it after redeploying, because Eclipse likes to persist the application state between redeployments. If you also include a URI fragment, the parameter should be given before the fragment.

## 4.7.5. UI Expiration

**UI** instances are cleaned up if no communication is received from them after some time. If no other server requests are made, the client-side sends keep-alive heartbeat requests. A UI is kept alive for as long as requests or heartbeats are received from it. It expires if three consecutive heartbeats are missed.

The heartbeats occur at an interval of 5 minutes, which can be changed with the `heartbeatInterval` parameter of the servlet. You can configure the parameter in **@VaadinServletConfiguration** or in `web.xml` as described in Section 4.8.6, “Other Servlet Configuration Parameters”.

When the UI cleanup happens, a **DetachEvent** is sent to all **DetachListeners** added to the UI. When the UI is detached from the session, `detach()` is called for it.

## 4.7.6. Closing UIs Explicitly

You can explicitly close a UI with `close()`. The method marks the UI to be detached from the session after processing the current request. Therefore, the method does not invalidate the UI instance immediately and the response is sent as usual.

Detaching a UI does not close the page or browser window in which the UI is running and further server request will cause error. Typically, you either want to close the window, reload it, or redirect it to another URL. If the page is a regular browser window or tab, browsers generally do not allow closing them programmatically, but redirection is possible. You can redirect the window to another URL with `setLocation()`, as is done in the examples in Section 4.7.8, “Closing a Session”. You can close popup windows by making JavaScript `close()` call for them, as described in Section 11.1.2, “Closing Popup Windows”.

If you close other UI than the one associated with the current request, they will not be detached at the end of the current request, but after next request from the particular UI. You can make that occur quicker by making the UI heartbeat faster or immediately by using server push.

## 4.7.7. Session Expiration

A session is kept alive by server requests caused by user interaction with the application as well as the heartbeat monitoring of the UIs. Once all UIs have expired, the session still remains. It is cleaned up from the server when the session timeout configured in the web application expires.

If there are active UIs in an application, their heartbeat keeps the session alive indefinitely. You may want to have the sessions timeout if the user is inactive long enough, which is the original purpose of the session timeout setting. If the `closeIdleSessions` parameter of the servlet is set to `true` in the `web.xml`, as described in Section 4.8.4, “Using a `web.xml` Deployment Descriptor”, the session and all of its UIs are closed when the timeout specified by the `session-timeout` parameter of the servlet expires after the last non-heartbeat request. Once the session is gone, the browser will show an Out Of Sync error on the next server request. To avoid the ugly message, you may want to set a redirect URL for the UIs, as described in Section 4.5.2, “Customizing System Messages”.

The related configuration parameters are described in Section 4.8.6, “Other Servlet Configuration Parameters”.

You can handle session expiration on the server-side with a `SessionDestroyListener`, as described in Section 4.7.3, “User Session”.

#### 4.7.8. Closing a Session

You can close a session by calling `close()` on the **VaadinSession**. It is typically used when logging a user out and the session and all the UIs belonging to the session should be closed. The session is closed immediately and any objects related to it are not available after calling the method.

When closing the session from a UI, you typically want to redirect the user to another URL. You can do the redirect using the `setLocation()` method in **Page**. This needs to be done before closing the session, as the UI or page are not available after that. In the following example, we display a logout button, which closes the user session.

```
public class MyUI extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        setContent(new Button("Logout", event -> { // Java 8  
            // Redirect this page immediately  
            getPage().setLocation("/myapp/logout.html");  
  
            // Close the session  
            getSession().close();  
        }));  
  
        // Notice quickly if other UIs are closed  
        setPollInterval(3000);  
    }  
}
```

This is not enough. When a session is closed from one UI, any other UIs attached to it are left hanging. When the client-side engine notices that a UI and the session are gone on the server-side, it displays a "Session Expired" message and, by default, reloads the UI when the message is clicked. You can customize the message and the redirect URL in the system messages, as described in Section 4.5.2, "Customizing System Messages".

The client-side engine notices the expiration when user interaction causes a server request to be made or when the keep-alive heartbeat occurs. To make the UIs detect the situation faster, you need to make the heart beat faster, as was done in the example above. You can also use server push to close the other UIs immediately, as is done in the following example. Access to the UIs must be synchronized as described in Section 11.16, "Server Push".

```
@Push  
public class MyPushyUI extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        setContent(new Button("Logout", event -> { // Java 8  
            for (UI ui: VaadinSession.getCurrent().getUIs())  
                ui.access(() -> {  
                    // Redirect from the page  
                    ui.getPage().setLocation("/logout.html");  
                });  
  
            getSession().close();  
        }));  
    }  
}
```

In the above example, we assume that all UIs in the session have push enabled and that they should be redirected; popups you might want to close instead of redirecting. It is not necessary to call `close()` for them individually, as we close the entire session afterwards.

## 4.8. Deploying an Application

Vaadin applications are deployed as *Java web applications*, which can contain a number of servlets, each of which can be a Vaadin application or some other servlet, and static resources such as HTML files. Such a web application is normally packaged as a WAR (Web application ARchive) file, which can be deployed to a Java application server (or a servlet container to be exact). A WAR file, which has the `.war` extension, is a subtype of JAR (Java ARchive), and like a regular JAR, is a ZIP-compressed file with a special content structure.

For a detailed tutorial on how web applications are packaged, please refer to any Java book that discusses Java Servlets.

In the Java Servlet parlance, a "web application" means a collection of Java servlets or portlets, JSP and static HTML pages, and various other resources that form an application. Such a Java web application is typically packaged as a WAR package for deployment. Server-side Vaadin UIs run as servlets within such a Java web application. There exists also other kinds of web applications. To avoid confusion with the general meaning of "web application", we often refer to Java web applications with the slight misnomer "WAR" in this book.

### 4.8.1. Creating Deployable WAR in Eclipse

To deploy an application to a web server, you need to create a WAR package. Here we give the instructions for Eclipse.

1. Select **File Export** and then **Web WAR File**. Or, right-click the project in the Project Explorer and select **Web WAR File**.
2. Select the **Web project** to export. Enter **Destination** file name (`.war`).
3. Make any other settings in the dialog, and click **Finish**.

### 4.8.2. Web Application Contents

The following files are required in a web application in order to run it.

#### Web Application Organization

`WEB-INF/web.xml` (optional with Servlet 3.0)

This is the web application descriptor that defines how the application is organized, that is, what servlets and such it has. You can refer to any Java book about the contents of this file. It is not needed if you define the Vaadin servlet with the `@.WebServlet` annotation in Servlet API 3.0.

`WEB-INF/lib/*.jar`

These are the Vaadin libraries and their dependencies. They can be found in the installation package or as loaded by a dependency management system such as Maven or Ivy.

#### Your UI classes

You must include your UI classes either in a JAR file in `WEB-INF/lib` or as classes in `WEB-INF/classes`

#### Your own theme files (OPTIONAL)

If your application uses a special theme (look and feel), you must include it in `VAADIN/themes/themename` directory.

#### Widget sets (OPTIONAL)

If your application uses a project-specific widget set, it must be compiled in the `VAADIN/widgetset/` directory.

### 4.8.3. Web Servlet Class

When using the Servlet 3.0 API, you normally declare the Vaadin servlet classes with the `@WebServlet` annotation. The Vaadin UI associated with the servlet and other Vaadin-specific parameters are declared with a separate `@VaadinServletConfiguration` annotation.

```
@WebServlet(value = "/*",
             asyncSupported = true)
@VaadinServletConfiguration(
    productionMode = false,
    ui = MyProjectUI.class)
public class MyProjectServlet extends VaadinServlet { }
```

The Vaadin Plugin for Eclipse creates the servlet class as a static inner class of the UI class. Normally, you may want to have it as a separate regular class.

The `value` parameter is the URL pattern for mapping request URLs to the servlet, as described in Section 4.8.5, “Servlet Mapping with URL Patterns”. The `ui` parameter is the UI class. Production mode is disabled by default, which enables on-the-fly theme compilation, debug window, and other such development features. See the subsequent sections for details on the different servlet and Vaadin configuration parameters.

You can also use a `web.xml` deployment descriptor in Servlet 3.0 projects.

### 4.8.4. Using a `web.xml` Deployment Descriptor

A deployment descriptor is an XML file with the name `web.xml` in the `WEB-INF` sub-directory of a web application. It is a standard component in Java EE describing how a web application should be deployed. The descriptor is not required with Servlet API 3.0, where you can also define servlets with the `@WebServlet` annotation as described earlier, as web fragments, or programmatically. You can use both a `web.xml` and `WebServlet` in the same application. Settings in the `web.xml` override the ones given in annotations.

The following example shows the basic contents of a deployment descriptor for a Servlet 2.4 application. You simply specify the UI class with the `UI` parameter for the `com.vaadin.server.VaadinServlet`. The servlet is then mapped to a URL path in a standard way for Java Servlets.

```
<?xml version="1.0" encoding="UTF-8"?>
<web-app
    id="WebApp_ID" version="2.4"
    xmlns="http://java.sun.com/xml/ns/j2ee"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/j2ee
```

```
http://java.sun.com/xml/ns/j2ee/web-app_2_4.xsd">

<servlet>
    <servlet-name>myservlet</servlet-name>
    <servlet-class>
        com.vaadin.server.VaadinServlet
    </servlet-class>

    <init-param>
        <param-name>UI</param-name>
        <param-value>com.ex.myprj.MyUI</param-value>
    </init-param>

    <!-- If not using the default widget set-->
    <init-param>
        <param-name>widgetset</param-name>
        <param-value>com.ex.myprj.MyWidgetSet</param-value>
    </init-param>
</servlet>

<servlet-mapping>
    <servlet-name>myservlet</servlet-name>
    <url-pattern>/*</url-pattern>
</servlet-mapping>
</web-app>
```

The descriptor defines a servlet with the name `myservlet`. The servlet class, **com.vaadin.server.VaadinServlet**, is provided by Vaadin framework and is normally the same for all Vaadin projects. For some purposes, you may need to use a custom servlet class that extends the **VaadinServlet**. The class name must include the full package path.

## Servlet API Version

The descriptor example given above was for Servlet 2.4. For a later version, such as Servlet 3.0, you should use:

```
<web-app
    id="WebApp_ID" version="3.0"
    xmlns="http://java.sun.com/xml/ns/j2ee"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
        http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd">
```

Servlet 3.0 support is useful for at least server push.

## Widget Set

If the UI uses add-on components or custom widgets, it needs a custom widget set, which can be specified with the `widgetset` parameter for the servlet. Alternatively, you can define it with the `@WidgetSet` annotation for the UI class. The parameter is a class name with the same path but without the `.gwt.xml` extension as the widget set definition file. If the parameter is not given, the **com.vaadin.DefaultWidgetSet** is used, which contains all the widgets for the built-in Vaadin components.

Unless using the default widget set (which is included in the `vaadin-client-compiled` JAR), the widget set must be compiled, as described in Chapter 17, *Using Vaadin Add-ons* or Section 13.4, “Compiling a Client-Side Module”, and properly deployed with the application.

## 4.8.5. Servlet Mapping with URL Patterns

The servlet needs to be mapped to an URL path, which requests it is to handle.

With **@WebServlet** annotation for the servlet class:

```
@WebServlet(value = "/*", asyncSupported = true)
```

In a web.xml:

```
<servlet-mapping>
    <servlet-name>myservlet</servlet-name>
    <url-pattern>/*</url-pattern>
</servlet-mapping>
```

The URL pattern is defined in the above examples as `/*`. This matches any URL under the project context. We defined above the project context as `myproject` so the URL for the page of the UI will be `http://localhost:8080/myproject/`.

## Mapping Sub-Paths

If an application has multiple UIs or servlets, they have to be given different paths in the URL, matched by a different URL pattern. Also, you may need to have statically served content under some path. Having an URL pattern `/myui/*` would match a URL such as `http://localhost:8080/myproject/myui/`. Notice that the slash and the asterisk *must* be included at the end of the pattern. In such case, you also need to map URLs with `/VAADIN/*` to a servlet (unless you are serving it statically as noted below).

With a **@WebServlet** annotation for a servlet class, you can define multiple mappings as a list enclosed in curly braces as follows:

```
@WebServlet(value = {"/myui/*", "/VAADIN/*"}, 
            asyncSupported = true)
```

In a web.xml:

```
...
<servlet-mapping>
    <servlet-name>myservlet</servlet-name>
    <url-pattern>/myui/*</url-pattern>
</servlet-mapping>

<servlet-mapping>
    <servlet-name>myservlet</servlet-name>
    <url-pattern>/VAADIN/*</url-pattern>
</servlet-mapping>
```

If you have multiple servlets, you should specify only one `/VAADIN/*` mapping. It does not matter which servlet you map the pattern to, as long as it is a Vaadin servlet.

You do not have to provide the above `/VAADIN/*` mapping if you serve both the widget sets and (custom and default) themes statically in the `/VAADIN` directory in the web application. The mapping simply allows serving them dynamically from the Vaadin JAR. Serving them statically is recommended for production environments as it is faster. If you serve the content from within the same web application, you may not have the root pattern `/*` for the Vaadin servlet, as then all the requests would be mapped to the servlet.

## 4.8.6. Other Servlet Configuration Parameters

The servlet class or deployment descriptor can have many parameters and options that control the execution of a servlet. You can find complete documentation of the basic servlet parameters in the appropriate Java Servlet Specification. `@VaadinServletConfiguration` accepts a number of special parameters, as described below.

In a `web.xml`, you can set most parameters either as a `<context-param>` for the entire web application, in which case they apply to all Vaadin servlets, or as an `<init-param>` for an individual servlet. If both are defined, servlet parameters override context parameters.

### Production Mode

By default, Vaadin applications run in *debug mode* (or *development mode*), which should be used during development. This enables various debugging features. For production use, you should have the `productionMode=true` setting in the `@VaadinServletConfiguration`, or in `web.xml`:

```
<context-param>
    <param-name>productionMode</param-name>
    <param-value>true</param-value>
    <description>Vaadin production mode</description>
</context-param>
```

The parameter and the debug and production modes are described in more detail in Section 11.3, “Debug Mode and Window”.

### Custom UI Provider

Vaadin normally uses the `DefaultUIProvider` for creating `UI` class instances. If you need to use a custom UI provider, you can define its class with the `UIProvider` parameter. The provider is registered in the `VaadinSession`.

In a `web.xml`:

```
<servlet>
    ...
    <init-param>
        <param-name>UIProvider</param-name>
        <param-value>com.ex.my.MyUIProvider</param-value>
    </init-param>
```

The parameter is logically associated with a particular servlet, but can be defined in the context as well.

### UI Heartbeat

Vaadin follows UIs using a heartbeat, as explained in Section 4.7.5, “UI Expiration”. If the user closes the browser window of a Vaadin application or navigates to another page, the Client-Side Engine running in the page stops sending heartbeat to the server, and the server eventually cleans up the `UI` instance.

The interval of the heartbeat requests can be specified in seconds with the `heartbeatInterval` parameter either as a context parameter for the entire web application or an init parameter for the individual servlet. The default value is 300 seconds (5 minutes).

In a `web.xml`:

```
<context-param>
    <param-name>heartbeatInterval</param-name>
    <param-value>300</param-value>
</context-param>
```

## Session Timeout After User Inactivity

In normal servlet operation, the session timeout defines the allowed time of inactivity after which the server should clean up the session. The inactivity is measured from the last server request. Different servlet containers use varying defaults for timeouts, such as 30 minutes for Apache Tomcat. You can set the timeout under `<web-app>` with:

In a `web.xml`:

```
<session-config>
    <session-timeout>30</session-timeout>
</session-config>
```

The session timeout should be longer than the heartbeat interval or otherwise sessions are closed before the heartbeat can keep them alive. As the session expiration leaves the UIs in a state where they assume that the session still exists, this would cause an Out Of Sync error notification in the browser.

However, having a shorter heartbeat interval than the session timeout, which is the normal case, prevents the sessions from expiring. If the `closeIdleSessions` parameter for the servlet is enabled (disabled by default), Vaadin closes the UIs and the session after the time specified in the `session-timeout` parameter expires after the last non-heartbeat request.

In a `web.xml`:

```
<servlet>
    ...
    <init-param>
        <param-name>closeIdleSessions</param-name>
        <param-value>true</param-value>
    </init-param>
```

## Push Mode

You can enable server push, as described in Section 11.16, “Server Push”, for a UI either with a `@Push` annotation for the UI or in the descriptor. The push mode is defined with a `pushmode` parameter. The `automatic` mode pushes changes to the browser automatically after `access()` finishes. With `manual` mode, you need to do the push explicitly with `push()`. If you use a Servlet 3.0 compatible server, you also want to enable asynchronous processing with the `async-supported` parameter.

In a `web.xml`:

```
<servlet>
    ...
    <init-param>
        <param-name>pushmode</param-name>
        <param-value>automatic</param-value>
    </init-param>
    <async-supported>true</async-supported>
```

## Cross-Site Request Forgery Prevention

Vaadin uses a protection mechanism to prevent malicious cross-site request forgery (XSRF or CSRF), also called one-click attacks or session riding, which is a security exploit for executing unauthorized commands in a web server. This protection is normally enabled. However, it prevents some forms of testing of Vaadin applications, such as with JMeter. In such cases, you can disable the protection by setting the `disable-xsrf-protection` parameter to true.

In a `web.xml`:

```
<context-param>
    <param-name>disable-xsrf-protection</param-name>
    <param-value>true</param-value>
</context-param>
```

### 4.8.7. Deployment Configuration

The Vaadin-specific parameters defined in the deployment configuration are available from the **DeploymentConfiguration** object managed by the **VaadinSession**.

```
DeploymentConfiguration conf =
    getSession().getConfiguration();

// Heartbeat interval in seconds
int heartbeatInterval = conf.getHeartbeatInterval();
```

Parameters defined in the Java Servlet definition, such as the session timeout, are available from the low-level **HttpSession** or **PortletSession** object, which are wrapped in a **WrappedSession** in Vaadin. You can access the low-level session wrapper with `getSession()` of the **VaadinSession**.

```
WrappedSession session = getSession().getSession();
int sessionTimeout = session.getMaxInactiveInterval();
```

You can also access other **HttpSession** and **PortletSession** session properties through the interface, such as set and read session attributes that are shared by all servlets belonging to a particular servlet or portlet session.

---

# Chapter 5

# User Interface Components

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This chapter provides an overview and a detailed description of all non-layout components in Vaadin.

*Because of pressing release schedules to get this edition to your hands, some topics still require revision for Vaadin 7, especially the data binding of the **Table** component. Please consult the web version once it is updated, or the next print edition.*

## 5.1. Overview

Vaadin provides a comprehensive set of user interface components and allows you to define custom components. Figure 5.1, “User Interface Component Class Hierarchy” illustrates the inheritance hierarchy of the UI component classes and interfaces. Interfaces are displayed in gray, abstract classes in orange, and regular classes in blue. An annotated version of the diagram is featured in the [Vaadin Cheat Sheet](#).

At the top of the interface hierarchy, we have the **Component** interface. At the top of the class hierarchy, we have the **AbstractComponent** class. It is inherited by two other abstract classes: **AbstractField**, inherited further by field components, and **AbstractComponentContainer**, inherited by various container and layout components. Components that are not bound to a content data model, such as labels and links, inherit **AbstractComponent** directly.

The layout of the various components in a window is controlled, logically, by layout components, just like in conventional Java UI toolkits for desktop applications. In addition, with the **CustomLayout** component, you can write a custom layout as an HTML template that includes the locations of any contained components. Looking at the inheritance diagram, we can see that layout components inherit the **AbstractComponentContainer** and the **Layout** interface. Layout components are described in detail in Chapter 6, *Managing Layout*.

Looking at it from the perspective of an object hierarchy, we would have a **Window** object, which contains a hierarchy of layout components, which again contain other layout components, field components, and other visible components.

You can browse the built-in UI components of Vaadin library in the Sampler application of the Vaadin Demo. The Sampler shows a description, JavaDoc documentation, and a code samples for each of the components.

In addition to the built-in components, many components are available as add-ons, either from the Vaadin Directory or from independent sources. Both commercial and free components exist. The installation of add-ons is described in Chapter 17, *Using Vaadin Add-ons*.

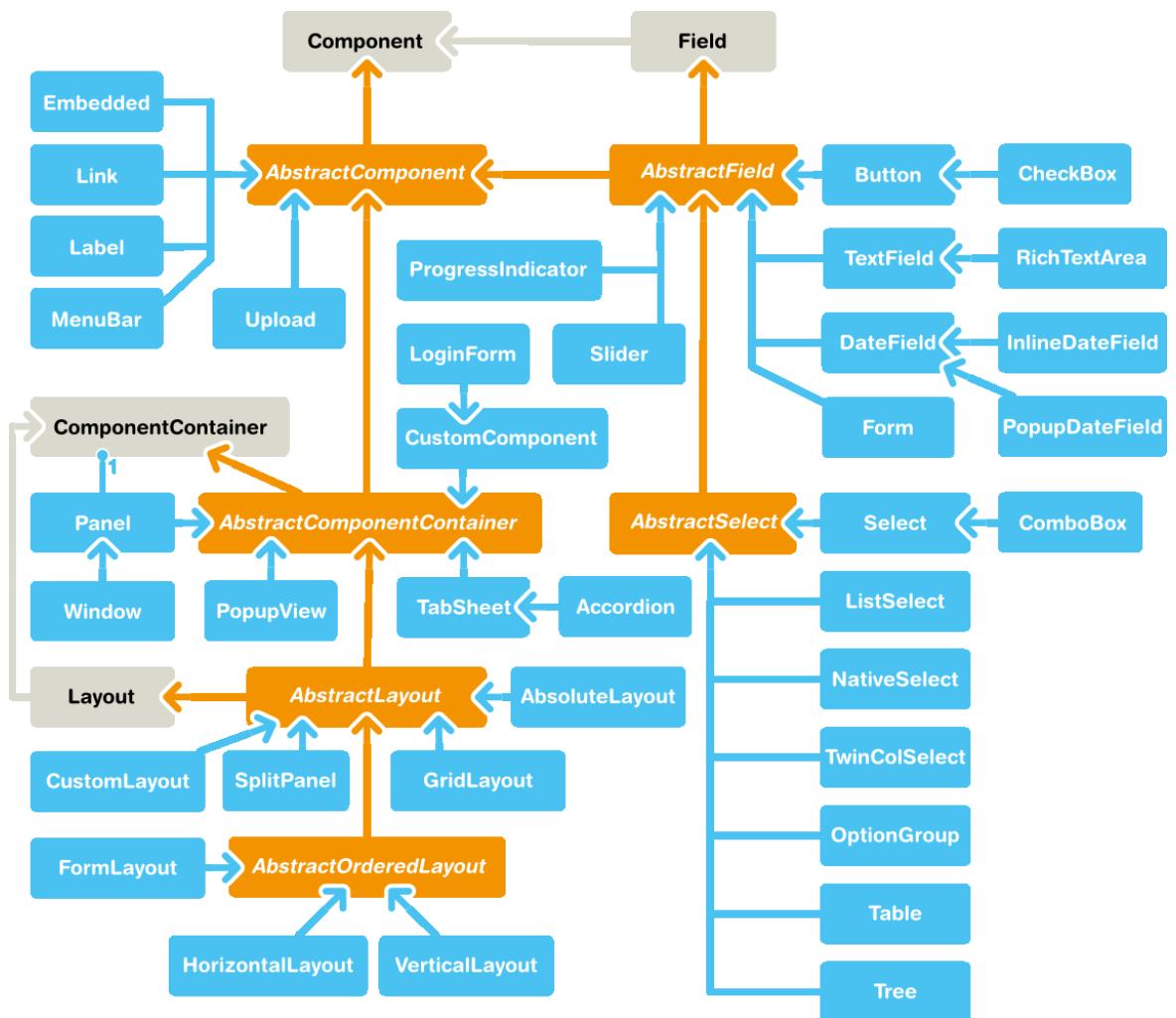
**Figure 5.1. User Interface Component Class Hierarchy****Vaadin Cheat Sheet and Refcard**

Figure 5.1, “User Interface Component Class Hierarchy” is included in the Vaadin Cheat Sheet that illustrates the basic relationship hierarchy of the user interface components and data binding classes and interfaces. You can download it at <http://vaadin.com/book>.

The diagram is also included in the six-page DZone Refcard, which you can find at <https://vaadin.com/refcard>.

## 5.2. Interfaces and Abstractions

Vaadin user interface components are built on a skeleton of interfaces and abstract classes that define and implement the features common to all components and the basic logic how the component states are serialized between the server and the client.

This section gives details on the basic component interfaces and abstractions. The layout and other component container abstractions are described in Chapter 6, *Managing Layout*. The inter-

faces that define the Vaadin data model are described in Chapter 8, *Binding Components to Data*.

All components also implement the **Paintable** interface, which is used for serializing ("painting") the components to the client, and the reverse **VariableOwner** interface, which is needed for deserializing component state or user interaction from the client.

In addition to the interfaces defined within the Vaadin framework, all components implement the **java.io.Serializable** interface to allow serialization. Serialization is needed in many clustering and cloud computing solutions.

## 5.2.1. Component Interface

The **Component** interface is paired with the **AbstractComponent** class, which implements all the methods defined in the interface.

### Component Tree Management

Components are laid out in the user interface hierarchically. The layout is managed by layout components, or more generally components that implement the **ComponentContainer** interface. Such a container is the parent of the contained components.

The `getParent()` method allows retrieving the parent component of a component. While there is a `setParent()`, you rarely need it as you usually add components with the `addComponent()` method of the **ComponentContainer** interface, which automatically sets the parent.

A component does not know its parent when the component is still being created, so you can not refer to the parent in the constructor with `getParent()`.

Attaching a component to an UI triggers a call to its `attach()` method. Correspondingly, removing a component from a container triggers calling the `detach()` method. If the parent of an added component is already connected to the UI, the `attach()` is called immediately from `setParent()`.

```
public class AttachExample extends CustomComponent {
    public AttachExample() {
    }

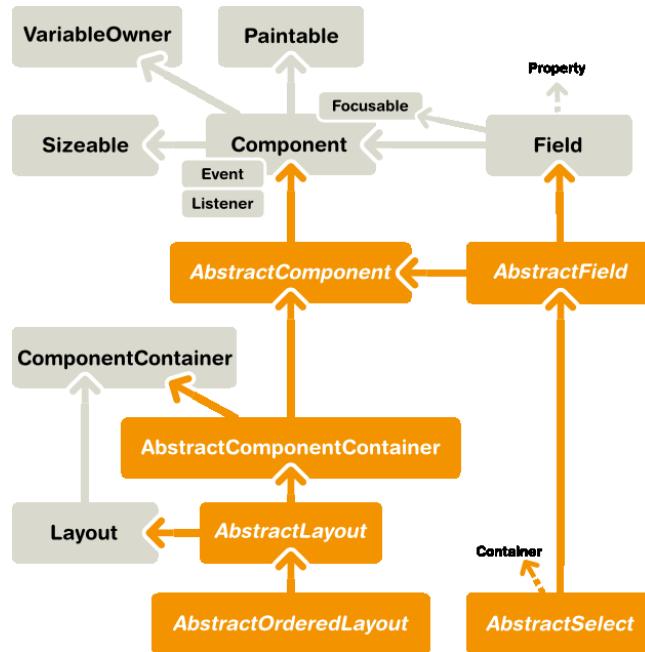
    @Override
    public void attach() {
        super.attach(); // Must call.

        // Now we know who ultimately owns us.
        ClassResource r = new ClassResource("smiley.jpg");
        Image image = new Image("Image:", r);
        setCompositionRoot(image);
    }
}
```

The attachment logic is implemented in **AbstractComponent**, as described in Section 5.2.2, “**AbstractComponent**”.

## 5.2.2. AbstractComponent

**AbstractComponent** is the base class for all user interface components. It is the (only) implementation of the **Component** interface, implementing all the methods defined in the interface.

**Figure 5.2. Component Interfaces and Abstractions**

**AbstractComponent** has a single abstract method, `getTag()`, which returns the serialization identifier of a particular component class. It needs to be implemented when (and only when) creating entirely new components. **AbstractComponent** manages much of the serialization of component states between the client and the server. Creation of new components and serialization is described in Chapter 16, *Integrating with the Server-Side*.

## 5.3. Common Component Features

The component base classes and interfaces provide a large number of features. Let us look at some of the most commonly needed features. Features not documented here can be found from the Java API Reference.

The interface defines a number of properties, which you can retrieve or manipulate with the corresponding setters and getters.

### 5.3.1. Caption

A caption is an explanatory textual label accompanying a user interface component, usually shown above, left of, or inside the component. The contents of a caption are automatically quoted, so no raw HTML can be rendered in a caption.

The caption text can usually be given as the first parameter of a constructor of a component or with `setCaption()`.

```
// New text field with caption "Name"
TextField name = new TextField( "Name" );
layout.addComponent(name);
```

The caption of a component is, by default, managed and displayed by the layout component or component container inside which the component is placed. For example, the **VerticalLayout** component shows the captions left-aligned above the contained components, while the **Form**-

**Layout** component shows the captions on the left side of the vertically laid components, with the captions and their associated components left-aligned in their own columns. The **CustomComponent** does not manage the caption of its composition root, so if the root component has a caption, it will not be rendered.

Some components, such as **Button** and **Panel**, manage the caption themselves and display it inside the component.

Icon (see Section 5.3.4, “Icon”) is closely related to caption and is usually displayed horizontally before or after it, depending on the component and the containing layout. Also the required indicator in field components is usually shown before or after the caption.

An alternative way to implement a caption is to use another component as the caption, typically a **Label**, a **TextField**, or a **Panel**. A **Label**, for example, allows highlighting a shortcut key with HTML markup or to bind the caption to a data source. The **Panel** provides an easy way to add both a caption and a border around a component.

## CSS Style Rules

```
.v-caption {}  
.v-captiontext {}  
.v-caption-clear elem {}  
.v-required-field-indicator {}
```

A caption is be rendered inside an HTML element that has the `v-caption` CSS style class. The containing layout may enclose a caption inside other caption-related elements.

Some layouts put the caption text in a `v-captiontext` element. A `v-caption-clear elem` is used in some layouts to clear a CSS `float` property in captions. An optional required indicator in field components is contained in a separate element with `v-required-field-indicator` style.

### 5.3.2. Description and Tooltips

All components (that inherit **AbstractComponent**) have a description separate from their caption. The description is usually shown as a tooltip that appears when the mouse pointer hovers over the component for a short time.

You can set the description with `setDescription()` and retrieve with `getDescription()`.

```
Button button = new Button("A Button");  
button.setDescription("This is the tooltip");
```

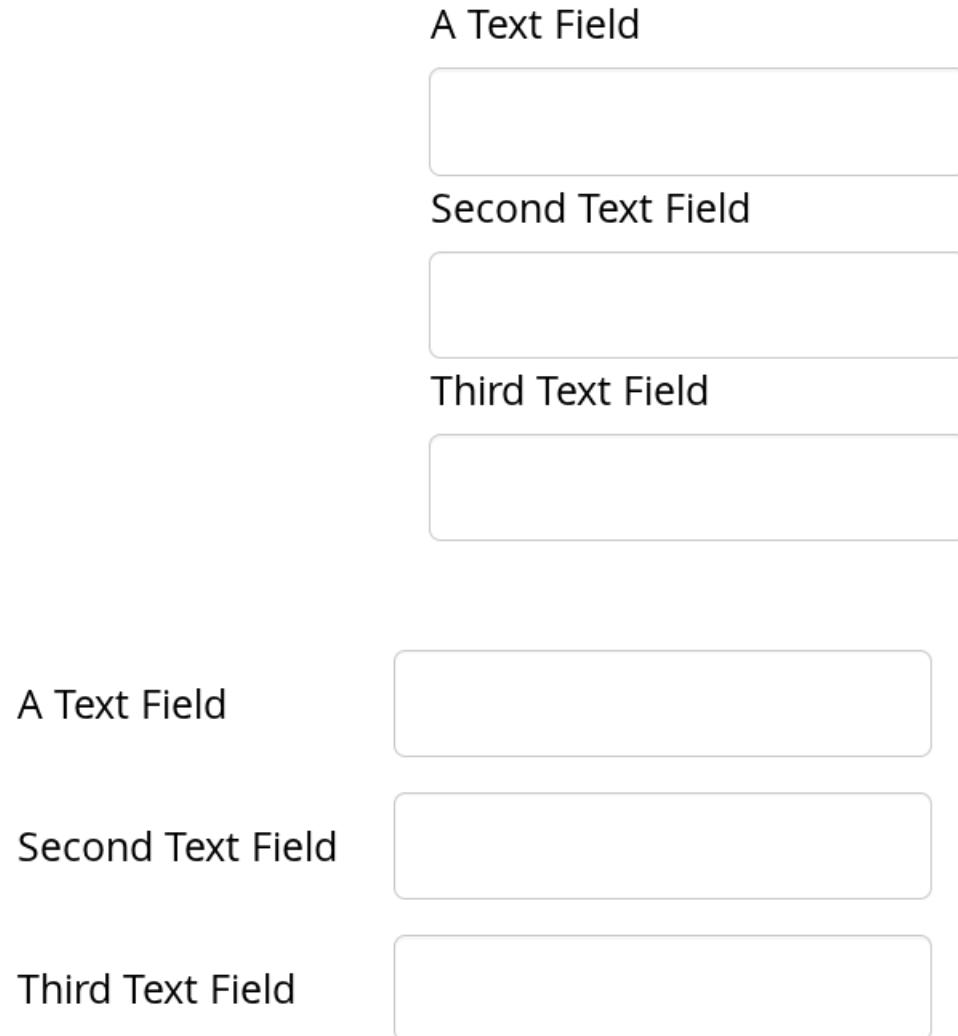
The tooltip is shown in Figure 5.4, “Component Description as a Tooltip”.

#### Figure 5.4. Component Description as a Tooltip



A description is rendered as a tooltip in most components.

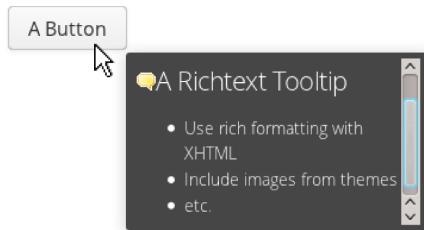
When a component error has been set with `setComponentError()`, the error is usually also displayed in the tooltip, below the description. Components that are in error state will also display the error indicator. See Section 4.5.1, “Error Indicator and Message”.

**Figure 5.3. Caption Management by VerticalLayout and FormLayout.**

The description is actually not plain text, but you can use HTML tags to format it. Such a rich text description can contain any HTML elements, including images.

```
button.setDescription(  
    "<h2><img src=\"../VAADIN/themes/sampler/icons/comment_yellow.gif\" />" +  
    "A richtext tooltip</h2>" +  
    "<ul>" +  
    "  <li>Use rich formatting with HTML</li>" +  
    "  <li>Include images from themes</li>" +  
    "  <li>etc.</li>" +  
    "</ul>");
```

The result is shown in Figure 5.5, “A Rich Text Tooltip”.

**Figure 5.5. A Rich Text Tooltip**

Notice that the setter and getter are defined for all fields in the **Field** interface, not for all components in the **Component** interface.

### 5.3.3. Enabled

The *enabled* property controls whether the user can actually use the component. A disabled component is visible, but grayed to indicate the disabled state.

Components are always enabled by default. You can disable a component with `setEnabled(false)`.

```
Button enabled = new Button("Enabled");
enabled.setEnabled(true); // The default
layout.addComponent(enabled);

Button disabled = new Button("Disabled");
disabled.setEnabled(false);
layout.addComponent(disabled);
```

Figure 5.6, “An Enabled and Disabled **Button**” shows the enabled and disabled buttons.

**Figure 5.6. An Enabled and Disabled Button**

A disabled component is automatically put in read-only state. No client interaction with such a component is sent to the server and, as an important security feature, the server-side components do not receive state updates from the client in the read-only state. This feature exists in all built-in components in Vaadin and is automatically handled for all **Field** components for the field property value. For custom widgets, you need to make sure that the read-only state is checked on the server-side for all safety-critical variables.

## CSS Style Rules

Disabled components have the `v-disabled` CSS style in addition to the component-specific style. To match a component with both the styles, you have to join the style class names with a dot as done in the example below.

```
.v-textfield.v-disabled {
    border: dotted;
}
```

This would make the border of all disabled text fields dotted.

In Valo theme, the opacity of disabled components is specified with the `$v-disabled-opacity` parameter, as described in Section 7.6.2, “Common Settings”.

### 5.3.4. Icon

An icon is an explanatory graphical label accompanying a user interface component, usually shown above, left of, or inside the component. Icon is closely related to caption (see Section 5.3.1, “Caption”) and is usually displayed horizontally before or after it, depending on the component and the containing layout.

The icon of a component can be set with the `setIcon()` method. The image is provided as a resource, perhaps most typically a **ThemeResource**.

```
// Component with an icon from a custom theme
TextField name = new TextField("Name");
name.setIcon(new ThemeResource("icons/user.png"));
layout.addComponent(name);

// Component with an icon from another theme ('runo')
Button ok = new Button("OK");
ok.setIcon(new ThemeResource("../runo/icons/16/ok.png"));
layout.addComponent(ok);
```

The icon of a component is, by default, managed and displayed by the layout component or component container in which the component is placed. For example, the **VerticalLayout** component shows the icons left-aligned above the contained components, while the **FormLayout** component shows the icons on the left side of the vertically laid components, with the icons and their associated components left-aligned in their own columns. The **CustomComponent** does not manage the icon of its composition root, so if the root component has an icon, it will not be rendered.

**Figure 5.7. Displaying an Icon from a Theme Resource.**



Some components, such as **Button** and **Panel**, manage the icon themselves and display it inside the component.

In addition to image resources, you can use *font icons*, which are icons included in special fonts, but which are handled as special resources. See Section 7.7, “Font Icons” for more details.

### CSS Style Rules

An icon will be rendered inside an HTML element that has the `v-icon` CSS style class. The containing layout may enclose an icon and a caption inside elements related to the caption, such as `v-caption`.

### 5.3.5. Locale

The locale property defines the country and language used in a component. You can use the locale information in conjunction with an internationalization scheme to acquire localized resources. Some components, such as **DateField**, use the locale for component localization.

You can set the locale of a component (or the application) with `setLocale()` as follows:

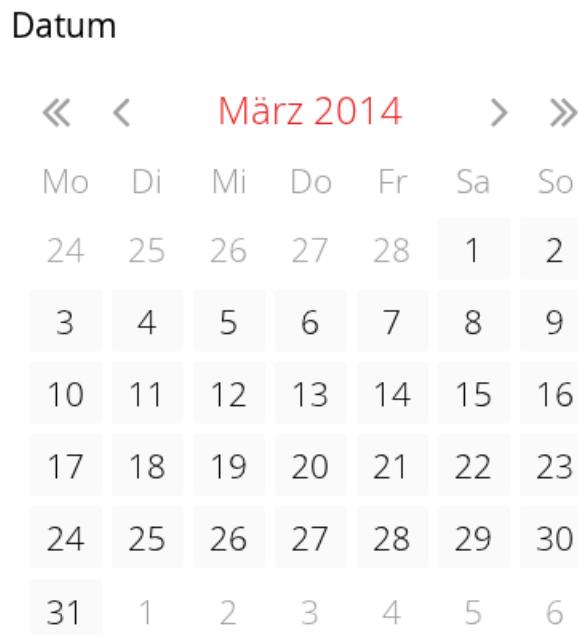
```
// Component for which the locale is meaningful
InlineDateField date = new InlineDateField("Datum");

// German language specified with ISO 639-1 language
// code and ISO 3166-1 alpha-2 country code.
date.setLocale(new Locale("de", "DE"));

date.setResolution(Resolution.DAY);
layout.addComponent(date);
```

The resulting date field is shown in Figure 5.8, “Set Locale for **InlineDateField**”.

**Figure 5.8. Set Locale for **InlineDateField****



### Getting the Locale

You can get the locale of a component with `getLocale()`. If the locale is undefined for a component, that is, not explicitly set, the locale of the parent component is used. If none of the parent components have a locale set, the locale of the UI is used, and if that is not set, the default system locale is set, as given by `Locale.getDefault()`.

The `getLocale()` returns null if the component is not yet attached to the UI, which is usually the case in most constructors, so it is a bit awkward to use it for internationalization. You can get the locale in `attach()`, as shown in the following example:

```
Button cancel = new Button() {
    @Override
    public void attach() {
        super.attach();
        ResourceBundle bundle = ResourceBundle.getBundle(
            MyAppCaptions.class.getName(), getLocale());
        setCaption(bundle.getString(MyAppCaptions.CancelKey));
    }
};
layout.addComponent(cancel);
```

However, it is normally a better practice to use the locale of the current UI to get the localized resource right when the component is created.

```
// Captions are stored in MyAppCaptions resource bundle
// and the UI object is known in this context.
ResourceBundle bundle =
    ResourceBundle.getBundle(MyAppCaptions.class.getName(),
        UI.getCurrent().getLocale());

// Get a localized resource from the bundle
Button cancel =
    new Button(bundle.getString(MyAppCaptions.CancelKey));
layout.addComponent(cancel);
```

## Selecting a Locale

A common task in many applications is selecting a locale. This is done in the following example with a **ComboBox**, which gets the available locales in Java.

```
// The locale in which we want to have the language
// selection list
Locale displayLocale = Locale.ENGLISH;

// All known locales
final Locale[] locales = Locale.getAvailableLocales();

// Allow selecting a language. We are in a constructor of a
// CustomComponent, so preselecting the current
// language of the application can not be done before
// this (and the selection) component are attached to
// the application.
final ComboBox select = new ComboBox("Select a language") {
    @Override
    public void attach() {
        super.attach();
        setValue(getLocale());
    }
};
for (int i=0; i<locales.length; i++) {
    select.addItem(locales[i]);
    select.setItemCaption(locales[i],
        locales[i].getDisplayName(displayLocale));

    // Automatically select the current locale
    if (locales[i].equals(getLocale()))
        select.setValue(locales[i]);
}
layout.addComponent(select);
```

```
// Locale code of the selected locale
final Label localeCode = new Label("");
layout.addComponent(localeCode);

// A date field which language the selection will change
final InlineDateField date =
    new InlineDateField("Calendar in the selected language");
date.setResolution(Resolution.DAY);
layout.addComponent(date);

// Handle language selection
select.addValueChangeListener(new Property.ValueChangeListener() {
    public void valueChange(ValueChangeEvent event) {
        Locale locale = (Locale) select.getValue();
        date.setLocale(locale);
        localeCode.setValue("Locale code: " +
            locale.getLanguage() + "_" +
            locale.getCountry());
    }
});
select.setImmediate(true);
```

The user interface is shown in Figure 5.9, “Selecting a Locale”.

**Figure 5.9. Selecting a Locale**



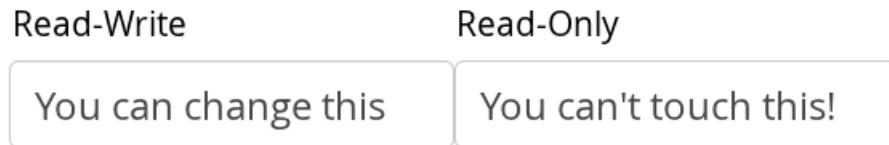
### 5.3.6. Read-Only

The **property** defines whether the value of a component can be changed. The property is mainly applicable to **Field** components, as they have a value that can be edited by the user.

```
TextField readwrite = new TextField("Read-Write");
readwrite.setValue("You can change this");
readwrite.setReadOnly(false); // The default
layout.addComponent(readwrite);

TextField readonly = new TextField("Read-Only");
readonly.setValue("You can't touch this!");
readonly.setReadOnly(true);
layout.addComponent(readonly);
```

The resulting read-only text field is shown in Figure 5.10, “A Read-Only Component”.

**Figure 5.10. A Read-Only Component.**

Setting a layout or some other component container as read-only does not usually make the contained components read-only recursively. This is different from, for example, the disabled state, which is usually applied recursively.

Notice that the value of a selection component is the selection, not its items. A read-only selection component doesn't therefore allow its selection to be changed, but other changes are possible. For example, if you have a read-only **Table** in editable mode, its contained fields and the underlying data model can still be edited, and the user could sort it or reorder the columns.

Client-side state modifications will not be communicated to the server-side and, more importantly, server-side field components will not accept changes to the value of a read-only **Field** component. The latter is an important security feature, because a malicious user can not fabricate state changes in a read-only field. This is handled at the level of **AbstractField** in `setValue()`, so you can not change the value programmatically either. Calling `setValue()` on a read-only field results in **Property.ReadOnlyException**.

Also notice that while the read-only status applies automatically to the property value of a field, it does not apply to other component variables. A read-only component can accept some other variable changes from the client-side and some of such changes could be acceptable, such as change in the scroll bar position of a **Table**. Custom widgets should check the read-only state for variables bound to business data.

## CSS Style Rules

Setting a normally editable component to read-only state can change its appearance to disallow editing the value. In addition to CSS styling, also the HTML structure can change. For example, **TextField** loses the edit box and appears much like a **Label**.

A read-only component will have the `v-readonly` style. The following CSS rule would make the text in all read-only **TextField** components appear in italic.

```
.v-textfield.v-readonly {
    font-style: italic;
}
```

### 5.3.7. Style Name

The `style name` property defines one or more custom CSS style class names for the component. The `getStyleName()` returns the current style names as a space-separated list. The `setStyleName()` replaces all the styles with the given style name or a space-separated list of style names. You can also add and remove individual style names with `addStyleName()` and `removeStyleName()`. A style name must be a valid CSS style name.

```
Label label = new Label("This text has a lot of style");
label.addStyleName("mystyle");
layout.addComponent(label);
```

The style name will appear in the component's HTML element in two forms: literally as given and prefixed with the component-specific style name. For example, if you add a style name `mystyle` to a **Button**, the component would get both `mystyle` and `v-button-mystyle` styles. Neither form may conflict with built-in style names of Vaadin. For example, `focus` style would conflict with a built-in style of the same name, and an `content` style for a **Panel** component would conflict with the built-in `v-panel-content` style.

The following CSS rule would apply the style to any component that has the `mystyle` style.

```
.mystyle {  
    font-family: fantasy;  
    font-style: italic;  
    font-size: 25px;  
    font-weight: bolder;  
    line-height: 30px;  
}
```

The resulting styled component is shown in Figure 5.11, "Component with a Custom Style"

**Figure 5.11. Component with a Custom Style**



***This text has a lot of style***

### 5.3.8. Visible

Components can be hidden by setting the `visible` property to `false`. Also the caption, icon and any other component features are made hidden. Hidden components are not just invisible, but their content is not communicated to the browser at all. That is, they are not made invisible cosmetically with only CSS rules. This feature is important for security if you have components that contain security-critical information that must only be shown in specific application states.

```
TextField invisible = new TextField("No-see-um");  
invisible.setValue("You can't see this!");  
invisible.setVisible(false);  
layout.addComponent(invisible);
```

The resulting invisible component is shown in Figure 5.12, "An Invisible Component".

**Figure 5.12. An Invisible Component.**

Beware that invisible beings can leave footprints. The containing layout cell that holds the invisible component will not go away, but will show in the layout as extra empty space. Also expand ratios work just like if the component was visible - it is the layout cell that expands, not the component.

If you need to make a component only cosmetically invisible, you should use a custom theme to set its `display: none` style. This is mainly useful for some special components that have effects even when made invisible in CSS. If the hidden component has undefined size and is enclosed in a layout that also has undefined size, the containing layout will collapse when the component disappears. If you want to have the component keep its size, you have to make it invisible by setting all its font and other attributes to be transparent. In such cases, the invisible content of the component can be made visible easily in the browser.

A component made invisible with the `visible` property has no particular CSS style class to indicate that it is hidden. The element does exist though, but has `display: none` style, which overrides any CSS styling.

### 5.3.9. Sizing Components

Vaadin components are sizeable; not in the sense that they were fairly large or that the number of the components and their features are sizeable, but in the sense that you can make them fairly large on the screen if you like, or small or whatever size.

The **Sizeable** interface, shared by all components, provides a number of manipulation methods and constants for setting the height and width of a component in absolute or relative units, or for leaving the size undefined.

The size of a component can be set with `setWidth()` and `setHeight()` methods. The methods take the size as a floating-point value. You need to give the unit of the measure as the second parameter for the above methods. The available units are listed in Table 5.1, "Size Units" below.

```
mycomponent.setWidth(100, Sizeable.UNITS_PERCENTAGE);  
mycomponent.setWidth(400, Sizeable.UNITS_PIXELS);
```

Alternatively, you can specify the size as a string. The format of such a string must follow the HTML/CSS standards for specifying measures.

```
mycomponent.setWidth("100%");  
mycomponent.setHeight("400px");
```

The "100%" percentage value makes the component take all available size in the particular direction (see the description of `Sizeable.UNITS_PERCENTAGE` in the table below). You can also use the shorthand method `setSizeFull()` to set the size to 100% in both directions.

The size can be *undefined* in either or both dimensions, which means that the component will take the minimum necessary space. Most components have *undefined* size by default, but some layouts have full size in horizontal direction. You can set the height or width as *undefined* with `Sizeable.SIZE_UNDEFINED` parameter for `setWidth()` and `setHeight()`.

You always need to keep in mind that a *layout with undefined size may not contain components with defined relative size*, such as "full size". See Section 6.13.1, "Layout Size" for details.

The Table 5.1, "Size Units" lists the available units and their codes defined in the **Sizeable** interface.

**Table 5.1. Size Units**

<code>Unit.PIXELS</code>	<code>px</code>	The <i>pixel</i> is the basic hardware-specific measure of one physical display pixel.
<code>Unit.POINTS</code>	<code>pt</code>	The <i>point</i> is a typographical unit, which is usually defined as 1/72 inches or about 0.35 mm. However, on displays the size can vary significantly depending on display metrics.
<code>Unit.PICAS</code>	<code>pc</code>	The <i>pica</i> is a typographical unit, defined as 12 points, or 1/7 inches or about 4.233 mm. On displays, the size can vary depending on display metrics.
<code>Unit.EM</code>	<code>em</code>	A unit relative to the used font, the width of the upper-case "M" letter.

<i>Unit.EX</i>	ex	A unit relative to the used font, the height of the lower-case "x" letter.
<i>Unit.MM</i>	mm	A physical length unit, millimeters on the surface of a display device. However, the actual size depends on the display, its metrics in the operating system, and the browser.
<i>Unit.CM</i>	cm	A physical length unit, <i>centimeters</i> on the surface of a display device. However, the actual size depends on the display, its metrics in the operating system, and the browser.
<i>Unit.INCH</i>	in	A physical length unit, <i>inches</i> on the surface of a display device. However, the actual size depends on the display, its metrics in the operating system, and the browser.
<i>Unit.PERCENTAGE</i>	%	A relative percentage of the available size. For example, for the top-level layout 100% would be the full width or height of the browser window. The percentage value must be between 0 and 100.

If a component inside **HorizontalLayout** or **VerticalLayout** has full size in the namesake direction of the layout, the component will expand to take all available space not needed by the other components. See Section 6.13.1, “Layout Size” for details.

### 5.3.10. Managing Input Focus

When the user clicks on a component, the component gets the *input focus*, which is indicated by highlighting according to style definitions. If the component allows inputting text, the focus and insertion point are indicated by a cursor. Pressing the **Tab** key moves the focus to the component next in the *focus order*.

Focusing is supported by all **Field** components and also by **Upload**.

The focus order or *tab index* of a component is defined as a positive integer value, which you can set with `setTabIndex()` and get with `getTabIndex()`. The tab index is managed in the context of the page in which the components are contained. The focus order can therefore jump between two any lower-level component containers, such as sub-windows or panels.

The default focus order is determined by the natural hierarchical order of components in the order in which they were added under their parents. The default tab index is 0 (zero).

Giving a negative integer as the tab index removes the component from the focus order entirely.

### CSS Style Rules

The component having the focus will have an additional style class with the `-focus` suffix. For example, a **TextField**, which normally has the `v-textfield` style, would additionally have the `v-textfield-focus` style.

For example, the following would make a text field blue when it has focus.

```
.v-textfield-focus {  
    background: lightblue;  
}
```

## 5.4. Field Components

*Fields* are components that have a value that the user can change through the user interface. Figure 5.13, “Field Components” illustrates the inheritance relationships and the important interfaces and base classes.

Field components are built upon the framework defined in the **Field** interface and the **AbstractField** base class. **AbstractField** is the base class for all field components. In addition to the component features inherited from **AbstractComponent**, it implements a number of features defined in **Property**, **Buffered**, **Validatable**, and **Component.Focusable** interfaces.

The description of the field interfaces and base classes is broken down in the following sections.

### 5.4.1. Field Interface

The **Field** interface inherits the **Component** superinterface and also the **Property** interface to have a value for the field. **AbstractField** is the only class implementing the **Field** interface directly. The relationships are illustrated in Figure 5.14, “Field Interface Inheritance Diagram”.

You can set the field value with the `setValue()` and read with the `getValue()` method defined in the **Property** interface. The actual value type depends on the component.

The **Field** interface defines a number of attributes, which you can retrieve or manipulate with the corresponding setters and getters.

#### description

All fields have a description. Notice that while this attribute is defined in the **Field** component, it is implemented in **AbstractField**, which does not directly implement **Field**, but only through the **AbstractField** class.

#### required

When enabled, a required indicator (usually the asterisk \* character) is displayed on the left, above, or right the field, depending on the containing layout and whether the field has a caption. If such fields are validated but are empty and the `requiredError` property (see below) is set, an error indicator is shown and the component error is set to the text defined with the `error` property. Without validation, the required indicator is merely a visual guide.

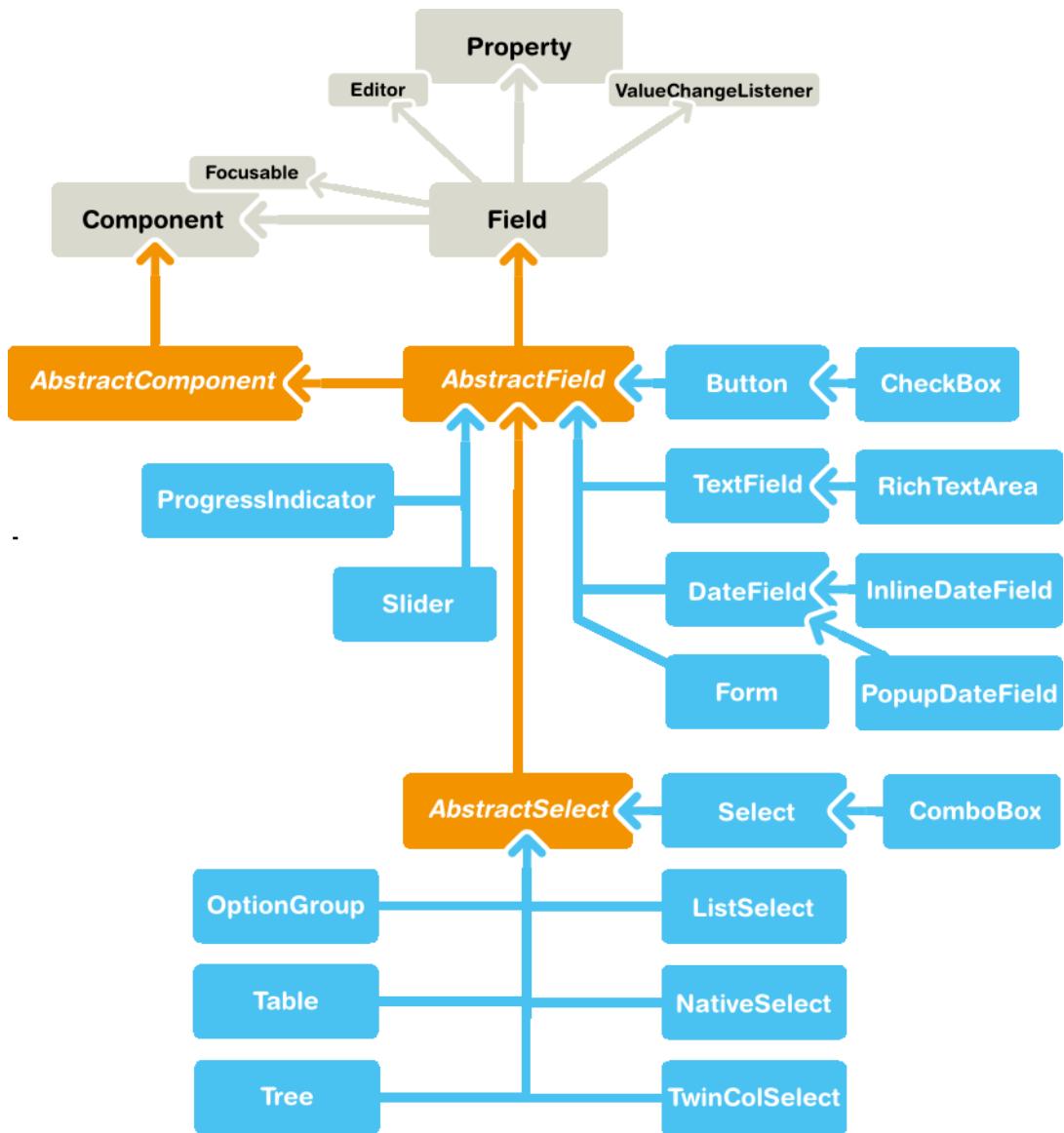
#### requiredError

Defines the error message to show when a value is required, but none is entered. The error message is set as the component error for the field and is usually displayed in a tooltip when the mouse pointer hovers over the error indicator.

### 5.4.2. Data Binding and Conversions

Fields are strongly coupled with the Vaadin data model. The field value is handled as a **Property** of the field component, as documented in Section 8.2, “Properties”. Selection fields allow management of the selectable items through the **Container** interface.

Fields are *editors* for some particular type. For example, **TextField** allows editing **String** values. When bound to a data source, the property type of the data model can be something different, say an **Integer**. **Converters** are used for converting the values between the representation and the model. They are described in Section 8.2.3, “Converting Between Property Type and Representation”.

**Figure 5.13. Field Components**

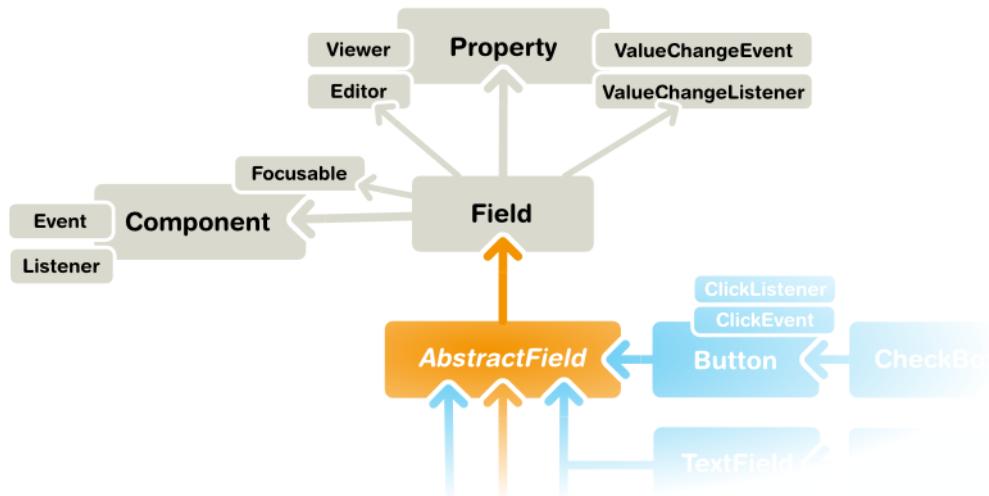
### 5.4.3. Handling Field Value Changes

Field inherits **Property.ValueChangeListener** to allow listening for field value changes and **Property.Editor** to allow editing values.

When the value of a field changes, a **Property.ValueChangeEvent** is triggered for the field. You should not implement the `valueChange()` method in a class inheriting **AbstractField**, as it is already implemented in **AbstractField**. You should instead implement the method explicitly by adding the implementing object as a listener.

### 5.4.4. Field Buffering

Field components implement the **Buffered** and **BufferedValidatable** interfaces. When buffering is enabled for a field with `setBuffered(true)`, the value is not written to the property

**Figure 5.14. Field Interface Inheritance Diagram**

data source before the `commit()` method is called for the field. Calling `commit()` also runs validators added to the field, and if any fail (and the `invalidCommitted` is disabled), the value is not written.

```

form.addComponent(new Button("Commit",
    new Button.ClickListener() {
        @Override
        public void buttonClick(ClickEvent event) {
            try {
                editor.commit();
            } catch (InvalidValueException e) {
                Notification.show(e.getMessage());
            }
        }
    }));
  
```

Calling `discard()` reads the value from the property date source to the current input.

If the fields are bound in a **FieldGroup** that has buffering enabled, calling `commit()` for the group runs validation on all fields in the group, and if successful, all the field values are written to the item data source. See Section 8.4.4, “Buffering Forms”.

## 5.4.5. Field Validation

The input for a field component can be syntactically or semantically invalid. Fields implement the **Validatable** interface, which allows checking validity of the input with **validators** that implement the **Validator** interface. You can add validators to fields with `addValidator()`.

```

TextField field = new TextField("Name");
field.addValidator(new StringLengthValidator(
    "The name must be 1-10 letters (was {0})",
    1, 10, true));
layout.addComponent(field);
  
```

Failed validation is indicated with the error indicator of the field, described in Section 4.5.1, “Error Indicator and Message”, unless disabled with `setValidationVisible(false)`. Hovering mouse on the field displays the error message given as a parameter for the validator. If validated

explicitly with `validate()`, as described later, the **InvalidValueException** is thrown if the validation fails, also carrying the error message. The value `{0}` in the error message string is replaced with the invalid input value.

Validators validate the property type of the field after a possible conversion, not the presentation type. For example, an **IntegerRangeValidator** requires that the value type of the property data source is **Integer**.

## Built-in Validators

Vaadin includes the following built-in validators. The property value type is indicated.

### **BeanValidator**

Validates a bean property according to annotations defined in the Bean Validation API 1.0 (JSR-303). This validator is usually not used explicitly, but they are created implicitly when binding fields in a **BeanFieldGroup**. Using bean validation requires an implementation library of the API. See Section 8.4.6, “Bean Validation” for details.

### **CompositeValidator**

Combines validators using logical AND and OR operators.

### **DateRangeValidator: Date**

Checks that the date value is within the range at or between two given dates/times.

### **DoubleRangeValidator: Double**

Checks that the double value is at or between two given values.

### **EmailValidator: String**

Checks that the string value is a syntactically valid email address. The validated syntax is close to the RFC 822 standard regarding email addresses.

### **IntegerRangeValidator: Integer**

Checks that the integer value is at or between two given values.

### **NullValidator**

Checks that the value is or is not a null value.

### **RegexpValidator: String**

Checks that the value matches with the given regular expression.

### **StringLengthValidator: String**

Checks that the length of the input string is at or between two given lengths.

Please see the API documentation for more details.

## Automatic Validation

The validators are normally, when `validationVisible` is true for the field, executed implicitly on the next server request if the input has changed. If the field is in immediate mode, it (and any other fields with changed value) are validated immediately when the focus leaves the field.

```
TextField field = new TextField("Name");
field.addValidator(new StringLengthValidator(
    "The name must be 1-10 letters (was {0})",
    1, 10, true));
```

```
field.setImmediate(true);
layout.addComponent(field);
```

## Explicit Validation

The validators are executed when the `validate()` or `commit()` methods are called for the field.

```
// A field with automatic validation disabled
final TextField field = new TextField("Name");
layout.addComponent(field);

// Define validation as usual
field.addValidator(new StringLengthValidator(
    "The name must be 1-10 letters (was {0})",
    1, 10, true));

// Run validation explicitly
Button validate = new Button("Validate");
validate.addClickListener(new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        field.setValidationVisible(false);
        try {
            field.validate();
        } catch (InvalidValueException e) {
            Notification.show(e.getMessage());
            field.setValidationVisible(true);
        }
    }
});
layout.addComponent(validate);
```

## Implementing a Custom Validator

You can create custom validators by implementing the `Validator` interface and implementing its `validate()` method. If the validation fails, the method should throw either **InvalidValueException** or **EmptyValueException**.

```
class MyValidator implements Validator {
    @Override
    public void validate(Object value)
        throws InvalidValueException {
        if (!(value instanceof String &&
              ((String)value).equals("hello")))
            throw new InvalidValueException("You're impolite");
    }
}

final TextField field = new TextField("Say hello");
field.addValidator(new MyValidator());
field.setImmediate(true);
layout.addComponent(field);
```

## Validation in Field Groups

If the field is bound to a **FieldGroup**, described in Section 8.4, “Creating Forms by Binding Fields to Items”, calling `commit()` for the group runs the validation for all the fields in the group, and if successful, writes the input values to the data source.

## 5.5. Selection Components

Vaadin offers many alternative ways for selecting one or more items. The core library includes the following selection components, all based on the **AbstractSelect** class:

### ComboBox (Section 5.16)

A drop-down list with a text box, where the user can type text to find matching items. The component also provides an input prompt and the user can enter new items.

### ListSelect (Section 5.17)

A vertical list box for selecting items in either single or multiple selection mode.

### NativeSelect (Section 5.18)

Provides selection using the native selection component of the browser, typically a drop-down list for single selection and a multi-line list in multiselect mode. This uses the `<select>` element in HTML.

### OptionGroup (Section 5.19)

Shows the items as a vertically arranged group of radio buttons in the single selection mode and of check boxes in multiple selection mode.

### TwinColSelect (Section 5.20)

Shows two list boxes side by side where the user can select items from a list of available items and move them to a list of selected items using control buttons.

In addition, the **Tree**, **Table**, and **TreeTable** components allow special forms of selection. They also inherit the **AbstractSelect**.

### 5.5.1. Binding Selection Components to Data

The selection components are strongly coupled with the Vaadin Data Model, described in Chapter 8, *Binding Components to Data*. The selectable items in all selection components are objects that implement the **Item** interface. The items are contained in a **Container**.

All selection components are containers themselves and simply forward all container operations to the underlying container data source. You can give the container in the constructor or set it via `setContainerDataSource()`. This is further described in Section 8.5.1, “Basic Use of Containers”.

```
// Have a container data source of some kind
IndexedContainer container = new IndexedContainer();
container.addContainerProperty("name", String.class, null);
...

// Create a selection component bound to the container
OptionGroup group = new OptionGroup("My Select", container);
```

If you do not bind a selection component to a container data source, a default container is used. It is usually either an **IndexedContainer** or a **HierarchicalContainer**.

The current selection of a selection component is bound to the **Property** interface, so you can get the current selection as the value of the selection component. Also selection changes are handled as value change events, as is described later.

### 5.5.2. Adding New Items

New items are added with the `addItem()` method defined in the **Container** interface, described in Section 8.5.1, “Basic Use of Containers”.

```
// Create a selection component
ComboBox select = new ComboBox("My ComboBox");

// Add items with given item IDs
select.addItem("Mercury");
select.addItem("Venus");
select.addItem("Earth");
```

The `addItem()` method creates an empty **Item**, which is identified by its *item identifier* (IID) object, given as the parameter. This item ID is by default used also as the caption of the item, as described in more detail later.

We emphasize that `addItem()` is a factory method that *takes an item ID, not the actual item* as the parameter - the item is returned by the method. The item is of a type that is specific to the container and has itself little relevance for most selection components, as the properties of an item may not be used in any way (except in **Table**), only the item ID.

The item identifier is typically a string, in which case it can be used as the caption, but can be any object type. We could as well have given integers for the item identifiers and set the captions explicitly with `setItemCaption()`. You could also add an item with the parameterless `addItem()`, which returns an automatically generated item ID.

```
// Create a selection component
ComboBox select = new ComboBox("My Select");

// Add an item with a generated ID
Object itemId = select.addItem();
select.setItemCaption(itemId, "The Sun");

// Select the item
select.setValue(itemId);
```

Some container types may support passing the actual data object to the add method. For example, you can add items to a **BeanItemContainer** with `addBean()`. Such implementations can use a separate item ID object, or the data object itself as the item ID, as is done in `addBean()`. In the latter case you can not depend on the default way of acquiring the item caption; see the description of the different caption modes later.

The next section describes the different options for determining the item captions.

### 5.5.3. Item Captions

The displayed captions of items in a selection component can be set explicitly with `setItemCaption()` or determined from the item IDs or item properties. The caption determination is defined with the *caption mode*, any of the modes in the **AbstractSelect.ItemCaptionMode** enum, which you can set with `setItemCaptionMode()`. The default mode is `EXPLICIT_DEFAULTS_ID`, which uses the item identifiers for the captions, unless given explicitly.

In addition to a caption, an item can have an icon. The icon is set with `setItemIcon()`.

The caption modes defined in **ItemCaptionMode** are the following:

## Caption Modes for Selection Components

### EXPLICIT\_DEFAULTS\_ID

This is the default caption mode and its flexibility allows using it in most cases. By default, the item identifier will be used as the caption. The identifier object does not necessarily have to be a string; the caption is retrieved with `toString()` method. If the caption is specified explicitly with `setItemCaption()`, it overrides the item identifier.

```
// Create a selection component
ComboBox select = new ComboBox("Moons of Mars");
select.setItemCaptionMode(ItemCaptionMode.EXPLICIT_DEFAULTS_ID);

// Use the item ID also as the caption of this item
select.addItem(new Integer(1));

// Set item caption for this item explicitly
select.addItem(2); // same as "new Integer(2)"
select.setItemCaption(2, "Deimos");
```

### EXPLICIT

Captions must be explicitly specified with `setItemCaption()`. If they are not, the caption will be empty. Such items with empty captions will nevertheless be displayed in the selection component as empty items. If they have an icon, they will be visible.

### ICON\_ONLY

Only icons are shown, captions are hidden.

### ID

String representation of the item identifier object is used as caption. This is useful when the identifier is a string, and also when the identifier is an complex object that has a string representation. For example:

```
ComboBox select = new ComboBox("Inner Planets");
select.setItemCaptionMode(ItemCaptionMode.ID);

// A class that implements toString()
class PlanetId extends Object implements Serializable {
    String planetName;

    PlanetId (String name) {
        planetName = name;
    }
    public String toString () {
        return "The Planet " + planetName;
    }
}

// Use such objects as item identifiers
String planets[] = {"Mercury", "Venus", "Earth", "Mars"};
for (int i=0; i<planets.length; i++)
    select.addItem(new PlanetId(planets[i]));
```

**INDEX**

Index number of item is used as caption. This caption mode is applicable only to data sources that implement the **Container.Indexed** interface. If the interface is not available, the component will throw a **ClassCastException**. The **AbstractSelect** itself does not implement this interface, so the mode is not usable without a separate data source. An **IndexedContainer**, for example, would work.

**ITEM**

**String** representation of item, acquired with `toString()`, is used as the caption. This is applicable mainly when using a custom **Item** class, which also requires using a custom **Container** that is used as a data source for the selection component.

**PROPERTY**

Item captions are read from the **String** representation of the property with the identifier specified with `setItemCaptionPropertyId()`. This is useful, for example, when you have a container that you use as the data source for the selection component, and you want to use a specific property for caption.

In the example below, we bind a selection component to a bean container and use a property of the bean as the caption.

```
/** A bean with a "name" property. */
public class Planet implements Serializable {
    int id;
    String name;

    public Planet(int id, String name) {
        this.id = id;
        this.name = name;
    }

    ... setters and getters ...
}

public void captionproperty(VBoxLayout layout) {
    // Have a bean container to put the beans in
    BeanItemContainer<Planet> container =
        new BeanItemContainer<Planet>(Planet.class);

    // Put some example data in it
    container.addItem(new Planet(1, "Mercury"));
    container.addItem(new Planet(2, "Venus"));
    container.addItem(new Planet(3, "Earth"));
    container.addItem(new Planet(4, "Mars"));

    // Create a selection component bound to the container
    ComboBox select = new ComboBox("Planets", container);

    // Set the caption mode to read the caption directly
    // from the 'name' property of the bean
    select.setItemCaptionMode(ItemCaptionMode.PROPERTY);
    select.setItemCaptionPropertyId("name");

    ...
}
```

### 5.5.4. Getting and Setting Selection

A selection component provides the current selection as the property of the component (with the **Property** interface). The property value is an item identifier object that identifies the selected item. You can get the identifier with `getValue()` of the **Property** interface.

You can select an item with the corresponding `setValue()` method. In multiselect mode, the property will be an unmodifiable set of item identifiers. If no item is selected, the property will be `null` in single selection mode or an empty collection in multiselect mode.

The **ComboBox** and **NativeSelect** will show empty selection when no actual item is selected. This is the *null selection item identifier*. You can set an alternative ID with `setNullSelectionItemId()`. Setting the alternative null ID is merely a visual text; the `getValue()` will still return `null` value if no item is selected, or an empty set in multiselect mode.

### 5.5.5. Handling Selection Changes

The item identifier of the currently selected item will be set as the property of the selection component. You can access it with the `getValue()` method of the **Property** interface of the component. Also, when handling selection changes with a **Property.ValueChangeListener**, the **ValueChangeEvent** will have the selected item as the property of the event, accessible with the `getProperty()` method.

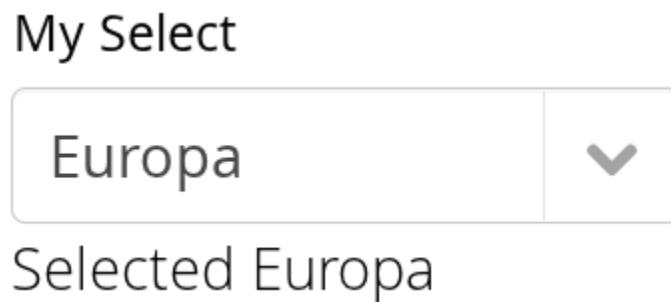
```
// Create a selection component with some items
ComboBox select = new ComboBox("My Select");
select.addItems("Io", "Europa", "Ganymedes", "Callisto");

// Handle selection change
select.addValueChangeListener(event -> // Java 8
    layout.addComponent(new Label("Selected " +
        event.getProperty().getValue())));

```

The result of user interaction is shown in Figure 5.15, “Selected Item”.

**Figure 5.15. Selected Item**



### 5.5.6. Allowing Adding New Items

Some selection components can allow the user to add new items. Currently, only **ComboBox** allows it, when the user types in a value and presses **Enter**. You need to enable the mode with `setNewItemAllowed(true)`. Setting the component also in immediate mode may be necessary, as otherwise the item would not be added immediately when the user interacts with the component, but after some other component causes a server request.

```
myselect.setNewItemAllowed(true);
myselect.setImmediate(true);
```

The user interface for adding new items depends on the selection component. The regular **ComboBox** component allows you to simply type the new item in the combo box and hit **Enter** to add it.

Adding new items is not possible if the selection component is read-only or is bound to a **Container** that does not allow adding new items, and an attempt may result in an exception.

## Handling New Items

Adding new items is handled by a **NewItemHandler**, which gets the item caption string as parameter for the `addNewItem()` method. The default implementation, **DefaultNewItemHandler**, checks for read-only state, adds the item using the entered caption as the item ID, and if the selection component gets the captions from a property, copies the caption to that property. It also selects the item. The default implementation may not be suitable for all container types, in which case you need to define a custom handler. For example, a **BeanItemContainer** expects the items to have the bean object itself as the ID, not a string.

```
// Have a bean container to put the beans in
final BeanItemContainer<Planet> container =
    new BeanItemContainer<Planet>(Planet.class);

// Put some example data in it
container.addItem(new Planet(1, "Mercury"));
container.addItem(new Planet(2, "Venus"));
container.addItem(new Planet(3, "Earth"));
container.addItem(new Planet(4, "Mars"));

final ComboBox select =
    new ComboBox("Select or Add a Planet", container);
select.setNullSelectionAllowed(false);

// Use the name property for item captions
select.setItemCaptionPropertyId("name");

// Allow adding new items
select.setNewItemAllowed(true);
select.setImmediate(true);

// Custom handling for new items
select.setNewItemHandler(new NewItemHandler() {
    @Override
    public void addNewItem(String newItemCaption) {
        // Create a new bean - can't set all properties
        Planet newPlanet = new Planet(0, newItemCaption);
        container.addBean(newPlanet);

        // Remember to set the selection to the new item
        select.select(newPlanet);

        Notification.show("Added new planet called " +
            newItemCaption);
    }
});
```

### 5.5.7. Multiple Selection

Some selection components, such as **OptionGroup** and **ListSelect** support a multiple selection mode, which you can enable with `setMultiSelect()`. For **TwinColSelect**, which is especially intended for multiple selection, it is enabled by default.

```
myselect.setMultiSelect(true);
```

As in single selection mode, the property value of the component indicates the selection. In multiple selection mode, however, the property value is a **Collection** of the item IDs of the currently selected items. You can get and set the property with the `getValue()` and `setValue()` methods as usual.

A change in the selection will trigger a **ValueChangeEvent**, which you can handle with a **Property.ValueChangeListener**. As usual, you should use `setImmediate(true)` to trigger the event immediately when the user changes the selection. The following example shows how to handle selection changes with a listener.

```
// A selection component with some items
ListSelect select = new ListSelect("My Selection");
select.addItems("Mercury", "Venus", "Earth",
    "Mars", "Jupiter", "Saturn", "Uranus", "Neptune");

// Multiple selection mode
select.setMultiSelect(true);

// Feedback on value changes
select.addValueChangeListener(
    new Property.ValueChangeListener() {
        public void valueChange(ValueChangeEvent event) {
            // Some feedback
            layout.addComponent(new Label("Selected: " +
                event.getProperty().getValue().toString()));
        }
});
select.setImmediate(true);
```

### 5.5.8. Item Icons

You can set an icon for each item with `setItemIcon()`, or define an item property that provides the icon resource with `setItemIconPropertyId()`, in a fashion similar to captions. Notice, however, that icons are not supported in **NativeSelect**, **TwinColSelect**, and some other selection components and modes. This is because HTML does not support images inside the native `select` elements. Icons are also not really visually applicable.

## 5.6. Component Extensions

Components and UIs can have extensions which are attached to the component dynamically. Especially, many add-ons are extensions.

How a component is extended depends on the extension. Typically, they have an `extend()` method that takes the component to be extended as the parameter.

```
TextField tf = new TextField("Hello");
layout.addComponent(tf);
```

```
// Add a simple extension
new CapsLockWarning().extend(tf);

// Add an extension that requires some parameters
CSValidator validator = new CSValidator();
validator.setRegExp("[0-9]*");
validator.setErrorMessage("Must be a number");
validator.extend(tf);
```

Development of custom extensions is described in Section 16.7, “Component and UI Extensions”.

## 5.7. Label

**Label** component displays non-editable text. This text can be used for short simple labels or for displaying long text, such as paragraphs. The text can be formatted in HTML or as preformatted text, depending on the *content mode* of the label.

You can give the label text most conveniently in the constructor, as is done in the following. Label has 100% default width, so the containing layout must also have defined width.

```
// A container that is 100% wide by default
VerticalLayout layout = new VerticalLayout();

Label label = new Label("Labeling can be dangerous");
layout.addComponent(label);
```

**Label** implements the `Property` interface to allow accessing the text value, so you can get and set the text with `getValue()` and `setValue()`.

```
// Get the label's text to initialize a field
TextField editor = new TextField(null, // No caption
                                 label.getValue());

// Change the label's text
editor.addValueChangeListener(event -> // Java 8
    label.setValue(editor.getValue()));
editor.setImmediate(true); // Send on Enter
```

Label also supports data binding to a property data source, as described later in Section 5.7.4, “Data Binding”. However, in that case the value can not be set through the label, as **Label** is not a `Property.Editor` and is not allowed to write to a bound property.

Even though **Label** is text and is often used as a caption, it is a normal component and therefore also has a caption that you can set with `setCaption()`. As with most other components, the caption is managed by the containing layout.

### 5.7.1. Text Width and Wrapping

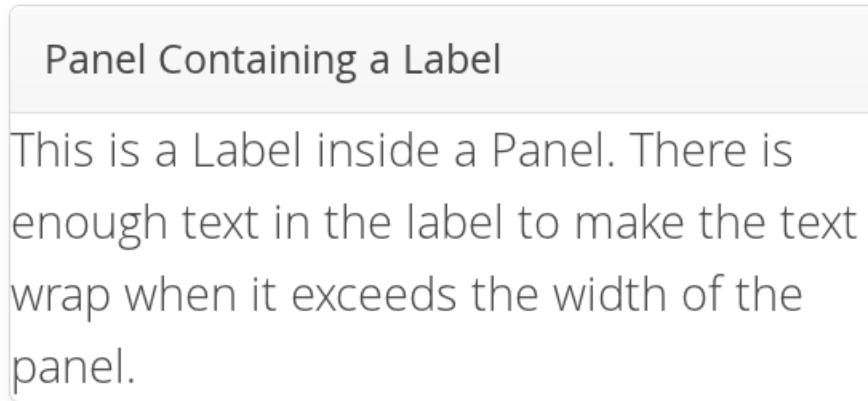
**Label** has 100% default width, so the containing layout must also have a defined width. If the width of the label’s text exceeds the width of the label, the text will wrap around and continue on the next line. Some layout components have undefined width by default, such as **HorizontalLayout**, so you need to pay special care with them.

```
// A container with a defined width.
Panel panel = new Panel("Panel Containing a Label");
panel.setWidth("300px");
```

```
panel.setContent(  
    new Label("This is a Label inside a Panel. There is " +  
        "enough text in the label to make the text " +  
        "wrap when it exceeds the width of the panel."));
```

As the size of the **Panel** in the above example is fixed and the width of **Label** is the default 100%, the text in the **Label** will wrap to fit the panel, as shown in Figure 5.16, “The Label Component”.

**Figure 5.16. The Label Component**



Setting **Label** to undefined width will cause it to not wrap at the end of the line, as the width of the content defines the width. If placed inside a layout with defined width, the **Label** will overflow the layout horizontally and, normally, be truncated.

## 5.7.2. Content Mode

The content of a label is formatted depending on a *content mode*. By default, the text is assumed to be plain text and any contained XML-specific characters will be quoted appropriately to allow rendering the contents of a label in HTML in a web browser. The content mode can be set in the constructor or with `setContentMode()`, and can have the values defined in the **ContentMode** enumeration type in `com.vaadin.shared.ui.label` package:

### TEXT

The default content mode where the label contains only plain text. All characters are allowed, including the special <, >, and & characters in XML or HTML, which are quoted properly in HTML while rendering the component. This is the default mode.

### PREFORMATTED

Content mode where the label contains preformatted text. It will be, by default, rendered with a fixed-width typewriter font. Preformatted text can contain line breaks, written in Java with the \n escape sequence for a newline character (ASCII 0x0a), or tabulator characters written with \t (ASCII 0x09).

### HTML

Content mode where the label contains HTML.

Please note the following security and validity warnings regarding the HTML content mode.



### Cross-Site Scripting Warning

Having **Label** in HTML content mode allows pure HTML content. If the content comes from user input, you should always carefully sanitize it to prevent cross-site scripting (XSS) attacks. Please see Section 11.8.1, “Sanitizing User Input to Prevent Cross-Site Scripting”.

Also, the validity of the HTML content is not checked when rendering the component and any errors can result in an error in the browser. If the content comes from an uncertain source, you should always validate it before displaying it in the component.

The following example demonstrates the use of **Label** in different modes.

```
Label textLabel = new Label(  
    "Text where formatting characters, such as \\n, " +  
    "and HTML, such as <b>here</b>, are quoted.",  
    ContentMode.TEXT);  
  
Label preLabel = new Label(  
    "Preformatted text is shown in an HTML <pre> tag.\n" +  
    "Formatting such as\n" +  
    " * newlines\n" +  
    " * whitespace\n" +  
    "and such are preserved. HTML tags, \n"+  
    "such as <b>bold</b>, are quoted.",  
    ContentMode.PREFORMATTED);  
  
Label htmlLabel = new Label(  
    "In HTML mode, all HTML formatting tags, such as \n" +  
    "<ul>" +  
    " * <li><b>bold</b></li>" +  
    " * <li>itemized lists</li>" +  
    " * <li>etc.</li>" +  
    "</ul> " +  
    "are preserved.",  
    ContentMode.HTML);
```

The rendering will look as shown in Figure 5.17, “Label Content Modes”.

### Figure 5.17. Label Content Modes

TEXT	Text where formatting characters, such as \n, and HTML, such as <b>here</b>, are quoted.
PREFORMATTED	Preformatted text is shown in an HTML <pre> tag. Formatting such as <ul style="list-style-type: none"> <li>* newlines</li> <li>* whitespace</li> </ul> and such are preserved. HTML tags, such as <b>bold</b>, are quoted.
HTML	In HTML mode, all HTML formatting tags, such as <ul style="list-style-type: none"> <li>• bold</li> <li>• itemized lists</li> <li>• etc.</li> </ul> are preserved.

### 5.7.3. Spacing with a Label

You can use a **Label** to create vertical or horizontal space in a layout. If you need a empty "line" in a vertical layout, having just a label with empty text is not enough, as it will collapse to zero height. The same goes for a label with only whitespace as the label text. You need to use a non-breaking space character, either `&ampnbsp` or `&#160;`:

```
layout.addComponent(new Label("&ampnbsp", ContentMode.HTML));
```

Using the `ContentMode.PREFORMATTED` mode has the same effect; preformatted spaces do not collapse in a vertical layout. In a **HorizontalLayout**, the width of a space character may be unpredictable if the label font is proportional, so you can use the preformatted mode to add em-width wide spaces.

If you want a gap that has adjustable width or height, you can use an empty label if you specify a height or width for it. For example, to create vertical space in a **VerticalLayout**:

```
Label gap = new Label();
gap.setHeight("1em");
verticalLayout.addComponent(gap);
```

You can make a flexible expanding spacer by having a relatively sized empty label with 100% height or width and setting the label as expanding in the layout.

```
// A wide component bar
HorizontalLayout horizontal = new HorizontalLayout();
horizontal.setWidth("100%");

// Have a component before the gap (a collapsing cell)
```

```
Button button1 = new Button("I'm on the left");
horizontal.addComponent(button1);

// An expanding gap spacer
Label expandingGap = new Label();
expandingGap.setWidth("100%");
horizontal.addComponent(expandingGap);
horizontal.setExpandRatio(expandingGap, 1.0f);

// A component after the gap (a collapsing cell)
Button button2 = new Button("I'm on the right");
horizontal.addComponent(button2);
```

## 5.7.4. Data Binding

While **Label** is not a field component, it is a `Property.Viewer` and can be bound to a property data source, described in Section 8.2, “Properties”. You can specify the data source either in the constructor or by the `setPropertyDataSource()` method.

```
// Some property
ObjectProperty<String> property =
    new ObjectProperty<String>("some value");

// Label that is bound to the property
Label label = new Label(property);
```

Further, as **Label** is a `Property`, you can edit its value with a property editor, such as a field:

```
Label label = new Label("some value");
TextField editor = new TextField();
editor.setPropertyDataSource(label);
editor.setImmediate(true);
```

However, **Label** is *not* a `Property.Editor`, so it is read-only when bound to a data source. Therefore, you can not use `setValue()` to set the value of a connected data source through a **Label** nor bind the label to an editor field, in which case writes would be delegated through the label.

## 5.7.5. CSS Style Rules

```
.v-label { }
pre { } /* In PREFORMATTED content mode */
```

The **Label** component has a `v-label` overall style. In the `PREFORMATTED` content mode, the text is wrapped inside a `<pre>` element.

## 5.8. Link

The **Link** component allows making hyperlinks. References to locations are represented as resource objects, explained in Section 4.4, “Images and Other Resources”. The **Link** is a regular HTML hyperlink, that is, an `<a href>` anchor element that is handled natively by the browser. Unlike when clicking a **Button**, clicking a **Link** does not cause an event on the server-side.

Links to an arbitrary URL can be made by using an **ExternalResource** as follows:

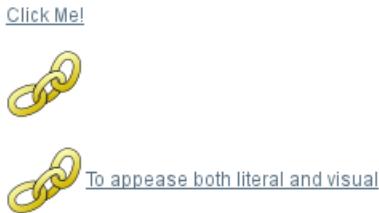
```
// Textual link  
Link link = new Link("Click Me!",  
                     new ExternalResource("http://vaadin.com/"));
```

You can use `setIcon()` to make image links as follows:

```
// Image link  
Link iconic = new Link(null,  
                      new ExternalResource("http://vaadin.com/"));  
iconic.setIcon(new ThemeResource("img/nicubunu_Chain.png"));  
  
// Image + caption  
Link combo = new Link("To appease both literal and visual",  
                      new ExternalResource("http://vaadin.com/"));  
combo.setIcon(new ThemeResource("img/nicubunu_Chain.png"));
```

The resulting links are shown in Figure 5.18, “Link Example”. You could add a “display: block” style for the icon element to place the caption below it.

### Figure 5.18. Link Example



With the simple constructor used in the above example, the resource is opened in the current window. Using the constructor that takes the target window as a parameter, or by setting the target window with `setTargetName()`, you can open the resource in another window, such as a popup browser window/tab. As the target name is an HTML target string managed by the browser, the target can be any window, including windows not managed by the application itself. You can use the special underscored target names, such as `_blank` to open the link to a new browser window or tab.

```
// Hyperlink to a given URL  
Link link = new Link("Take me a away to a faraway land",  
                     new ExternalResource("http://vaadin.com/"));  
  
// Open the URL in a new window/tab  
link.setTargetName("_blank");  
  
// Indicate visually that it opens in a new window/tab  
link.setIcon(new ThemeResource("icons/external-link.png"));  
link.addStyleName("icon-after-caption");
```

Normally, the link icon is before the caption. You can have it right of the caption by reversing the text direction in the containing element.

```
/* Position icon right of the link caption. */  
.icon-after-caption {  
    direction: rtl;  
}  
/* Add some padding around the icon. */  
.icon-after-caption .v-icon {
```

```
padding: 0 3px;  
}
```

The resulting link is shown in Figure 5.19, “Link That Opens a New Window”.

### Figure 5.19. Link That Opens a New Window



With the `_blank` target, a normal new browser window is opened. If you wish to open it in a popup window (or tab), you need to give a size for the window with `setTargetWidth()` and `setTargetHeight()`. You can control the window border style with `setTargetBorder()`, which takes any of the defined border styles `TARGET_BORDER_DEFAULT`, `TARGET_BORDER_MINIMAL`, and `TARGET_BORDER_NONE`. The exact result depends on the browser.

```
// Open the URL in a popup  
link.setTargetName("_blank");  
link.setTargetBorder(Link.TARGET_BORDER_NONE);  
link.setTargetHeight(300);  
link.setTargetWidth(400);
```

In addition to the **Link** component, Vaadin allows alternative ways to make hyperlinks. The **Button** component has a `Reindeer.BUTTON_LINK` style name that makes it look like a hyperlink, while handling clicks in a server-side click listener instead of in the browser. Also, you can make hyperlinks (or any other HTML) in a **Label** in HTML content mode.

## CSS Style Rules

```
.v-link { }  
a { }  
.v-icon {}  
span {}
```

The overall style for the **Link** component is `v-link`. The root element contains the `<a href>` hyperlink anchor. Inside the anchor are the icon, with `v-icon` style, and the caption in a text span.

Hyperlink anchors have a number of *pseudo-classes* that are active at different times. An unvisited link has `a:link` class and a visited link `a:visited`. When the mouse pointer hovers over the link, it will have `a:hover`, and when the mouse button is being pressed over the link, the `a:active` class. When combining the pseudo-classes in a selector, please notice that `a:hover` must come after an `a:link` and `a:visited`, and `a:active` after the `a:hover`.

## 5.9. TextField

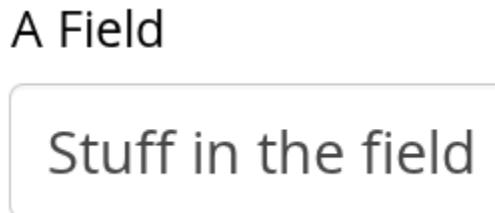
**TextField** is one of the most commonly used user interface components. It is a **Field** component that allows entering textual values using keyboard.

The following example creates a simple text field:

```
// Create a text field  
TextField tf = new TextField("A Field");  
  
// Put some initial content in it  
tf.setValue("Stuff in the field");
```

The result is shown in Figure 5.20, “**TextField** Example”.

**Figure 5.20. TextField Example**



Value changes are handled with a **Property.ValueChangeListener**, as in most other fields. The value can be acquired with `getValue()` directly from the text field, as is done in the example below, or from the property reference of the event.

```
// Handle changes in the value
tf.addValueChangeListener(new Property.ValueChangeListener() {
    public void valueChange(ValueChangeEvent event) {
        // Assuming that the value type is a String
        String value = (String) event.getProperty().getValue();

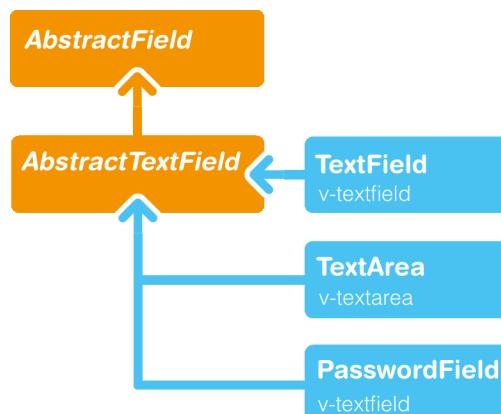
        // Do something with the value
        Notification.show("Value is: " + value);
    }
});

// Fire value changes immediately when the field loses focus
tf.setImmediate(true);
```

As with other event listeners, you can use lambda expression with one parameter to handle the events in Java 8.

Much of the API of **TextField** is defined in **AbstractTextField**, which allows different kinds of text input fields, such as rich text editors, which do not share all the features of the single-line text fields.

**Figure 5.21. Text Field Class Relationships**



### 5.9.1. Data Binding

**TextField** edits **String** values, but you can bind it to any property type that has a proper converter, as described in Section 8.2.3, “Converting Between Property Type and Representation”.

```
// Have an initial data model. As Double is unmodifiable and
// doesn't support assignment from String, the object is
// reconstructed in the wrapper when the value is changed.
Double trouble = 42.0;

// Wrap it in a property data source
final ObjectProperty<Double> property =
    new ObjectProperty<Double>(trouble);

// Create a text field bound to it
// (StringToDoubleConverter is used automatically)
TextField tf = new TextField("The Answer", property);
tf.setImmediate(true);

// Show that the value is really written back to the
// data source when edited by user.
Label feedback = new Label(property);
feedback.setCaption("The Value");
```

When you put a **Table** in editable mode or create fields with a **FieldGroup**, the **DefaultFieldFactory** creates a **TextField** for almost every property type by default. You often need to make a custom factory to customize the creation and to set the field tooltip, validation, formatting, and so on.

See Chapter 8, *Binding Components to Data* for more details on data binding, field factories for **Table** in Section 5.21.3, “Editing the Values in a Table”, and Section 8.4, “Creating Forms by Binding Fields to Items” regarding forms.

### 5.9.2. String Length

The `setMaxLength()` method sets the maximum length of the input string so that the browser prevents the user from entering a longer one. As a security feature, the input value is automatically truncated on the server-side, as the maximum length setting could be bypassed on the client-side. The maximum length property is defined at **AbstractTextField** level.

Notice that the maximum length setting does not affect the width of the field. You can set the width with `setWidth()`, as with other components. Using *em* widths is recommended to better approximate the proper width in relation to the size of the used font. There is no standard way in HTML for setting the width exactly to a number of letters (in a monospaced font). You can trick your way around this restriction by putting the text field in an undefined-width **VerticalLayout** together with an undefined-width **Label** that contains a sample text, and setting the width of the text field as 100%. The layout will get its width from the label, and the text field will use that.

### 5.9.3. Handling Null Values

As with any field, the value of a **TextField** can be set as `null`. This occurs most commonly when you create a new field without setting a value for it or bind the field value to a data source that allows null values. In such case, you might want to show a special value that stands for the null value. You can set the null representation with the `setNullRepresentation()` method. Most typically, you use an empty string for the null representation, unless you want to differentiate from

a string that is explicitly empty. The default null representation is "null", which essentially warns that you may have forgotten to initialize your data objects properly.

The `setNullSettingAllowed()` controls whether the user can actually input a null value by using the null value representation. If the setting is `false`, which is the default, inputting the null value representation string sets the value as the literal value of the string, not null. This default assumption is a safeguard for data sources that may not allow null values.

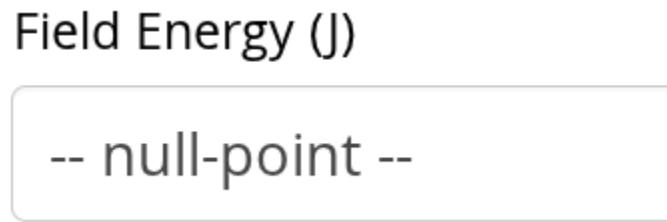
```
// Have a property with null value
ObjectProperty<Double> dataModel =
    new ObjectProperty<Double>(new Double(0.0));
dataModel.setValue(null); // Have to set it null here

// Create a text field bound to the null data
TextField tf = new TextField("Field Energy (J)", dataModel);
tf.setNullRepresentation("-- null-point --");

// Allow user to input the null value by its representation
tf.setNullSettingAllowed(true);
```

The **Label**, which is bound to the value of the **TextField**, displays a null value as empty. The resulting user interface is shown in Figure 5.22, "Null Value Representation".

**Figure 5.22. Null Value Representation**



#### 5.9.4. Text Change Events

Often you want to receive a change event immediately when the text field value changes. The *immediate* mode is not literally immediate, as the changes are transmitted only after the field loses focus. In the other extreme, using keyboard events for every keypress would make typing unbearably slow and also processing the keypresses is too complicated for most purposes. *Text change events* are transmitted asynchronously soon after typing and do not block typing while an event is being processed.

Text change events are received with a **TextChangeListener**, as is done in the following example that demonstrates how to create a text length counter:

```
// Text field with maximum length
final TextField tf = new TextField("My Eventful Field");
tf.setValue("Initial content");
tf.setMaxLength(20);

// Counter for input length
final Label counter = new Label();
counter.setValue(tf.getValue().length() +
    " of " + tf.getMaxLength());

// Display the current length interactively in the counter
```

```

tf.addTextChangeListener(new TextChangeListener() {
    public void textChange(TextChangeEvent event) {
        int len = event.getText().length();
        counter.setValue(len + " of " + tf.getMaxLength());
    }
});

// The lazy mode is actually the default
tf.setTextChangeEventMode(TextChangeEventMode.LAZY);

```

The result is shown in Figure 5.23, “Text Change Events”.

**Figure 5.23. Text Change Events**

## My Eventful Field



Initial content

15 of 20

The *text change event mode* defines how quickly the changes are transmitted to the server and cause a server-side event. Lazier change events allow sending larger changes in one event if the user is typing fast, thereby reducing server requests.

You can set the text change event mode of a **TextField** with `setTextChangeEventMode()`. The allowed modes are defined in **TextChangeEventMode** enum and are as follows:

### *TextChangeEventMode.LAZY* (default)

An event is triggered when there is a pause in editing the text. The length of the pause can be modified with `setInputEventTimeout()`. As with the *TIMEOUT* mode, a text change event is forced before a possible **ValueChangeEvent**, even if the user did not keep a pause while entering the text.

This is the default mode.

### *TextChangeEventMode.TIMEOUT*

A text change in the user interface causes the event to be communicated to the application after a timeout period. If more changes are made during this period, the event sent to the server-side includes the changes made up to the last change. The length of the timeout can be set with `setInputEventTimeout()`.

If a **ValueChangeEvent** would occur before the timeout period, a **TextChangeEvent** is triggered before it, on the condition that the text content has changed since the previous **TextChangeEvent**.

### *TextChangeEventMode.EAGER*

An event is triggered immediately for every change in the text content, typically caused by a key press. The requests are separate and are processed sequentially one after another. Change events are nevertheless communicated asynchronously to the server, so further input can be typed while event requests are being processed.

### 5.9.5. CSS Style Rules

```
.v-textfield { }
```

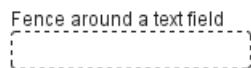
The HTML structure of **TextField** is extremely simple, consisting only of an element with the `v-textfield` style.

For example, the following custom style uses dashed border:

```
.v-textfield-dashing {
    border: thin dashed;
    background: white; /* Has shading image by default */
}
```

The result is shown in Figure 5.24, “Styling TextField with CSS”.

**Figure 5.24. Styling TextField with CSS**



The style name for **TextField** is also used in several components that contain a text input field, even if the text input is not an actual **TextField**. This ensures that the style of different text input boxes is similar.

## 5.10. TextArea

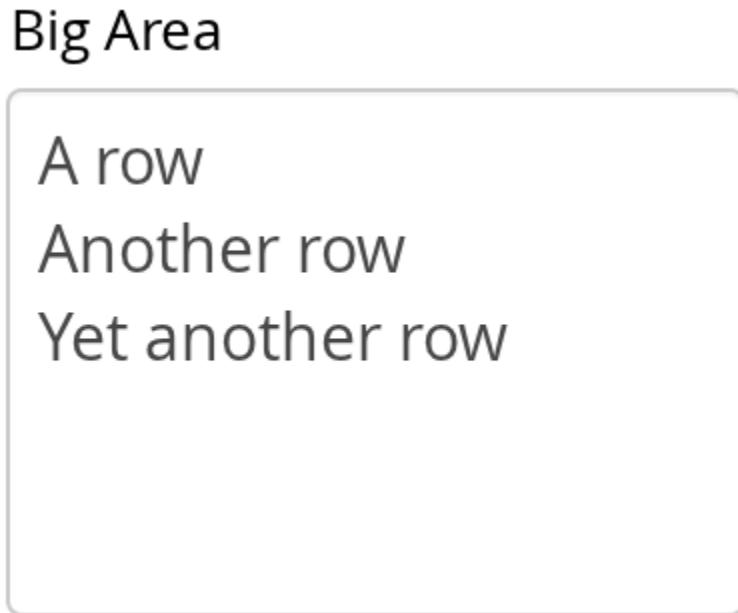
**TextArea** is a multi-line version of the **TextField** component described in Section 5.9, “**TextField**”.

The following example creates a simple text area:

```
// Create the area
TextArea area = new TextArea("Big Area");

// Put some content in it
area.setValue("A row\n"+
    "Another row\n"+
    "Yet another row");
```

The result is shown in Figure 5.25, “**TextArea** Example”.

**Figure 5.25. TextArea Example**

You can set the number of visible rows with `setRows()` or use the regular `setHeight()` to define the height in other units. If the actual number of rows exceeds the number, a vertical scrollbar will appear. Setting the height with `setRows()` leaves space for a horizontal scrollbar, so the actual number of visible rows may be one higher if the scrollbar is not visible.

You can set the width with the regular `setWidth()` method. Setting the size with the `em` unit, which is relative to the used font size, is recommended.

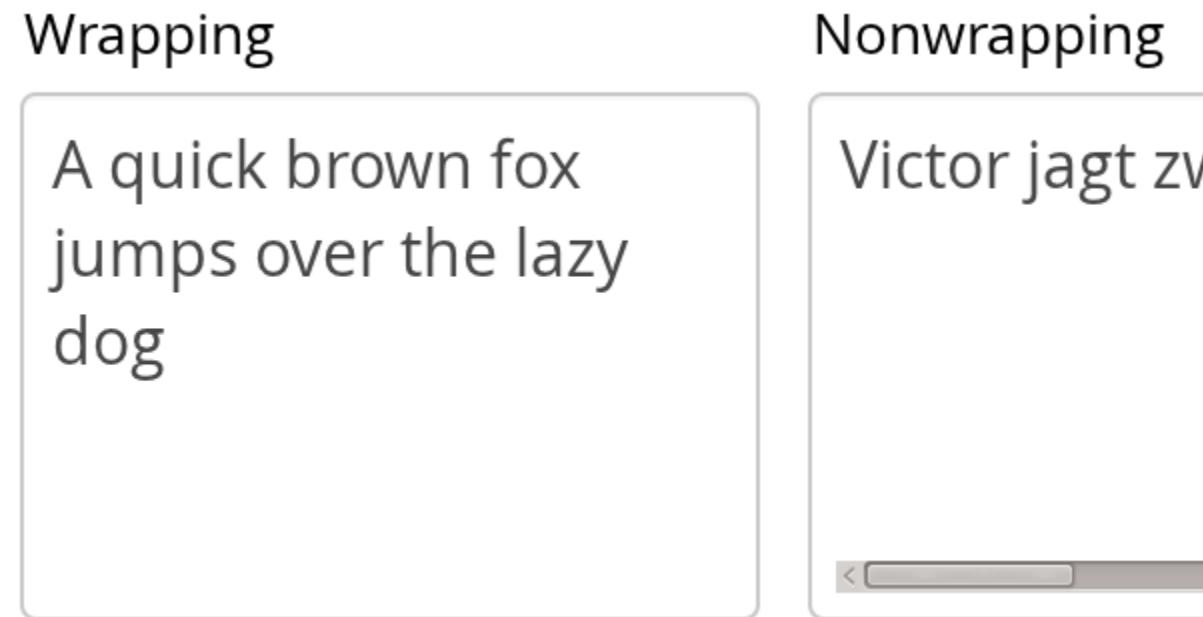
## Word Wrap

The `setWordwrap()` sets whether long lines are wrapped (`true` - default) when the line length reaches the width of the writing area. If the word wrap is disabled (`false`), a vertical scrollbar will appear instead. The word wrap is only a visual feature and wrapping a long line does not insert line break characters in the field value; shortening a wrapped line will undo the wrapping.

```
TextArea area1 = new TextArea("Wrapping");
area1.setWordwrap(true); // The default
area1.setValue("A quick brown fox jumps over the lazy dog");

TextArea area2 = new TextArea("Nonwrapping");
area2.setWordwrap(false);
area2.setValue("Victor jagt zwölf Boxkäufe quer +
    &über den Sylter Deich");
```

The result is shown in Figure 5.26, "Word Wrap in **TextArea**".

**Figure 5.26. Word Wrap in TextArea**

## CSS Style Rules

```
.v-textarea { }
```

The HTML structure of **TextArea** is extremely simple, consisting only of an element with v-textarea style.

## 5.11. PasswordField

The **PasswordField** is a variant of **TextField** that hides the typed input from visual inspection.

```
PasswordField tf = new PasswordField("Keep it secret");
```

The result is shown in Figure 5.27, “**PasswordField**”.

**Figure 5.27. PasswordField**

You should note that the **PasswordField** hides the input only from "over the shoulder" visual observation. Unless the server connection is encrypted with a secure connection, such as HTTPS, the input is transmitted in clear text and may be intercepted by anyone with low-level access to the network. Also phishing attacks that intercept the input in the browser may be possible by exploiting JavaScript execution security holes in the browser.

## CSS Style Rules

```
.v-textfield { }
```

The **PasswordField** does not have its own CSS style name but uses the same `v-textfield` style as the regular **TextField**. See Section 5.9.5, “CSS Style Rules” for information on styling it.

## 5.12. RichTextArea

The **RichTextArea** field allows entering or editing formatted text. The toolbar provides all basic editing functionalities. The text content of **RichTextArea** is represented in HTML format. **RichTextArea** inherits **TextField** and does not add any API functionality over it. You can add new functionality by extending the client-side components **VRichTextArea** and **VRichTextToolbar**.

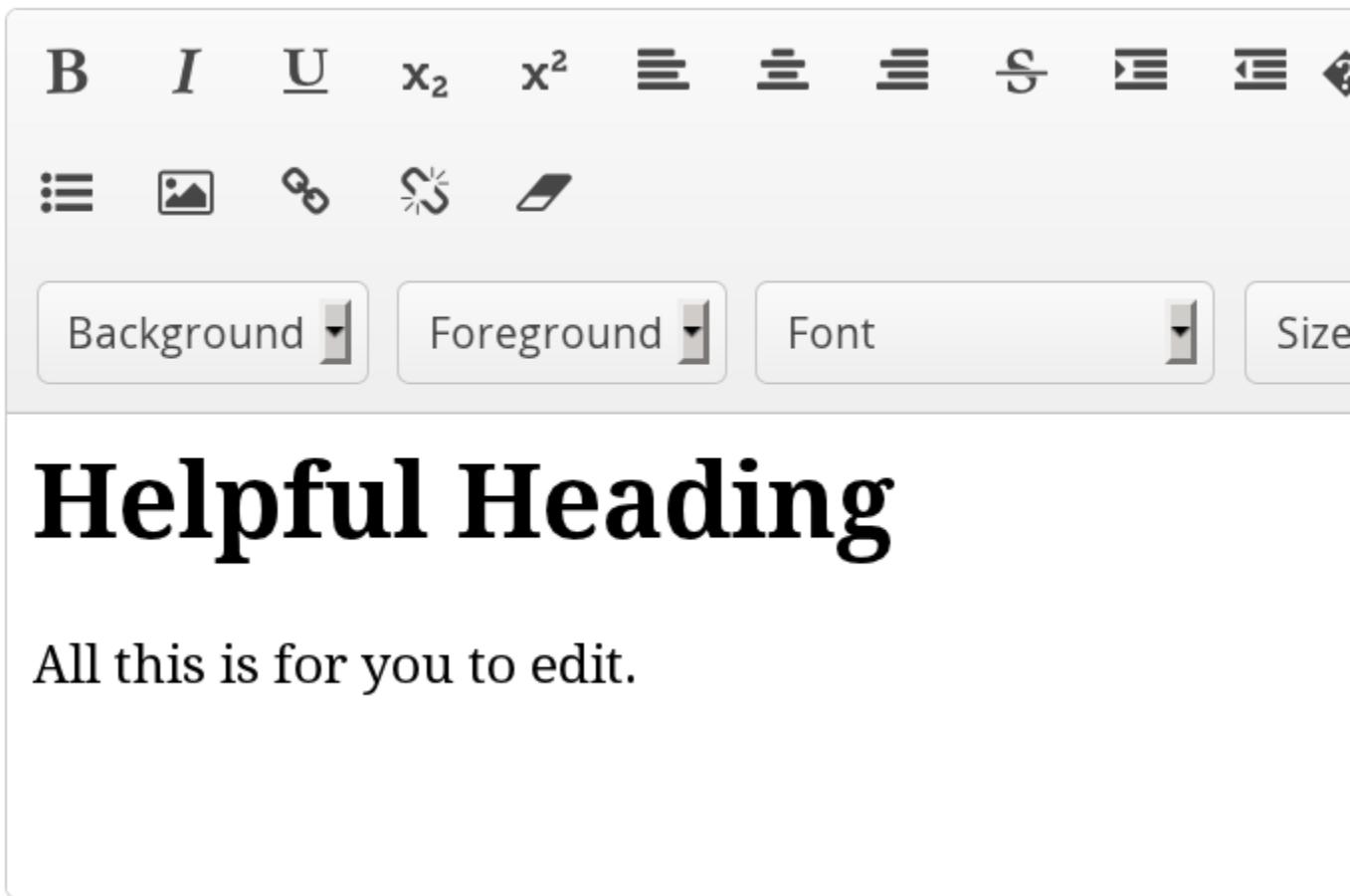
As with **TextField**, the textual content of the rich text area is the **Property** of the field and can be set with `setValue()` and read with `getValue()`.

```
// Create a rich text area
final RichTextArea rtarea = new RichTextArea();
rtarea.setCaption("My Rich Text Area");

// Set initial content as HTML
rtarea.setValue("<h1>Hello</h1>\n" +
    "<p>This rich text area contains some text.</p>");
```

**Figure 5.28. Rich Text Area Component**

## My Rich Textarea



Above, we used context-specific tags such as `<h1>` in the initial HTML content. The rich text area component does not allow creating such tags, only formatting tags, but it does preserve them unless the user edits them away. Any non-visible whitespace such as the new line character (`\n`) are removed from the content. For example, the value set above will be as follows when read from the field with `getValue()`:

```
<h1>Hello</h1> <p>This rich text area contains some text.</p>
```



### Cross-Site Scripting Warning

The user input from a **RichTextArea** is transmitted as HTML from the browser to server-side and is not sanitized. As the entire purpose of the **RichTextArea** component is to allow input of formatted text, you can not sanitize it just by removing all HTML tags. Also many attributes, such as `style`, should pass through the sanitization.

See Section 11.8.1, “Sanitizing User Input to Prevent Cross-Site Scripting” for more details on Cross-Site scripting vulnerabilities and sanitization of user input.

## Localizing RichTextArea Toolbars

The rich text area is one of the few components in Vaadin that contain textual labels. The selection boxes in the toolbar are in English and currently can not be localized in any other way than by inheriting or reimplementing the client-side **VRichTextToolbar** widget. The buttons can be localized simply with CSS by downloading a copy of the toolbar background image, editing it, and replacing the default toolbar. The toolbar is a single image file from which the individual button icons are picked, so the order of the icons is different from the rendered. The image file depends on the client-side implementation of the toolbar.

```
.v-richtextarea-richtextexample .gwt-ToggleButton
.gwt-Image {
    background-image: url(img/richtextarea-toolbar-fi.png)
    !important;
}
```

**Figure 5.29. Regular English and a Localized Rich Text Area Toolbar**



## CSS Style Rules

```
.v-richtextarea { }
.v-richtextarea .gwt-RichTextToolbar { }
.v-richtextarea .gwt-RichTextArea { }
```

The rich text area consists of two main parts: the toolbar with overall style `.gwt-RichTextToolbar` and the editor area with style `.gwt-RichTextArea`. The editor area obviously contains all the elements and their styles that the HTML content contains. The toolbar contains buttons and drop-down list boxes with the following respective style names:

```
.gwt-ToggleButton { }
.gwt-ListBox { }
```

## 5.13. Date and Time Input with DateField

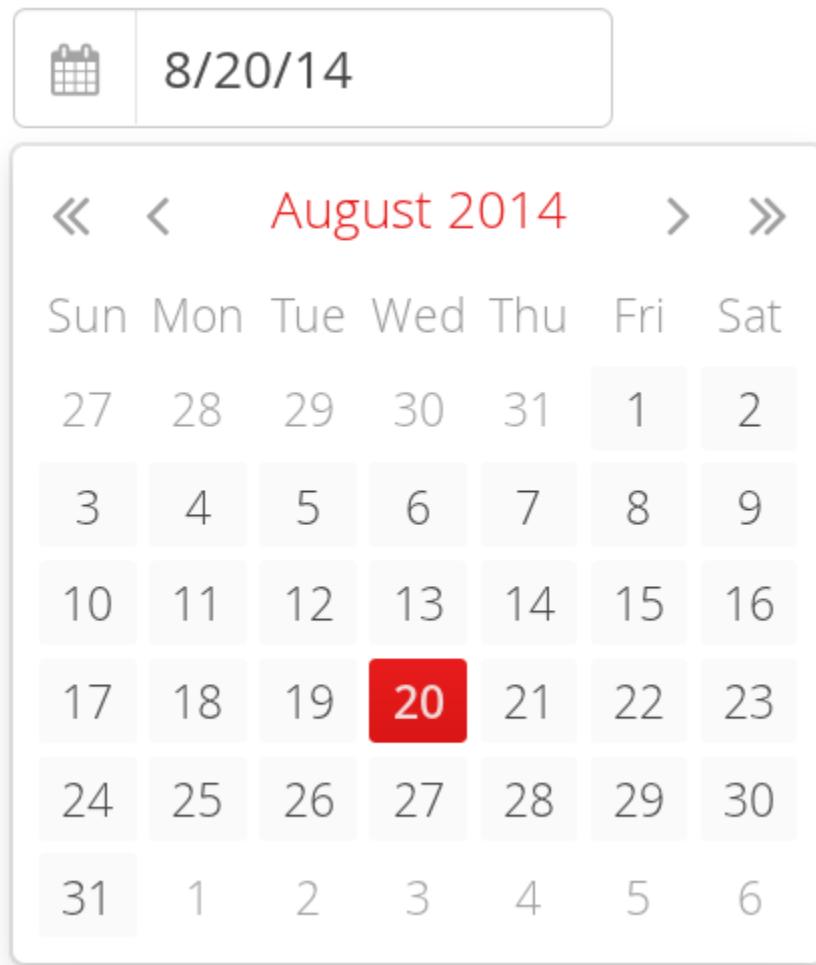
The **DateField** component provides the means to display and input date and time. The field comes in two variations: **PopupDateField**, with a numeric input box and a popup calendar view, and **InlineDateField**, with the calendar view always visible. The **DateField** base class defaults to the popup variation.

The example below illustrates the use of the **DateField** baseclass, which is equivalent to the **PopupDateField**. We set the initial time of the date field to current time by using the default constructor of the `java.util.Date` class.

```
// Create a DateField with the default style
DateField date = new DateField();

// Set the date and time to present
date.setValue(new Date());
```

The result is shown in Figure 5.30, “**DateField (PopupDateField)** for Selecting Date and Time”.

**Figure 5.30. DateField (PopupDateField) for Selecting Date and Time**

### 5.13.1. PopupDateField

The **PopupDateField** provides date input using a text box for the date and time. As the **DateField** defaults to this component, the use is exactly the same as described earlier. Clicking the handle right of the date opens a popup view for selecting the year, month, and day, as well as time. Also the **Down** key opens the popup. Once opened, the user can navigate the calendar using the cursor keys.

The date and time selected from the popup are displayed in the text box according to the default date and time format of the current locale, or as specified with `setDateFormat()`. The same format definitions are used for parsing user input.

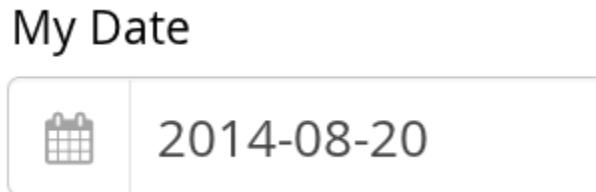
#### Date and Time Format

The date and time are normally displayed according to the default format for the current locale (see Section 5.3.5, “Locale”). You can specify a custom format with `setDateFormat()`. It takes a format string that follows the format of the **SimpleDateFormat** in Java.

```
// Display only year, month, and day in ISO format  
date.setDateFormat("yyyy-MM-dd");
```

The result is shown in Figure 5.31, “Custom Date Format for **PopupDateField**”.

**Figure 5.31. Custom Date Format for PopupDateField**



The same format specification is also used for parsing user-input date and time, as described later.

## Handling Malformed User Input

A user can easily input a malformed or otherwise invalid date or time. **DateField** has two validation layers: first on the client-side and then on the server-side.

The validity of the entered date is first validated on the client-side, immediately when the input box loses focus. If the date format is invalid, the `v-datepicker-parseerror` style is set. Whether this causes a visible indication of a problem depends on the theme. The built-in reindeer theme does not show any indication by default, making server-side handling of the problem more convenient.

```
.mydate.v-datepicker-parseerror .v-textfield {  
    background: pink;  
}
```

The `setLenient(true)` setting enables relaxed interpretation of dates, so that invalid dates, such as February 30th or March 0th, are wrapped to the next or previous month, for example.

The server-side validation phase occurs when the date value is sent to the server. If the date field is set in immediate state, it occurs immediately after the field loses focus. Once this is done and if the status is still invalid, an error indicator is displayed beside the component. Hovering the mouse pointer over the indicator shows the error message.

You can handle the errors by overriding the `handleUnparsableDateString()` method. The method gets the user input as a string parameter and can provide a custom parsing mechanism, as shown in the following example.

```
// Create a date field with a custom parsing and a  
// custom error message for invalid format  
PopupDateField date = new PopupDateField("My Date") {  
    @Override  
    protected Date handleUnparsableDateString(String dateString)  
        throws PropertyConversionException {  
        // Try custom parsing  
        String[] fields = dateString.split("/");  
        if (fields.length >= 3) {  
            try {  
                int year = Integer.parseInt(fields[0]);  
                int month = Integer.parseInt(fields[1])-1;
```

```
        int day    = Integer.parseInt(fields[2]);
        GregorianCalendar c =
            new GregorianCalendar(year, month, day);
        return c.getTime();
    } catch (NumberFormatException e) {
        throw new Property.
            ConversionException("Not a number");
    }
}

// Bad date
throw new Property.
    ConversionException("Your date needs two slashes");
}
};

// Display only year, month, and day in slash-delimited format
date.setDateFormat("yyyy/MM/dd");

// Don't be too tight about the validity of dates
// on the client-side
date.setLenient(true);
```

The handler method must either return a parsed **Date** object or throw a **ConversionException**. Returning `null` will set the field value to `null` and clear the input box.

## Customizing the Error Message

In addition to customized parsing, overriding the handler method for unparseable input is useful for internationalization and other customization of the error message. You can also use it for another way for reporting the errors, as is done in the example below:

```
// Create a date field with a custom error message for invalid format
PopupDateField date = new PopupDateField("My Date") {
    @Override
    protected Date handleUnparsableDateString(String dateString)
        throws Property.ConversionException {
        // Have a notification for the error
        Notification.show(
            "Your date needs two slashes",
            Notification.TYPE_WARNING_MESSAGE);

        // A failure must always also throw an exception
        throw new Property.ConversionException("Bad date");
    }
};
```

If the input is invalid, you should always throw the exception; returning a `null` value would make the input field empty, which is probably undesired.

## Input Prompt

Like other fields that have a text box, **PopupDateField** allows an input prompt that is visible until the user has input a value. You can set the prompt with `setInputPrompt`.

```
PopupDateField date = new PopupDateField();

// Set the prompt
date.setInputPrompt("Select a date");
```

```
// Set width explicitly to accommodate the prompt  
date.setWidth("10em");
```

The date field doesn't automatically scale to accommodate the prompt, so you need to set it explicitly with `setWidth()`.

The input prompt is not available in the **DatePicker** superclass.

## CSS Style Rules

```
.v-datepicker, v-datepicker-popupcalendar {}  
.v-textfield, v-datepicker-textfield {}  
.v-datepicker-button {}
```

The top-level element of **DatePicker** and all its variants have `v-datepicker` style. The base class and the **PopupDatePicker** also have the `v-datepicker-popupcalendar` style.

In addition, the top-level element has a style that indicates the resolution, with `v-datepicker-basename` and an extension, which is one of `full`, `day`, `month`, or `year`. The `-full` style is enabled when the resolution is smaller than a day. These styles are used mainly for controlling the appearance of the popup calendar.

The text box has `v-textfield` and `v-datepicker-textfield` styles, and the calendar button `v-datepicker-button`.

Once opened, the calendar popup has the following styles at the top level:

```
.v-datepicker-popup {}  
.v-popupcontent {}  
.v-datepicker-calendarpanel {}
```

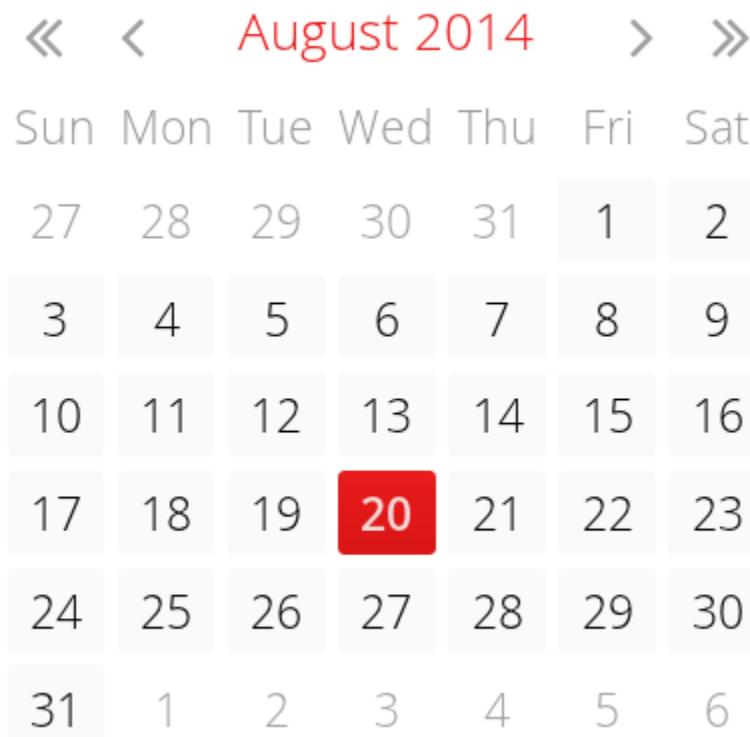
The top-level element of the floating popup calendar has `.v-datepicker-popup` style. Observe that the popup frame is outside the HTML structure of the component, hence it is not enclosed in the `v-datepicker` element and does not include any custom styles. The content in the `v-datepicker-calendarpanel` is the same as in **InlineDatePicker**, as described in Section 5.13.2, “**InlineDatePicker**”.

### 5.13.2. **InlineDatePicker**

The **InlineDatePicker** provides a date picker component with a month view. The user can navigate months and years by clicking the appropriate arrows. Unlike with the popup variant, the month view is always visible in the inline field.

```
// Create a DatePicker with the default style  
InlineDatePicker date = new InlineDatePicker();  
  
// Set the date and time to present  
date.setValue(new java.util.Date());
```

The result is shown in Figure 5.32, “Example of the **InlineDatePicker**”.

**Figure 5.32. Example of the InlineDateField**

The user can also navigate the calendar using the cursor keys.

## CSS Style Rules

```
.v-datepicker { }
.v-datepicker-calendarpanel { }
.v-datepicker-calendarpanel-header { }
.v-datepicker-calendarpanel-prevyear { }
.v-datepicker-calendarpanel-prevmonth { }
.v-datepicker-calendarpanel-month { }
.v-datepicker-calendarpanel-nextmonth { }
.v-datepicker-calendarpanel-nextyear { }
.v-datepicker-calendarpanel-body { }
.v-datepicker-calendarpanel-weekdays,
.v-datepicker-calendarpanel-weeknumbers { }
.v-first { }
.v-last { }
.v-datepicker-calendarpanel-weeknumber { }
.v-datepicker-calendarpanel-day { }
.v-datepicker-calendarpanel-time { }
.v-datepicker-time { }
.v-select { }
.v-label { }
```

The top-level element has the `v-datepicker` style. In addition, the top-level element has a style name that indicates the resolution of the calendar, with `v-datepicker-` basename and an extension, which is one of `full`, `day`, `month`, or `year`. The `-full` style is enabled when the resolution is smaller than a day.

The `v-datepicker-calendarpanel-weeknumbers` and `v-datepicker-calendarpanel-weeknumber` styles are enabled when the week numbers are enabled. The former controls the appearance of the weekday header and the latter the actual week numbers.

The other style names should be self-explanatory. For weekdays, the `v-first` and `v-last` styles allow making rounded endings for the weekday bar.

### 5.13.3. Date and Time Resolution

In addition to display a calendar with dates, **DateField** can also display the time in hours and minutes, or just the month or year. The visibility of the input components is controlled by *time resolution*, which you can set with `setResolution()`. The method takes as its parameters the lowest visible component, `DateField.Resolution.DAY` for just dates and `DateField.Resolution.MIN` for dates with time in hours and minutes. Please see the API Reference for the complete list of resolution parameters.

### 5.13.4. DateField Locale

The date and time are displayed according to the locale of the user, as reported by the browser. You can set a custom locale with the `setLocale()` method of **AbstractComponent**, as described in Section 5.3.5, “Locale”. Only Gregorian calendar is supported.

## 5.14. Button

The **Button** component is normally used for initiating some action, such as finalizing input in forms. When the user clicks a button, a **Button.ClickEvent** is fired, which can be handled with a `Button.ClickListener` in the `buttonClick()` method.

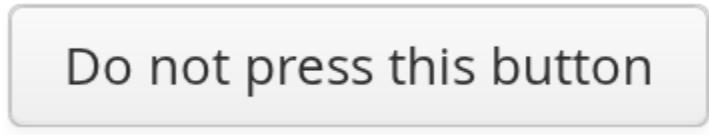
You can handle button clicks with an anonymous class as follows:

```
Button button = new Button("Do not press this button");

button.addClickListener(new Button.ClickListener() {
    public void buttonClick(ClickEvent event) {
        Notification.show("Do not press this button again");
    }
});
```

The result is shown in Figure 5.33, “An Example of a Button”. The listener can also be given in the constructor, which is often perhaps simpler.

**Figure 5.33. An Example of a Button**



Do not press this button

If you handle several buttons in the same listener, you can differentiate between them either by comparing the **Button** object reference returned by the `getButton()` method of **Button.ClickEvent** to a kept reference. For a detailed description of these patterns together with some examples, please see Section 3.4, “Events and Listeners”.

## CSS Style Rules

```
.v-button { }  
.v-button-wrap { }  
.v-button-caption { }
```

A button has an overall `v-button` style. The caption has `v-button-caption` style. There is also an intermediate wrap element, which may help in styling in some cases.

Some built-in themes contain a small style, which you can enable by adding `Reindeer.BUTTON_SMALL`, etc. The **BaseTheme** also has a `BUTTON_LINK` style, which makes the button look like a hyperlink.

## 5.15. CheckBox

**CheckBox** is a two-state selection component that can be either checked or unchecked. The caption of the check box will be placed right of the actual check box. Vaadin provides two ways to create check boxes: individual check boxes with the **CheckBox** component described in this section and check box groups with the **OptionGroup** component in multiple selection mode, as described in Section 5.19, “**OptionGroup**”.

Clicking on a check box will change its state. The state is a **Boolean** property that you can set with the `setValue()` method and obtain with the `getValue()` method of the **Property** interface. Changing the value of a check box will cause a **ValueChangeEvent**, which can be handled by a **ValueChangeListener**.

```
CheckBox checkbox1 = new CheckBox("Box with no Check");  
CheckBox checkbox2 = new CheckBox("Box with a Check");  
  
checkbox2.setValue(true);  
  
checkbox1.addValueChangeListener(event -> // Java 8  
    checkbox2.setValue(! checkbox1.getValue()));  
  
checkbox2.addValueChangeListener(event -> // Java 8  
    checkbox1.setValue(! checkbox2.getValue()));
```

The result is shown in Figure 5.34, “An Example of a Check Box”.

**Figure 5.34. An Example of a Check Box**



Box with no Check



Box with a Check

For an example on the use of check boxes in a table, see Section 5.21, “**Table**”.

## CSS Style Rules

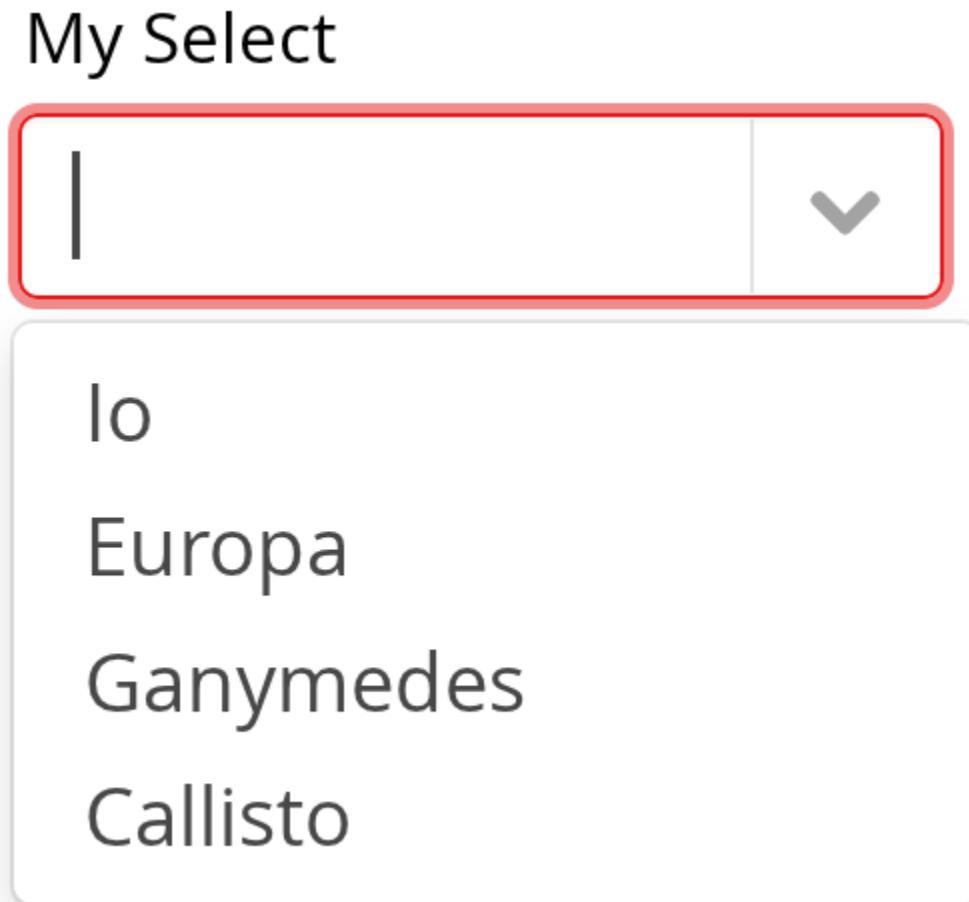
```
.v-checkbox { }  
.v-checkbox > input { }  
.v-checkbox > label { }
```

The top-level element of a **CheckBox** has the `v-checkbox` style. It contains two sub-elements: the actual check box `input` element and the `label` element. If you want to have the label on the left, you can change the positions with "direction: rtl" for the top element.

## 5.16. ComboBox

**ComboBox** is a selection component allows selecting an item from a drop-down list. The component also has a text field area, which allows entering search text by which the items shown in the drop-down list are filtered. Common selection component features are described in Section 5.5, "Selection Components".

**Figure 5.35. The ComboBox Component**



**ComboBox** supports adding new items when the user presses **Enter**, as described in Section 5.5.6, "Allowing Adding New Items".

### 5.16.1. Filtered Selection

**ComboBox** allows filtering the items available for selection in the drop-down list by the text entered in the input box.

Pressing **Enter** will complete the item in the input box. Pressing **Up-** and **Down-**arrows can be used for selecting an item from the drop-down list. The drop-down list is paged and clicking on the scroll buttons will change to the next or previous page. The list selection can also be done with the arrow keys on the keyboard. The shown items are loaded from the server as needed, so the number of items held in the component can be quite large. The number of matching items is displayed by the drop-down list.

Filtering is enabled by setting a *filtering mode* with `setFilteringMode()`.

```
cb.setFilteringMode(FilteringMode.CONTAINS);
```

The modes defined in the **FilteringMode** enum are as follows:

*CONTAINS*

Matches any item that contains the string given in the text field part of the component.

*STARTSWITH*

Matches only items that begin with the given string.

*OFF* (default)

Filtering is by default off and all items are shown all the time.

The above example uses the containment filter that matches to all items containing the input string. As shown in Figure 5.36, “Filtered Selection in **ComboBox**” below, when we type some text in the input area, the drop-down list will show all the matching items.

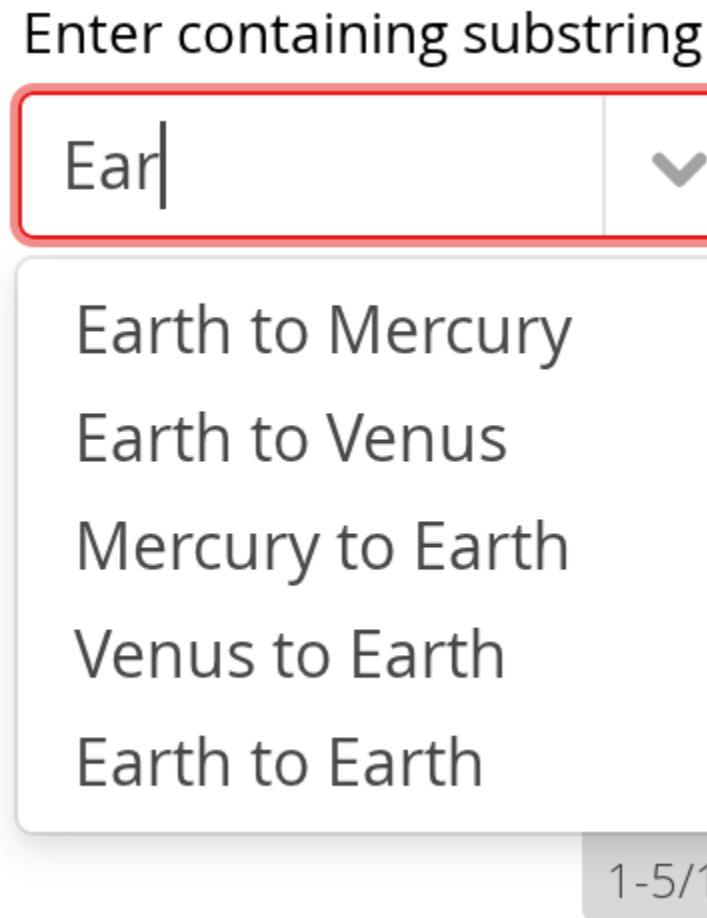
## CSS Style Rules

```
.v-filterselect { }
.v-filterselect-input { }
.v-filterselect-button { }

// Under v-overlay-container
.v-filterselect-suggestpopup { }
.popupContent { }
.v-filterselect-prevpage,
.v-filterselect-prevpage-off { }
.v-filterselect-suggestmenu { }
.gwt-MenuItem { }
.v-filterselect-nextpage,
.v-filterselect-nextpage-off { }
.v-filterselect-status { }
```

In its default state, only the input field of the **ComboBox** component is visible. The entire component is enclosed in `v-filterselect` style (a legacy remnant), the input field has `v-filterselect-input` style and the button in the right end that opens and closes the drop-down result list has `v-filterselect-button` style.

The drop-down result list has an overall `v-filterselect-suggestpopup` style. It contains the list of suggestions with `v-filterselect-suggestmenu` style. When there are more items that fit in the menu, navigation buttons with `v-filterselect-prevpage` and `v-filterselect-`

**Figure 5.36. Filtered Selection in ComboBox**

lect-nextpage styles are shown. When they are not shown, the elements have -off suffix. The status bar in the bottom that shows the paging status has v-filterselect-status style.

## 5.17. ListSelect

The **ListSelect** component is list box that shows the selectable items in a vertical list. If the number of items exceeds the height of the component, a scrollbar is shown. The component allows both single and multiple selection modes, which you can set with `setMultiSelect()`. It is visually identical in both modes.

```
// Create the selection component
ListSelect select = new ListSelect("The List");

// Add some items (here by the item ID as the caption)
select.addItems("Mercury", "Venus", "Earth", ...);

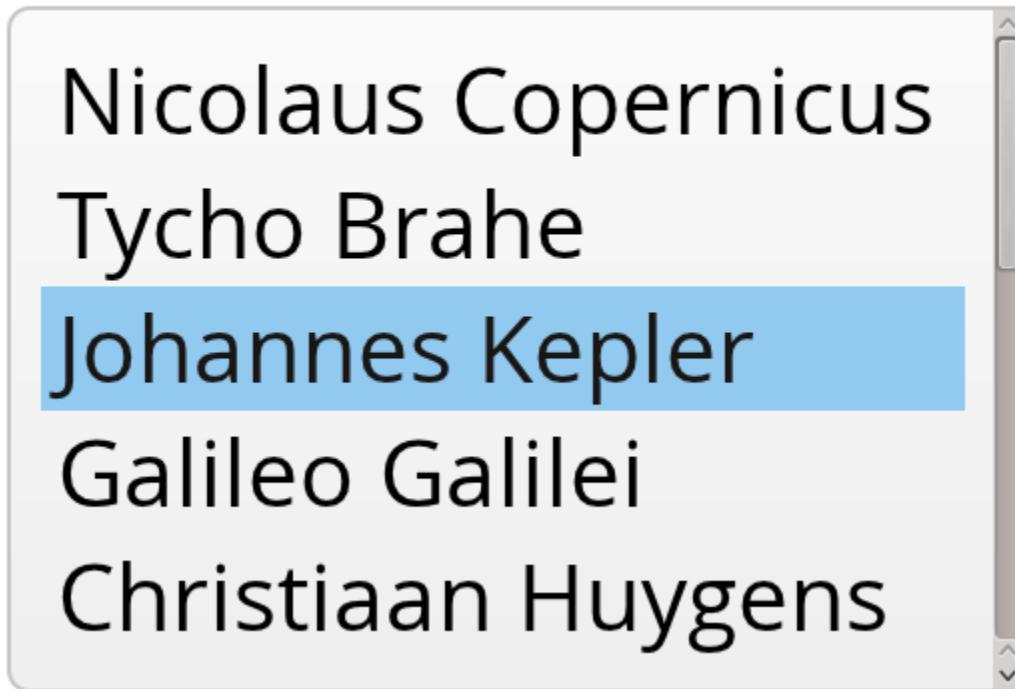
select.setNullSelectionAllowed(false);

// Show 5 items and a scrollbar if there are more
select.setRows(5);
```

The number of visible items is set with `setRows()`.

**Figure 5.37. The ListSelect Component**

## The List



Common selection component features are described in Section 5.5, “Selection Components”.

### CSS Style Rules

```
.v-select {}
.v-select-select {}
option {}
```

The component has an overall `v-select` style. The native `<select>` element has `v-select-select` style. The items are represented as `<option>` elements.

## 5.18. NativeSelect

**NativeSelect** is a drop-down selection component implemented with the native selection input of web browsers, using the HTML `<select>` element.

```
// Create the selection component
NativeSelect select = new NativeSelect("Native Selection");

// Add some items
select.addItems("Mercury", "Venus", ...);
```

The `setColumns()` allows setting the width of the list as "columns", which is a measure that depends on the browser.

**Figure 5.38. The NativeSelect Component**



Common selection component features are described in Section 5.5, “Selection Components”.

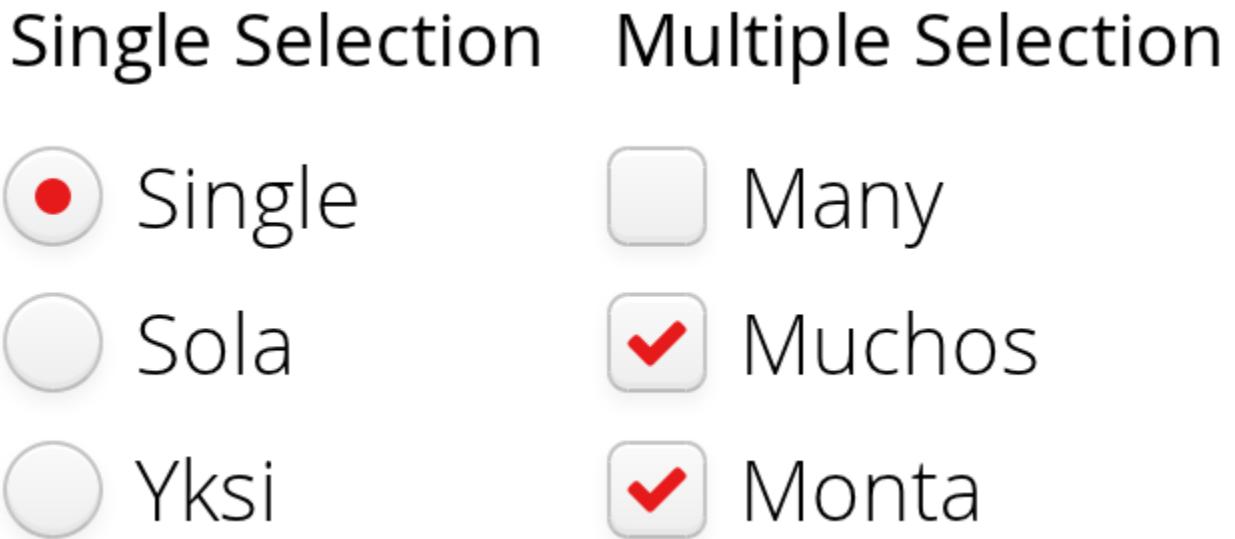
## CSS Style Rules

```
.v-select {}  
.v-select-select {}
```

The component has a `v-select` overall style. The native `select` element has `v-select-select` style.

## 5.19. OptionGroup

**OptionGroup** is a selection component that allows selection from a group of radio buttons in single selection mode. In multiple selection mode, the items show up as check boxes. The common selection component features are described in Section 5.5, “Selection Components”.

**Figure 5.39. Option Button Group in Single and Multiple Selection Mode**

Option group is by default in single selection mode. Multiple selection is enabled with `setMultiSelect()`.

```
// A single-select radio button group
OptionGroup single = new OptionGroup("Single Selection");
single.addItems("Single", "Sola", "Yksi");

// A multi-select check box group
OptionGroup multi = new OptionGroup("Multiple Selection");
multi.setMultiSelect(true);
multi.addItems("Many", "Muchos", "Monta");
```

Figure 5.39, “Option Button Group in Single and Multiple Selection Mode” shows the **OptionGroup** in both single and multiple selection mode.

You can also create check boxes individually using the **CheckBox** class, as described in Section 5.15, “**CheckBox**”. The advantages of the **OptionGroup** component are that as it maintains the individual check box objects, you can get an array of the currently selected items easily, and that you can easily change the appearance of a single component.

### 5.19.1. Disabling Items

You can disable individual items in an **OptionGroup** with `setItemEnabled()`. The user can not select or deselect disabled items in multi-select mode, but in single-select mode the user can change the selection from a disabled to an enabled item. The selections can be changed programmatically regardless of whether an item is enabled or disabled. You can find out whether an item is enabled with `isItemEnabled()`.

The `setItemEnabled()` identifies the item to be disabled by its item ID.

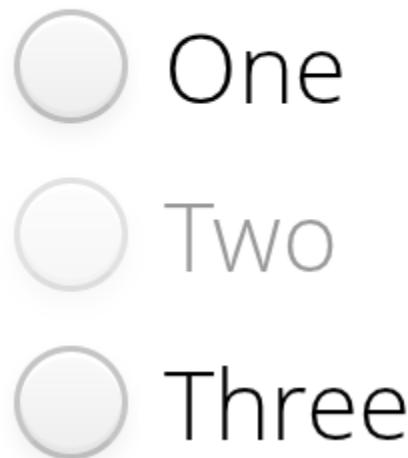
```
// Have an option group with some items
OptionGroup group = new OptionGroup("My Disabled Group");
group.addItems("One", "Two", "Three");
```

```
// Disable one item by its item ID  
group.setItemEnabled("Two", false);
```

The item IDs are also used for the captions in this example. The result is shown in Figure 5.40, “**OptionGroup** with a Disabled Item”.

**Figure 5.40. OptionGroup with a Disabled Item**

## My Disabled Group



Setting an item as disabled turns on the `v-disabled` style for it.

## CSS Style Rules

```
.v-select-optiongroup {}  
.v-select-option.v-checkbox {}  
.v-select-option.v-radiobutton {}
```

The `v-select-optiongroup` is the overall style for the component. Each check box will have the `v-checkbox` style, borrowed from the **CheckBox** component, and each radio button the `v-radiobutton` style. Both the radio buttons and check boxes will also have the `v-select-option` style that allows styling regardless of the option type. Disabled items have additionally the `v-disabled` style.

The options are normally laid out vertically. You can use horizontal layout by setting `display: inline-block` for the options. The `nowrap` setting for the overall element prevents wrapping if there is not enough horizontal space in the layout, or if the horizontal width is undefined.

```
/* Lay the options horizontally */  
.v-select-optiongroup-horizontal .v-select-option {  
    display: inline-block;  
}  
  
/* Avoid wrapping if the layout is too tight */  
.v-select-optiongroup-horizontal {  
    white-space: nowrap;
```

```
}

/* Some extra spacing is needed */
.v-select-optiongroup-horizontal
    .v-select-option.v-radiobutton {
        padding-right: 10px;
}
```

Use of the above rules requires setting a custom `horizontal` style name for the component. The result is shown in Figure 5.41, “Horizontal **OptionGroup**”.

**Figure 5.41. Horizontal OptionGroup**

## Horizontal Group



## 5.20. TwinColSelect

The **TwinColSelect** field provides a multiple selection component that shows two lists side by side, with the left column containing unselected items and the right column the selected items. The user can select items from the list on the left and click on the ">>" button to move them to the list on the right. Items can be deselected by selecting them in the right list and clicking on the "<<" button.

**TwinColSelect** is always in multi-select mode, so its property value is always a collection of the item IDs of the selected items, that is, the items in the right column.

The selection columns can have their own captions, separate from the overall component caption, which is managed by the containing layout. You can set the column captions with `setLeftColumnCaption()` and `setRightColumnCaption()`.

```
TwinColSelect select = new TwinColSelect("Select Targets");

// Put some items in the select
select.addItems("Mercury", "Venus", "Earth", "Mars",
    "Jupiter", "Saturn", "Uranus", "Neptune");

// Few items, so we can set rows to match item count
select.setRows(select.size());

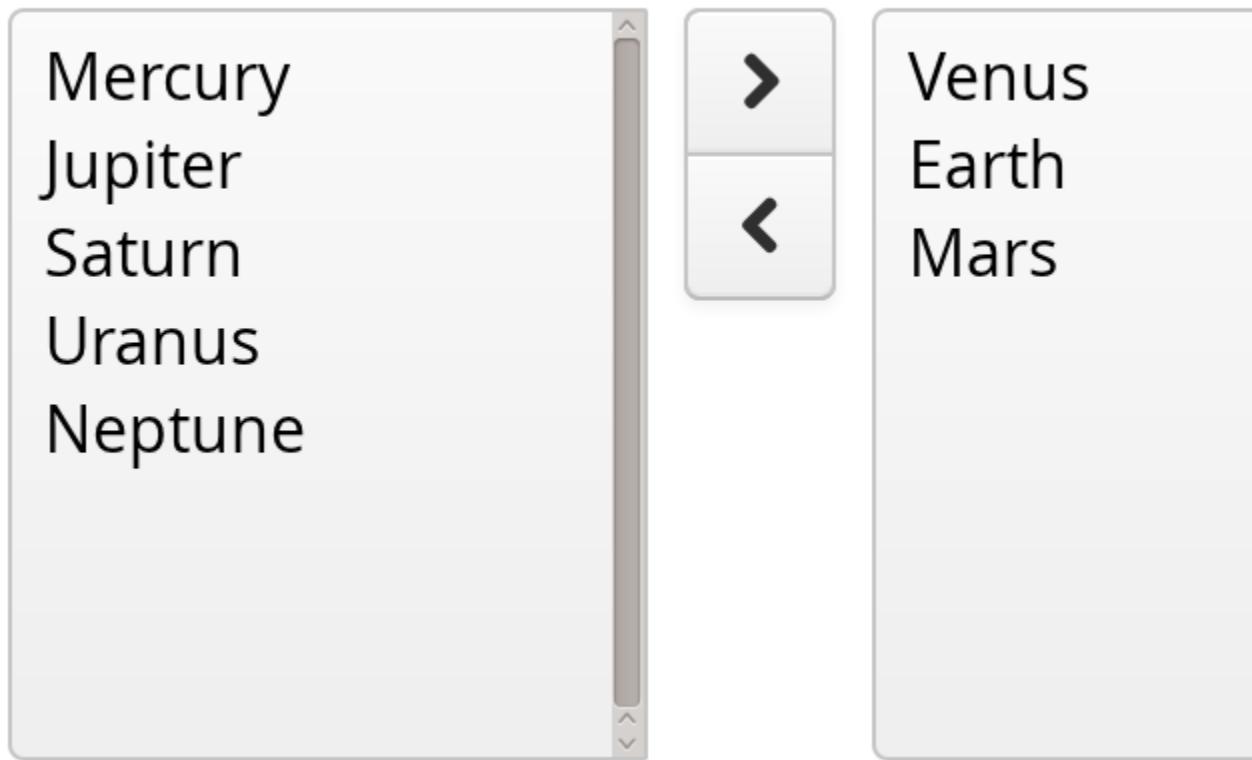
// Preselect a few items by creating a set
select.setValue(new HashSet<String>(
    Arrays.asList("Venus", "Earth", "Mars")));

// Handle value changes
select.addValueChangeListener(event -> // Java 8
    layout.addComponent(new Label("Selected: " +
        event.getProperty().getValue())));
```

The resulting component is shown in Figure 5.42, “Twin Column Selection”.

**Figure 5.42. Twin Column Selection**

## Select Targets



The `setRows()` method sets the height of the component by the number of visible items in the selection boxes. Setting the height with `setHeight()` to a defined value overrides the `rows` setting.

Common selection component features are described in Section 5.5, “Selection Components”.

## CSS Style Rules

```
.v-select-twincol {}  
.v-select-twincol-options-caption {}  
.v-select-twincol-selections-caption {}  
.v-select-twincol-options {}  
.v-select-twincol-buttons {}  
.v-button {}  
.v-button-wrap {}  
.v-button-caption {}  
.v-select-twincol-deco {}  
.v-select-twincol-selections {}
```

The **TwinColSelect** component has an overall `v-select-twincol` style. If set, the left and right column captions have `v-select-twincol-options-caption` and `v-select-twincol-selections-caption` style names, respectively. The left box, which displays the unselected items, has `v-select-twincol-options` style and the right box, which displays the selected items, has `v-select-twincol-options-selections` style. Between them is the button area, which has overall `v-select-twincol-buttons` style; the actual buttons reuse the styles

for the **Button** component. Between the buttons is a divider element with `v-select-twincol-deco` style.

## 5.21. Table

The **Table** component is intended for presenting tabular data organized in rows and columns. The **Table** is one of the most versatile components in Vaadin. Table cells can include text or arbitrary UI components. You can easily implement editing of the table data, for example clicking on a cell could change it to a text field for editing.

The data contained in a **Table** is managed using the Data Model of Vaadin (see Chapter 8, *Binding Components to Data*), through the **Container** interface of the **Table**. This makes it possible to bind a table directly to a data source, such as a database query. Only the visible part of the table is loaded into the browser and moving the visible window with the scrollbar loads content from the server. While the data is being loaded, a tooltip will be displayed that shows the current range and total number of items in the table. The rows of the table are *items* in the container and the columns are *properties*. Each table row (item) is identified with an *item identifier* (IID), and each column (property) with a *property identifier* (PID).

When creating a table, you first need to define columns with `addContainerProperty()`. This method comes in two flavors. The simpler one takes the property ID of the column and uses it also as the caption of the column. The more complex one allows differing PID and header for the column. This may make, for example, internationalization of table headers easier, because if a PID is internationalized, the internationalization has to be used everywhere where the PID is used. The complex form of the method also allows defining an icon for the column from a resource. The "default value" parameter is used when new properties (columns) are added to the table, to fill in the missing values. (This default has no meaning in the usual case, such as below, where we add items after defining the properties.)

```
Table table = new Table("The Brightest Stars");

// Define two columns for the built-in container
table.addContainerProperty("Name", String.class, null);
table.addContainerProperty("Mag", Float.class, null);

// Add a row the hard way
Object newItemId = table.addItem();
Item row1 = table.getItem(newItemId);
row1.getItemProperty("Name").setValue("Sirius");
row1.getItemProperty("Mag").setValue(-1.46f);

// Add a few other rows using shorthand addItem()
table.addItem(new Object[]{"Canopus", -0.72f}, 2);
table.addItem(new Object[]{"Arcturus", -0.04f}, 3);
table.addItem(new Object[]{"Alpha Centauri", -0.01f}, 4);

// Show exactly the currently contained rows (items)
table.setPageLength(table.size());
```

In this example, we used an increasing **Integer** object as the Item Identifier, given as the second parameter to `addItem()`. The actual rows are given simply as object arrays, in the same order in which the properties were added. The objects must be of the correct class, as defined in the `addContainerProperty()` calls.

**Figure 5.43. Basic Table Example**

## The Brightest Stars

Name	Mag
Sirius	-1,46
Canopus	-0,72
Arcturus	-0,04
Alpha Centauri	-0,01

Scalability of the **Table** is largely dictated by the container. The default **IndexedContainer** is relatively heavy and can cause scalability problems, for example, when updating the values. Use of an optimized application-specific container is recommended. Table does not have a limit for the number of items and is just as fast with hundreds of thousands of items as with just a few. With the current implementation of scrolling, there is a limit of around 500 000 rows, depending on the browser and the pixel height of rows.

Common selection component features are described in Section 5.5, “Selection Components”.

### 5.21.1. Selecting Items in a Table

The **Table** allows selecting one or more items by clicking them with the mouse. When the user selects an item, the IID of the item will be set as the property of the table and a **ValueChangeEvent** is triggered. To enable selection, you need to set the table `selectable`. You will also need to set it as *immediate* in most cases, as we do below, because without it, the change in the property will not be communicated immediately to the server.

The following example shows how to enable the selection of items in a **Table** and how to handle **ValueChangeEvent** events that are caused by changes in selection. You need to handle the event with the `valueChange()` method of the **Property.ValueChangeListener** interface.

```
// Allow selecting items from the table.
table.setSelectable(true);
```

```

// Send changes in selection immediately to server.
table.setImmediate(true);

// Shows feedback from selection.
final Label current = new Label("Selected: -");

// Handle selection change.
table.addValueChangeListener(new Property.ValueChangeListener() {
    public void valueChange(ValueChangeEvent event) {
        current.setValue("Selected: " + table.getValue());
    }
});

```

**Figure 5.44. Table Selection Example**

First Name	Last Name	Year	
Nicolaus	Copernicus	1473	▲
Tycho	Brahe	1546	⋮
Giordano	Bruno	1548	⋮
Galileo	Galilei	1564	⋮
Johannes	Kepler	1571	▼

Selected: 2

If the user clicks on an already selected item, the selection will deselect and the table property will have `null` value. You can disable this behaviour by setting `setNullSelectionAllowed(false)` for the table.

The selection is the value of the table's property, so you can get it with `getValue()`. You can get it also from a reference to the table itself. In single selection mode, the value is the item identifier of the selected item or `null` if no item is selected. In multiple selection mode (see below), the value is a **Set** of item identifiers. Notice that the set is unmodifiable, so you can not simply change it to change the selection.

## Multiple Selection Mode

A table can also be in *multiselect* mode, where a user can select multiple items by clicking them with left mouse button while holding the **Ctrl** key (or **Meta** key) pressed. If **Ctrl** is not held, clicking an item will select it and other selected items are deselected. The user can select a range by selecting an item, holding the **Shift** key pressed, and clicking another item, in which case all the items between the two are also selected. Multiple ranges can be selected by first selecting a range, then selecting an item while holding **Ctrl**, and then selecting another item with both **Ctrl** and **Shift** pressed.

The multiselect mode is enabled with the `setMultiSelect()` method of the **AbstractSelect** superclass of **Table**. Setting table in multiselect mode does not implicitly set it as `selectable`, so it must be set separately.

The `setMultiSelectMode()` property affects the control of multiple selection: *MultiSelectMode.DEFAULT* is the default behaviour, which requires holding the **Ctrl** (or **Meta**) key pressed while selecting items, while in *MultiSelectMode.SIMPLE* holding the **Ctrl** key is not needed. In the simple mode, items can only be deselected by clicking them.

## 5.21.2. Table Features

### Page Length and Scrollbar

The default style for **Table** provides a table with a scrollbar. The scrollbar is located at the right side of the table and becomes visible when the number of items in the table exceeds the page length, that is, the number of visible items. You can set the page length with `setPageLength()`.

Setting the page length to zero makes all the rows in a table visible, no matter how many rows there are. Notice that this also effectively disables buffering, as all the entire table is loaded to the browser at once. Using such tables to generate reports does not scale up very well, as there is some inevitable overhead in rendering a table with Ajax. For very large reports, generating HTML directly is a more scalable solution.

### Resizing Columns

You can set the width of a column programmatically from the server-side with `setColumnWidth()`. The column is identified by the property ID and the width is given in pixels.

The user can resize table columns by dragging the resize handle between two columns. Resizing a table column causes a **ColumnResizeEvent**, which you can handle with a **Table.ColumnResizeListener**. The table must be set in immediate mode if you want to receive the resize events immediately, which is typical.

```
table.addColumnResizeListener(new Table.ColumnResizeListener(){
    public void columnResize(ColumnResizeEvent event) {
        // Get the new width of the resized column
        int width = event.getCurrentWidth();

        // Get the property ID of the resized column
        String column = (String) event.getPropertyId();

        // Do something with the information
        table.setColumnFooter(column, String.valueOf(width) + "px");
    }
});

// Must be immediate to send the resize events immediately
table.setImmediate(true);
```

See Figure 5.45, “Resizing Columns” for a result after the columns of a table has been resized.

**Figure 5.45. Resizing Columns**

ColumnResize Events	
NAME	BORN IN
Väisälä	1891
Valtaoja	1951
Galileo	1564
124px	248px

### Reordering Columns

If `setColumnReorderingAllowed(true)` is set, the user can reorder table columns by dragging them with the mouse from the column header,

## Collapsing Columns

When `setColumnCollapsingAllowed(true)` is set, the right side of the table header shows a drop-down list that allows selecting which columns are shown. Collapsing columns is different than hiding columns with `setVisibleColumns()`, which hides the columns completely so that they can not be made visible (uncollapsed) from the user interface.

You can collapse columns programmatically with `setColumnCollapsed()`. Collapsing must be enabled before collapsing columns with the method or it will throw an `IllegalAccessException`.

```
// Allow the user to collapse and uncollapse columns
table.setColumnCollapsingAllowed(true);

// Collapse this column programmatically
try {
    table.setColumnCollapsed("born", true);
} catch (IllegalAccessException e) {
    // Can't occur - collapsing was allowed above
    System.err.println("Something horrible occurred");
}

// Give enough width for the table to accommodate the
// initially collapsed column later
table.setWidth("250px");
```

See Figure 5.46, “Collapsing Columns”.

**Figure 5.46. Collapsing Columns**

Column Collapsing	
NAME	DIED
Galileo	1642
Väisälä	1971
Valtaoja	

- Name
- Died
- Born

If the table has undefined width, it minimizes its width to fit the width of the visible columns. If some columns are initially collapsed, the width of the table may not be enough to accomodate them later, which will result in an ugly horizontal scrollbar. You should consider giving the table enough width to accomodate columns uncollapsed by the user.

## Components Inside a Table

The cells of a **Table** can contain any user interface components, not just strings. If the rows are higher than the row height defined in the default theme, you have to define the proper row height in a custom theme.

When handling events for components inside a **Table**, such as for the **Button** in the example below, you usually need to know the item the component belongs to. Components do not themselves know about the table or the specific item in which a component is contained. Therefore, the handling method must use some other means for finding out the Item ID of the item. There are a few possibilities. Usually the easiest way is to use the `setData()` method to attach an arbitrary object to a component. You can subclass the component and include the identity information there. You can also simply search the entire table for the item with the component, although that solution may not be so scalable.

The example below includes table rows with a **Label** in HTML content mode, a multiline **TextField**, a **CheckBox**, and a **Button** that shows as a link.

```
// Create a table and add a style to allow setting the row height in theme.
final Table table = new Table();
table.addStyleName("components-inside");

/* Define the names and data types of columns.
 * The "default value" parameter is meaningless here. */
table.addContainerProperty("Sum", Label.class, null);
table.addContainerProperty("Is Transferred", CheckBox.class, null);
table.addContainerProperty("Comments", TextField.class, null);
table.addContainerProperty("Details", Button.class, null);

/* Add a few items in the table. */
for (int i=0; i<100; i++) {
    // Create the fields for the current table row
    Label sumField = new Label(String.format(
        "Sum is <b>$%04.2f</b><br/><i>(VAT incl.)</i>",
        new Object[] {new Double(Math.random()*1000)}),
        ContentMode.HTML);
    CheckBox transferredField = new CheckBox("is transferred");

    // Multiline text field. This required modifying the
    // height of the table row.
    TextField commentsField = new TextField();
    commentsField.setRows(3);

    // The Table item identifier for the row.
    Integer itemId = new Integer(i);

    // Create a button and handle its click. A Button does not
    // know the item it is contained in, so we have to store the
    // item ID as user-defined data.
    Button detailsField = new Button("show details");
    detailsField.setData(itemId);
    detailsField.addClickListener(new Button.ClickListener() {
        public void buttonClick(ClickEvent event) {
            // Get the item identifier from the user-defined data.
            Integer iid = (Integer)event.getButton().getData();
            Notification.show("Link " +
                iid.intValue() + " clicked.");
        }
    });
    detailsField.addStyleName("link");

    // Create the table row.
    table.addItem(new Object[] {sumField, transferredField,
        commentsField, detailsField},
        itemId);
}

// Show just three rows because they are so high.
table.setPageLength(3);
```

The row height has to be set higher than the default with a style rule such as the following:

```
/* Table rows contain three-row TextField components. */
.v-table-components-inside .v-table-cell-content {
```

```
height: 54px;
}
```

The table will look as shown in Figure 5.47, “Components in a Table”.

**Figure 5.47. Components in a Table**

Sum	Is Transferred	Comments	Details
Sum is \$777,60 (VAT incl.)	<input checked="" type="checkbox"/> is transferred	We sent this money already in last week.	<a href="#">show details</a>
Sum is \$500,40 (VAT incl.)	<input type="checkbox"/> is transferred		<a href="#">show details</a>
Sum is \$836,10 (VAT incl.)	<input type="checkbox"/> is transferred		<a href="#">show details</a>

## Iterating Over a Table

As the items in a **Table** are not indexed, iterating over the items has to be done using an iterator. The `getItemIds()` method of the **Container** interface of **Table** returns a **Collection** of item identifiers over which you can iterate using an **Iterator**. For an example about iterating over a **Table**, please see Section 8.5, “Collecting Items in Containers”. Notice that you may not modify the **Table** during iteration, that is, add or remove items. Changing the data is allowed.

## Filtering Table Contents

A table can be filtered if its container data source implements the **Filterable** interface, as the default **IndexedContainer** does. See Section 8.5.7, “**Filterable** Containers”.

### 5.21.3. Editing the Values in a Table

Normally, a **Table** simply displays the items and their fields as text. If you want to allow the user to edit the values, you can either put them inside components as we did earlier or simply call `setEditable(true)`, in which case the cells are automatically turned into editable fields.

Let us begin with a regular table with some columns with usual Java types, namely a **Date**, **Boolean**, and a **String**.

```
// Create a table. It is by default not editable.
final Table table = new Table();

// Define the names and data types of columns.
table.addContainerProperty("Date", Date.class, null);
table.addContainerProperty("Work", Boolean.class, null);
table.addContainerProperty("Comments", String.class, null);

// Add a few items in the table.
for (int i=0; i<100; i++) {
    Calendar calendar = new GregorianCalendar(2008,0,1);
    calendar.add(Calendar.DAY_OF_YEAR, i);

    // Create the table row.
    Row row = table.addRow();
    row.setContainerProperty("Date", calendar);
    row.setContainerProperty("Work", true);
    row.setContainerProperty("Comments", "Comment " + i);
}
```

```

        table.addItem(new Object[] {calendar.getTime(),
                                new Boolean(false),
                                ""),
                    new Integer(i)); // Item identifier
    }

table.setPageLength(8);
layout.addComponent(table);

```

You could put the table in **editable** mode right away if you need to. We'll continue the example by adding a mechanism to switch the **Table** from and to the **editable** mode.

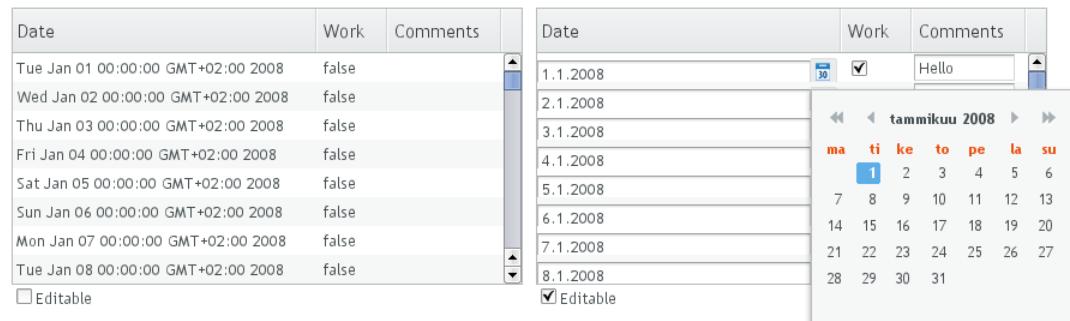
```

final CheckBox switchEditable = new CheckBox("Editable");
switchEditable.addValueChangeListener(
    new Property.ValueChangeListener() {
        public void valueChange(ValueChangeEvent event) {
            table.setEditable(((Boolean)event.getProperty()
                .getValue()).booleanValue());
        }
    });
switchEditable.setImmediate(true);
layout.addComponent(switchEditable);

```

Now, when you check to checkbox, the components in the table turn into editable fields, as shown in Figure 5.48, "A Table in Normal and Editable Mode".

**Figure 5.48. A Table in Normal and Editable Mode**



## Field Factories

The field components that allow editing the values of particular types in a table are defined in a field factory that implements the **TableFieldFactory** interface. The default implementation is **DefaultFieldFactory**, which offers the following crude mappings:

**Table 5.2. Type to Field Mappings in DefaultFieldFactory**

Property Type	Mapped to Field Class
Date	A <b>DateField</b> .
Boolean	A <b>CheckBox</b> .
Item	A <b>Form</b> (deprecated in Vaadin 7). The fields of the form are automatically created from the item's properties using a <b>FormFieldFactory</b> .

Property Type	Mapped to Field Class
	The normal use for this property type is inside a <b>Form</b> and is less useful inside a <b>Table</b> .
<i>other</i>	A <b>TextField</b> . The text field manages conversions from the basic types, if possible.

Field factories are covered with more detail in Section 8.4, “Creating Forms by Binding Fields to Items”. You could just implement the **TableFieldFactory** interface, but we recommend that you extend the **DefaultFieldFactory** according to your needs. In the default implementation, the mappings are defined in the `createFieldByPropertyType()` method (you might want to look at the source code) both for tables and forms.

## Navigation in Editable Mode

In the editable mode, the editor fields can have focus. Pressing **Tab** moves the focus to next column or, at the last column, to the first column of the next item. Respectively, pressing **Shift+Tab** moves the focus backward. If the focus is in the last column of the last visible item, the pressing **Tab** moves the focus outside the table. Moving backward from the first column of the first item moves the focus to the table itself. Some updates to the table, such as changing the headers or footers or regenerating a column, can move the focus from an editor component to the table itself.

The default behaviour may be undesirable in many cases. For example, the focus also goes through any read-only editor fields and can move out of the table inappropriately. You can provide better navigation is to use event handler for shortcut keys such as **Tab**, **Arrow Up**, **Arrow Down**, and **Enter**.

```
// Keyboard navigation
class KbdHandler implements Handler {
    Action tab_next = new ShortcutAction("Tab",
        ShortcutAction.KeyCode.TAB, null);
    Action tab_prev = new ShortcutAction("Shift+Tab",
        ShortcutAction.KeyCode.TAB,
        new int[] {ShortcutAction.ModifierKey.SHIFT});
    Action cur_down = new ShortcutAction("Down",
        ShortcutAction.KeyCode.ARROW_DOWN, null);
    Action cur_up   = new ShortcutAction("Up",
        ShortcutAction.KeyCode.ARROW_UP,   null);
    Action enter   = new ShortcutAction("Enter",
        ShortcutAction.KeyCode.ENTER,     null);
    public Action[] getActions(Object target, Object sender) {
        return new Action[] {tab_next, tab_prev, cur_down,
                            cur_up, enter};
    }

    public void handleAction(Action action, Object sender,
                           Object target) {
        if (target instanceof TextField) {
            // Move according to keypress
            int itemid = (Integer) ((TextField) target).getData();
            if (action == tab_next || action == cur_down)
                itemid++;
            else if (action == tab_prev || action == cur_up)
                itemid--;
            // On enter, just stay where you were. If we did
            // not catch the enter action, the focus would be
            // moved to wrong place.
        }
    }
}
```

```
        if (itemid >= 0 && itemid < table.size()) {
            TextField newTF = valueFields.get(itemid);
            if (newTF != null)
                newTF.focus();
        }
    }
}

// Panel that handles keyboard navigation
Panel navigator = new Panel();
navigator.setStyleName(Reindeer.PANEL_LIGHT);
navigator.addComponent(table);
navigator.addActionHandler(new KbdHandler());
```

The main issue in implementing keyboard navigation in an editable table is that the editor fields do not know the table they are in. To find the parent table, you can either look up in the component container hierarchy or simply store a reference to the table with `setData()` in the field component. The other issue is that you can not acquire a reference to an editor field from the **Table** component. One solution is to use some external collection, such as a **HashMap**, to map item IDs to the editor fields.

```
// Can't access the editable components from the table so
// must store the information
final HashMap<Integer,TextField> valueFields =
    new HashMap<Integer,TextField>();
```

The map has to be filled in a **TableFieldFactory**, such as in the following. You also need to set the reference to the table there and you can also set the initial focus there.

```
table.setTableFieldFactory(new TableFieldFactory () {
    public Field createField(Container container, Object itemId,
        Object propertyId, Component uiContext) {
        TextField field = new TextField((String) propertyId);

        // User can only edit the numeric column
        if ("Source of Fear".equals(propertyId))
            field.setReadOnly(true);
        else { // The numeric column
            // The field needs to know the item it is in
            field.setData(itemId);

            // Remember the field
            valueFields.put((Integer) itemId, field);

            // Focus the first editable value
            if (((Integer)itemId) == 0)
                field.focus();
        }
        return field;
});
```

The issues are complicated by the fact that the editor fields are not generated for the entire table, but only for a cache window that includes the visible items and some items above and below it. For example, if the beginning of a big scrollable table is visible, the editor component for the last item does not exist. This issue is relevant mostly if you want to have wrap-around navigation that jumps from the last to first item and vice versa.

## 5.21.4. Column Headers and Footers

Table supports both column headers and footers; the headers are enabled by default.

### Headers

The table header displays the column headers at the top of the table. You can use the column headers to reorder or resize the columns, as described earlier. By default, the header of a column is the property ID of the column, unless given explicitly with `setColumnHeader()`.

```
// Define the properties
table.addContainerProperty("lastname", String.class, null);
table.addContainerProperty("born", Integer.class, null);
table.addContainerProperty("died", Integer.class, null);

// Set nicer header names
table.setColumnHeader("lastname", "Name");
table.setColumnHeader("born", "Born");
table.setColumnHeader("died", "Died");
```

The text of the column headers and the visibility of the header depends on the *column header mode*. The header is visible by default, but you can disable it with `setColumnHeaderMode(Table.COLUMN_HEADER_MODE_HIDDEN)`.

### Footers

The table footer can be useful for displaying sums or averages of values in a column, and so on. The footer is not visible by default; you can enable it with `setFooterVisible(true)`. Unlike in the header, the column headers are empty by default. You can set their value with `setColumnFooter()`. The columns are identified by their property ID.

The following example shows how to calculate average of the values in a column:

```
// Have a table with a numeric column
Table table = new Table("Custom Table Footer");
table.addContainerProperty("Name", String.class, null);
table.addContainerProperty("Died At Age", Integer.class, null);

// Insert some data
Object people[][] = {{"Galileo", 77},
                     {"Monnier", 83},
                     {"Vaisala", 79},
                     {"Oterma", 86}};
for (int i=0; i<people.length; i++)
    table.addItem(people[i], new Integer(i));

// Calculate the average of the numeric column
double avgAge = 0;
for (int i=0; i<people.length; i++)
    avgAge += (Integer) people[i][1];
avgAge /= people.length;

// Set the footers
table.setFooterVisible(true);
table.setColumnFooter("Name", "Average");
table.setColumnFooter("Died At Age", String.valueOf(avgAge));
```

```
// Adjust the table height a bit  
table.setPageLength(table.size());
```

The resulting table is shown in Figure 5.49, “A Table with a Footer”.

**Figure 5.49. A Table with a Footer**

Custom Table Footer	
NAME	DIED AT AGE
Galileo	77
Monnier	83
Väisälä	79
Oterma	86
Average	81.25

## Handling Mouse Clicks on Headers and Footers

Normally, when the user clicks a column header, the table will be sorted by the column, assuming that the data source is **Sortable** and sorting is not disabled. In some cases, you might want some other functionality when the user clicks the column header, such as selecting the column in some way.

Clicks in the header cause a **HeaderClickEvent**, which you can handle with a **Table.HeaderClickListener**. Click events on the table header (and footer) are, like button clicks, sent immediately to server, so there is no need to set `setImmediate()`.

```
// Handle the header clicks  
table.addHeaderClickListener(new Table.HeaderClickListener() {  
    public void headerClick(HeaderClickEvent event) {  
        String column = (String) event.getPropertyId();  
        Notification.show("Clicked " + column +  
            "with " + event.getButtonName());  
    }  
});  
  
// Disable the default sorting behavior  
table.setSortDisabled(true);
```

Setting a click handler does not automatically disable the sorting behavior of the header; you need to disable it explicitly with `setSortDisabled(true)`. Header click events are not sent when the user clicks the column resize handlers to drag them.

The **HeaderClickEvent** object provides the identity of the clicked column with `getPropertyId()`. The `getButton()` reports the mouse button with which the click was made: `BUTTON_LEFT`, `BUTTON_RIGHT`, or `BUTTON_MIDDLE`. The `getButtonName()` a human-readable button name in English: `"left"`, `"right"`, or `"middle"`. The `isShiftKey()`, `isCtrlKey()`, etc., methods indicate if the **Shift**, **Ctrl**, **Alt** or other modifier keys were pressed during the click.

Clicks in the footer cause a **FooterClickEvent**, which you can handle with a **Table.FooterClickListener**. Footers do not have any default click behavior, like the sorting in the header. Otherwise, handling clicks in the footer is equivalent to handling clicks in the header.

## 5.21.5. Generated Table Columns

You might want to have a column that has values calculated from other columns. Or you might want to format table columns in some way, for example if you have columns that display currencies. The **ColumnGenerator** interface allows defining custom generators for such columns.

You add new generated columns to a **Table** with `addGeneratedColumn()`. It takes the column identifier as its parameters. Usually you want to have a more user-friendly and possibly internationalized column header. You can set the header and a possible icon by calling `addContainerProperty()` before adding the generated column.

```
// Define table columns.  
table.addContainerProperty(  
    "date", Date.class, null, "Date", null, null);  
table.addContainerProperty(  
    "quantity", Double.class, null, "Quantity (l)", null, null);  
table.addContainerProperty(  
    "price", Double.class, null, "Price (e/l)", null, null);  
table.addContainerProperty(  
    "total", Double.class, null, "Total (e)", null, null);  
  
// Define the generated columns and their generators.  
table.addGeneratedColumn("date",  
    new DateColumnGenerator());  
table.addGeneratedColumn("quantity",  
    new ValueColumnGenerator("%.2f l"));  
table.addGeneratedColumn("price",  
    new PriceColumnGenerator());  
table.addGeneratedColumn("total",  
    new ValueColumnGenerator("%.2f e"));
```

Notice that the `addGeneratedColumn()` always places the generated columns as the last column, even if you defined some other order previously. You will have to set the proper order with `setVisibleColumns()`.

```
table.setVisibleColumns(new Object[] {"date", "quantity", "price", "total"});
```

The generators are objects that implement the **Table.ColumnGenerator** interface and its `generateCell()` method. The method gets the identity of the item and column as its parameters, in addition to the table object. It has to return a component object.

The following example defines a generator for formatting **Double** valued fields according to a format string (as in **java.util.Formatter**).

```
/** Formats the value in a column containing Double objects. */  
class ValueColumnGenerator implements Table.ColumnGenerator {  
    String format; /* Format string for the Double values. */  
  
    /**  
     * Creates double value column formatter with the given  
     * format string.  
     */  
    public ValueColumnGenerator(String format) {  
        this.format = format;  
    }  
  
    /**  
     * Generates the cell containing the Double value.  
     */
```

```
* The column is irrelevant in this use case.  
*/  
public Component generateCell(Table source, Object itemId,  
    Object columnId) {  
    // Get the object stored in the cell as a property  
    Property prop =  
        source.getItem(itemId).getItemProperty(columnId);  
    if (prop.getType().equals(Double.class)) {  
        Label label = new Label(String.format(format,  
            new Object[] { (Double) prop.getValue() }));  
  
        // Set styles for the column: one indicating that it's  
        // a value and a more specific one with the column  
        // name in it. This assumes that the column name  
        // is proper for CSS.  
        label.addStyleName("column-type-value");  
        label.addStyleName("column-" + (String) columnId);  
        return label;  
    }  
    return null;  
}  
}  
}
```

The generator is called for all the visible (or more accurately cached) items in a table. If the user scrolls the table to another position in the table, the columns of the new visible rows are generated dynamically. The columns in the visible (cached) rows are also generated always when an item has a value change. It is therefore usually safe to calculate the value of generated cells from the values of different rows (items).

When you set a table as `editable`, regular fields will change to editing fields. When the user changes the values in the fields, the generated columns will be updated automatically. Putting a table with generated columns in editable mode has a few quirks. The editable mode of **Table** does not affect generated columns. You have two alternatives: either you generate the editing fields in the generator or, in case of formatter generators, remove the generator in the editable mode. The example below uses the latter approach.

```
// Have a check box that allows the user  
// to make the quantity and total columns editable.  
final CheckBox editable = new CheckBox(  
    "Edit the input values - calculated columns are regenerated");  
  
editable.setImmediate(true);  
editable.addClickListener(new ClickListener() {  
    public void buttonClick(ClickEvent event) {  
        table.setEditable(editable.booleanValue());  
  
        // The columns may not be generated when we want to  
        // have them editable.  
        if (editable.booleanValue()) {  
            table.removeGeneratedColumn("quantity");  
            table.removeGeneratedColumn("total");  
        } else { // Not editable  
            // Show the formatted values.  
            table.addGeneratedColumn("quantity",  
                new ValueColumnGenerator("%.2f l"));  
            table.addGeneratedColumn("total",  
                new ValueColumnGenerator("%.2f e"));  
        }  
        // The visible columns are affected by removal
```

```
// and addition of generated columns so we have
// to redefine them.
table.setVisibleColumns(new Object[] {"date", "quantity",
    "price", "total", "consumption", "dailycost"});
}
});
```

You will also have to set the editing fields in *immediate* mode to have the update occur immediately when an edit field loses the focus. You can set the fields in *immediate* mode with the a custom **TableFieldFactory**, such as the one given below, that just extends the default implementation to set the mode:

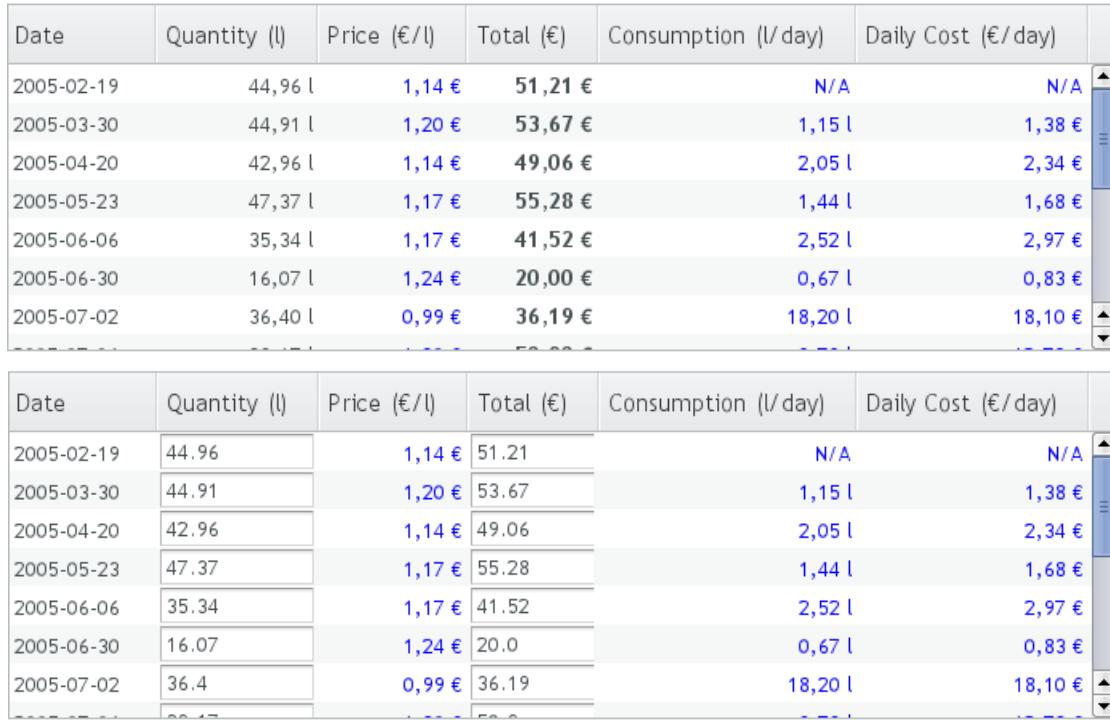
```
public class ImmediateFieldFactory extends DefaultFieldFactory {
    public Field createField(Container container,
        Object itemId,
        Object propertyId,
        Component uiContext) {
        // Let the DefaultFieldFactory create the fields...
        Field field = super.createField(container, itemId,
            propertyId, uiContext);

        // ...and just set them as immediate.
        ((AbstractField)field).setImmediate(true);

        return field;
    }
}
...
table.setTableFieldFactory(new ImmediateFieldFactory());
```

If you generate the editing fields with the column generator, you avoid having to use such a field factory, but of course have to generate the fields for both normal and editable modes.

Figure 5.50, “Table with Generated Columns in Normal and Editable Mode” shows a table with columns calculated (blue) and simply formatted (black) with column generators.

**Figure 5.50. Table with Generated Columns in Normal and Editable Mode**


Date	Quantity (l)	Price (€/l)	Total (€)	Consumption (l/day)	Daily Cost (€/day)	
2005-02-19	44,96 l	1,14 €	51,21 €	N/A	N/A	
2005-03-30	44,91 l	1,20 €	53,67 €	1,15 l	1,38 €	
2005-04-20	42,96 l	1,14 €	49,06 €	2,05 l	2,34 €	
2005-05-23	47,37 l	1,17 €	55,28 €	1,44 l	1,68 €	
2005-06-06	35,34 l	1,17 €	41,52 €	2,52 l	2,97 €	
2005-06-30	16,07 l	1,24 €	20,00 €	0,67 l	0,83 €	
2005-07-02	36,40 l	0,99 €	36,19 €	18,20 l	18,10 €	

Date	Quantity (l)	Price (€/l)	Total (€)	Consumption (l/day)	Daily Cost (€/day)	
2005-02-19	44.96	1,14 €	51.21	N/A	N/A	
2005-03-30	44.91	1,20 €	53.67	1,15 l	1,38 €	
2005-04-20	42.96	1,14 €	49.06	2,05 l	2,34 €	
2005-05-23	47.37	1,17 €	55.28	1,44 l	1,68 €	
2005-06-06	35.34	1,17 €	41.52	2,52 l	2,97 €	
2005-06-30	16.07	1,24 €	20.0	0,67 l	0,83 €	
2005-07-02	36.4	0,99 €	36.19	18,20 l	18,10 €	

## 5.21.6. Formatting Table Columns

The displayed values of properties shown in a table are normally formatted using the `toString()` method of each property. Customizing the format of a column can be done in several ways:

- Using **ColumnGenerator** to generate a second column that is formatted. The original column needs to be set invisible. See Section 5.21.5, “Generated Table Columns”.
- Using a **PropertyFormatter** as a proxy between the table and the data property. This also normally requires using an `ItemContainer` in the table.
- Overriding the default `formatPropertyValue()` in **Table**.

As using a **PropertyFormatter** is generally much more awkward than overriding the `formatPropertyValue()`, its use is not described here.

You can override `formatPropertyValue()` as is done in the following example:

```
// Create a table that overrides the default
// property (column) format
final Table table = new Table("Formatted Table") {
    @Override
    protected String formatPropertyValue(Object rowId,
                                         Object colId, Property property) {
        // Format by property type
        if (property.getType() == Date.class) {
            SimpleDateFormat df =
                new SimpleDateFormat("yyyy-MM-dd hh:mm:ss");
            return df.format((Date)property.getValue());
        }
    }
}
```

```
        return super.formatPropertyValue(rowId, colId, property);
    }

// The table has some columns
table.addContainerProperty("Time", Date.class, null);

... Fill the table with data ...
```

You can also distinguish between columns by the `colId` parameter, which is the property ID of the column. **DecimalFormat** is useful for formatting decimal values.

```
... in formatPropertyValue() ...
} else if ("Value".equals(pid)) {
    // Format a decimal value for a specific locale
    DecimalFormat df = new DecimalFormat("#.00",
        new DecimalFormatSymbols(locale));
    return df.format((Double) property.getValue());
}
...
table.addContainerProperty("Value", Double.class, null);
```

A table with the formatted date and decimal value columns is shown in Figure 5.51, “Formatted Table Columns”.

**Figure 5.51. Formatted Table Columns**

Formatted Table		
TIME	VALUE	MESSAGE
1970-01-01 02:00:00	708,42	Msg #55
1970-03-29 05:16:33	44,31	Msg #33
1970-07-22 04:40:13	741,61	Msg #1
1970-09-01 12:11:49	757,91	Msg #36
1970-12-21 02:32:50	793,82	Msg #92
1971-01-13 05:25:15	700,79	Msg #65

You can use CSS for further styling of table rows, columns, and individual cells by using a **CellStyleGenerator**. It is described in Section 5.21.7, “CSS Style Rules”.

## 5.21.7. CSS Style Rules

Styling the overall style of a **Table** can be done with the following CSS rules.

```
.v-table {}
.v-table-header-wrap {}
.v-table-header {}
.v-table-header-cell {}
.v-table-resizer {} /* Column resizer handle. */
.v-table-caption-container {}

.v-table-body {}
.v-table-row-spacer {}
.v-table-table {}
.v-table-row {}
.v-table-cell-content {}
```

Notice that some of the widths and heights in a table are calculated dynamically and can not be set in CSS.

## Setting Individual Cell Styles

The **Table.CellStyleGenerator** interface allows you to set the CSS style for each individual cell in a table. You need to implement the `getStyle()`, which gets the row (item) and column (property) identifiers as parameters and can return a style name for the cell. The returned style name will be concatenated to prefix "v-table-cell-content-".

The `getStyle()` is called also for each row, so that the `propertyId` parameter is `null`. This allows setting a row style.

Alternatively, you can use a **Table.ColumnGenerator** (see Section 5.21.5, “Generated Table Columns”) to generate the actual UI components of the cells and add style names to them.

```
Table table = new Table("Table with Cell Styles");
table.addStyleName("checkerboard");

// Add some columns in the table. In this example, the property
// IDs of the container are integers so we can determine the
// column number easily.
table.addContainerProperty("0", String.class, null, "", null, null);
for (int i=0; i<8; i++)
    table.addContainerProperty(""+(i+1), String.class, null,
                               String.valueOf((char) (65+i)), null, null);

// Add some items in the table.
table.addItem(new Object[]{
    "1", "R", "N", "B", "Q", "K", "B", "N", "R"}, new Integer(0));
table.addItem(new Object[]{
    "2", "P", "P", "P", "P", "P", "P", "P"}, new Integer(1));
for (int i=2; i<6; i++)
    table.addItem(new Object[]{String.valueOf(i+1),
                               "", "", "", "", "", "", ""}, new Integer(i));
table.addItem(new Object[]{
    "7", "P", "P", "P", "P", "P", "P", "P"}, new Integer(6));
table.addItem(new Object[]{
    "8", "R", "N", "B", "Q", "K", "B", "N", "R"}, new Integer(7));
table.setPageLength(8);

// Set cell style generator
table.setCellStyleGenerator(new Table.CellStyleGenerator() {
    public String getStyle(Object itemId, Object propertyId) {
        // Row style setting, not relevant in this example.
        if (propertyId == null)
            return "green"; // Will not actually be visible

        int row = ((Integer)itemId).intValue();
        int col = Integer.parseInt((String)propertyId);

        // The first column.
        if (col == 0)
            return "rowheader";

        // Other cells.
        if ((row+col)%2 == 0)
            return "black";
    }
});
```

```
        else
            return "white";
    }
});
```

You can then style the cells, for example, as follows:

```
/* Center the text in header. */
.v-table-header-cell {
    text-align: center;
}

/* Basic style for all cells. */
.v-table-checkerboard .v-table-cell-content {
    text-align: center;
    vertical-align: middle;
    padding-top: 12px;
    width: 20px;
    height: 28px;
}

/* Style specifically for the row header cells. */
.v-table-cell-content-rowheader {
    background: #E7EDF3
    url(..../default/table/img/header-bg.png) repeat-x scroll 0 0;
}

/* Style specifically for the "white" cells. */
.v-table-cell-content-white {
    background: white;
    color: black;
}

/* Style specifically for the "black" cells. */
.v-table-cell-content-black {
    background: black;
    color: white;
}
```

The table will look as shown in Figure 5.52, “Cell Style Generator for a Table”.

**Figure 5.52. Cell Style Generator for a Table**

	A	B	C	D	E	F	G	H
1	R	N	B	Q	K	B	N	R
2	P	P	P	P	P	P	P	P
3								
4								
5								
6								
7	P	P	P	P	P	P	P	P
8	R	N	B	Q	K	B	N	R

## 5.22. Tree

The **Tree** component allows a natural way to represent data that has hierarchical relationships, such as filesystems or message threads. The **Tree** component in Vaadin works much like the tree components of most modern desktop user interface toolkits, for example in directory browsing.

The typical use of the **Tree** component is for displaying a hierarchical menu, like a menu on the left side of the screen, as in Figure 5.53, “A **Tree** Component as a Menu”, or for displaying filesystems or other hierarchical datasets. The *menu* style makes the appearance of the tree more suitable for this purpose.

```
final Object[][][] planets = new Object[][][]{
    new Object[]{"Mercury"},
    new Object[]{"Venus"},
    new Object[]{"Earth", "The Moon"},
    new Object[]{"Mars", "Phobos", "Deimos"},
    new Object[]{"Jupiter", "Io", "Europa", "Ganymedes",
        "Callisto"},
    new Object[]{"Saturn", "Titan", "Tethys", "Dione",
        "Rhea", "Iapetus"},
    new Object[]{"Uranus", "Miranda", "Ariel", "Umbriel",
        "Titania", "Oberon"},
    new Object[]{"Neptune", "Triton", "Proteus", "Nereid",
        "Larissa"}};

Tree tree = new Tree("The Planets and Major Moons");

/* Add planets as root items in the tree. */
for (int i=0; i<planets.length; i++) {
    String planet = (String) (planets[i][0]);
    tree.addItem(planet);

    if (planets[i].length == 1) {
        // The planet has no moons so make it a leaf.
        tree.setChildrenAllowed(planet, false);
    } else {
        // Add children (moons) under the planets.
        for (int j=1; j<planets[i].length; j++) {
            String moon = (String) planets[i][j];

            // Add the item as a regular item.
            tree.addItem(moon);

            // Set it to be a child.
            tree.setParent(moon, planet);

            // Make the moons look like leaves.
            tree.setChildrenAllowed(moon, false);
        }

        // Expand the subtree.
        tree.expandItemsRecursively(planet);
    }
}

main.addComponent(tree);
```

Figure 5.53, “A **Tree** Component as a Menu” below shows the tree from the code example in a practical situation.

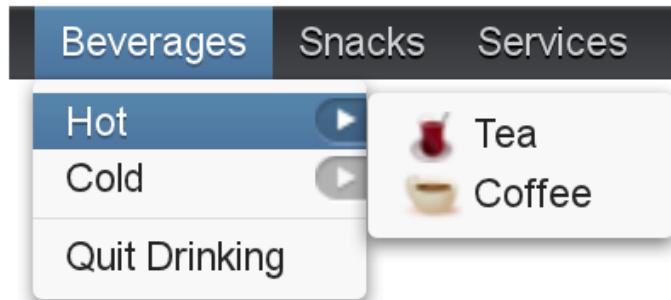
You can read or set the currently selected item by the value property of the **Tree** component, that is, with `getValue()` and `setValue()`. When the user clicks an item on a tree, the tree will receive an **ValueChangeEvent**, which you can catch with a **ValueChangeListener**. To receive the event immediately after the click, you need to set the tree as `setImmediate(true)`.

The **Tree** component uses **Container** data sources much like the **Table** component, with the addition that it also utilizes hierarchy information maintained by a **HierarchicalContainer**. The contained items can be of any item type supported by the container. The default container and its `addItem()` assume that the items are strings and the string value is used as the item ID.

## 5.23.MenuBar

The **MenuBar** component allows creating horizontal dropdown menus, much like the main menu in desktop applications.

**Figure 5.54. Menu Bar**



## Creating a Menu

The actual menu bar component is first created as follows:

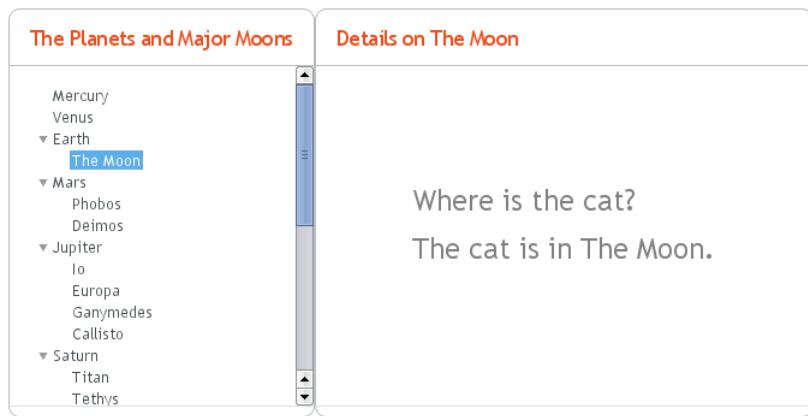
```
MenuBar menubar = new MenuBar();
main.addComponent(menubar);
```

You insert the top-level menu items to the **MenuBar** object with the `addItem()` method. It takes a string label, an icon resource, and a command as its parameters. The icon and command are not required and can be `null`. The `addItem()` method returns a **MenuBar.MenuItem** object, which you can use to add sub-menu items. The **MenuItem** has an identical `addItem()` method.

For example (the command is explained later):

```
// A top-level menu item that opens a submenu
MenuItem drinks = barmenu.addItem("Beverages", null, null);

// Submenu item with a sub-submenu
MenuItem hots = drinks.addItem("Hot", null, null);
hots.addItem("Tea",
    new ThemeResource("icons/tea-16px.png"), mycommand);
hots.addItem("Coffee",
    new ThemeResource("icons/coffee-16px.png"), mycommand);
```

**Figure 5.53. A Tree Component as a Menu**

```
// Another submenu item with a sub-submenu
MenuItem colds = drinks.addItem("Cold", null, null);
colds.addItem("Milk", null, mycommand);
colds.addItem("Weissbier", null, mycommand);

// Another top-level item
MenuItem snacks = barmenu.addItem("Snacks", null, null);
snacks.addItem("Weisswurst", null, mycommand);
snacks.addItem("Bratwurst", null, mycommand);
snacks.addItem("Currywurst", null, mycommand);

// Yet another top-level item
MenuItem servs = barmenu.addItem("Services", null, null);
servs.addItem("Car Service", null, mycommand);
```

## Handling Menu Selection

Menu selection is handled by executing a *command* when the user selects an item from the menu. A command is a call-back class that implements the **MenuBar.Command** interface.

```
// A feedback component
final Label selection = new Label("-");
main.addComponent(selection);

// Define a common menu command for all the menu items.
MenuBar.Command mycommand = new MenuBar.Command() {
    public void menuSelected(MenuItem selectedItem) {
        selection.setValue("Ordered a " +
                           selectedItem.getText() +
                           " from menu.");
    }
};
```

## Menu Items

Menu items have properties such as a caption, icon, enabled, visible, and description (tooltip). The meaning of these is the same as for components.

Submenus are created by adding sub-items to an item with `addItem()` or `addItemBefore()`.

The `command` property is a **MenuBar.Command** that is called when the particular menu item is selected. The `menuSelected()` callback gets the clicked menu item as its parameter.

Menus can have *separators*, which are defined before or after an item with `addSeparatorBefore()` or `addSeparator()` on the item, respectively.

```
MenuItem drinks = barmenu.addItem("Beverages", null, null);
...
// A sub-menu item after a separator
drinks.addSeparator();
drinks.addItem("Quit Drinking", null, null);
```

Enabling `checkable` on an menu item with `setCheckable()` allows the user to switch between checked and unchecked state by clicking on the item. You can set the checked state with `setChecked()`. Note that if such an item has a command, the checked state is not flipped automatically, but you need to do it explicitly.

Menu items have various other properties as well, see the API documentation for more details.

## CSS Style Rules

```
.v-menubar { }
.v-menubar-submenu { }
.v-menubar-menuitem { }
.v-menubar-menuitem-caption { }
.v-menubar-menuitem-selected { }
.v-menubar-submenu-indicator { }
```

The menu bar has the overall style name `.v-menubar`. Each menu item has `.v-menubar-menuitem` style normally and additionally `.v-menubar-selected` when the item is selected, that is, when the mouse pointer hovers over it. The item caption is inside a `v-menubar-menuitem-caption`. In the top-level menu bar, the items are directly under the `component` element.

Submenus are floating `v-menubar-submenu` elements outside the menu bar element. Therefore, you should not try to match on the `component` element for the submenu popups. In submenus, any further submenu levels are indicated with a `v-menubar-submenu-indicator`.

## Styling Menu Items

You can set the CSS style name for the menu items with `setStyleName()`, just like for components. The style name will be prepended with `v-menubar-menuitem-`. As **MenuBar** does not indicate the previous selection in any way, you can do that by highlighting the previously selected item. However, beware that the `selected` style for menu items, that is, `v-menubar-menuitem-selected`, is reserved for mouse-hover indication.

```
MenuBar barmenu = newMenuBar();
barmenu.setStyleName("mybarmenu");
layout.addComponent(barmenu);

// A feedback component
final Label selection = new Label("-");
layout.addComponent(selection);

// Define a common menu command for all the menu items
MenuBar.Command mycommand = newMenuBar.Command() {
    MenuItem previous = null;
```

```
public void menuSelected(MenuItem selectedItem) {
    selection.setValue("Ordered a " +
        selectedItem.getText() +
        " from menu.");
}

if (previous != null)
    previous.setStyleName(null);
selectedItem.setStyleName("highlight");
previous = selectedItem;
}

};

// Put some items in the menu
barmenu.addItem("Beverages", null, mycommand);
barmenu.addItem("Snacks", null, mycommand);
barmenu.addItem("Services", null, mycommand);
```

You could then style the highlighting in CSS as follows:

```
.mybarmenu .v-menubar-menuitem-highlight {
    background: #000040; /* Dark blue */
}
```

## 5.24. Upload

The **Upload** component allows a user to upload files to the server. It displays a file name entry box, a file selection button, and an upload submit button. The user can either write the filename in the text area or click the **Browse** button to select a file. After the file is selected, the user sends the file by clicking the upload submit button.

Uploading requires a receiver that implements `Upload.Receiver` to provide an output stream to which the upload is written by the server.

```
Upload upload = new Upload("Upload it here", receiver);
```

**Figure 5.55. Upload Component**



You can set the text of the upload button with `setButtonCaption()`. Note that it is difficult to change the caption or look of the **Browse** button. This is a security feature of web browsers. The language of the **Browse** button is determined by the browser, so if you wish to have the language of the **Upload** component consistent, you will have to use the same language in your application.

```
upload.setButtonCaption("Upload Now");
```

You can also hide the upload button with `.v-upload .v-button {display: none}` in theme, have custom logic for starting the upload, and call `startUpload()` to start it. If the upload component has `setImmediate(true)` enabled, uploading starts immediately after choosing the file.

## Receiving Upload Data

The uploaded files are typically stored as files in a file system, in a database, or as temporary objects in memory. The upload component writes the received data to an `java.io.OutputStream` so you have plenty of freedom in how you can process the upload content.

To use the **Upload** component, you need to implement the **Upload.Receiver** interface. The `receiveUpload()` method of the receiver is called when the user clicks the submit button. The method must return an **OutputStream**. To do this, it typically creates a file or a memory buffer to which the stream is written. The method gets the file name and MIME type of the file, as reported by the browser.

While uploading, the upload progress can be monitored with an `Upload.ProgressListener`. The `updateProgress()` method gets the number of read bytes and the content length as parameters. The content length is reported by the browser, is not reliable, and may be -1 if unknown. It is therefore recommended to follow the upload progress and check the allowed size in a progress listener. Upload can be terminated by calling `interruptUpload()` on the upload component. You may want to use a **ProgressBar** to visualize the progress, and in indeterminate mode if the content length is not known.

When an upload is finished, successfully or unsuccessfully, the **Upload** component will emit the **Upload.FinishedEvent** event, which you can handle with an **Upload.FinishedListener** added to the upload component. The event object will include the file name, MIME type, and final length of the file. More specific **Upload.FailedEvent** and **Upload.SucceededEvent** events will be called in the cases where the upload failed or succeeded, respectively.

The following example uploads images to `/tmp/uploads` directory in (UNIX) filesystem (the directory must exist or the upload fails). The component displays the uploaded image in an **Image** component.

```
// Show uploaded file in this placeholder
final Embedded image = new Embedded("Uploaded Image");
image.setVisible(false);

// Implement both receiver that saves upload in a file and
// listener for successful upload
class ImageUploader implements Receiver, SucceededListener {
    public File file;

    public OutputStream receiveUpload(String filename,
                                      String mimeType) {
        // Create upload stream
        FileOutputStream fos = null; // Stream to write to
        try {
            // Open the file for writing.
            file = new File("/tmp/uploads/" + filename);
            fos = new FileOutputStream(file);
        } catch (final java.io.FileNotFoundException e) {
            new Notification("Could not open file<br/>",
                            e.getMessage(),
                            Notification.Type.ERROR_MESSAGE)
                .show(Page.getCurrent());
            return null;
        }
        return fos; // Return the output stream to write to
    }
}
```

```
public void uploadSucceeded(SucceededEvent event) {  
    // Show the uploaded file in the image viewer  
    image.setVisible(true);  
    image.setSource(new FileResource(file));  
}  
};  
ImageUploader receiver = new ImageUploader();  
  
// Create the upload with a caption and set receiver later  
Upload upload = new Upload("Upload Image Here", receiver);  
upload.setButtonCaption("Start Upload");  
upload.addSucceededListener(receiver);  
  
// Put the components in a panel  
Panel panel = new Panel("Cool Image Storage");  
Layout panelContent = new VerticalLayout();  
panelContent.addComponents(upload, image);  
panel.setContent(panelContent);
```

Note that the example does not check the type of the uploaded files in any way, which will cause an error if the content is anything else but an image. The program also assumes that the MIME type of the file is resolved correctly based on the file name extension. After uploading an image, the component will look as shown in Figure 5.56, “Image Upload Example”.

**Figure 5.56. Image Upload Example**



## CSS Style Rules

```
.v-upload { }
.gwt-FileUpload { }
.v-button { }
.v-button-wrap { }
.v-button-caption { }
```

The **Upload** component has an overall `v-upload` style. The upload button has the same structure and style as a regular **Button** component.

## 5.25. ProgressBar

The **ProgressBar** component allows displaying the progress of a task graphically. The progress is specified as a floating-point value between 0.0 and 1.0.

**Figure 5.57. The Progress Bar Component**



To display upload progress with the **Upload** component, you can update the progress bar in a `ProgressListener`.

When the position of a progress bar is done in a background thread, the change is not shown in the browser immediately. You need to use either polling or server push to update the browser. You can enable polling with `setPollInterval()` in the current UI instance. See Section 11.16, “Server Push” for instructions about using server push. Whichever method you use to update the UI, it is important to lock the user session by modifying the progress bar value inside `access()` call, as illustrated in the following example and described in Section 11.16.3, “Accessing UI from Another Thread”.

```
final ProgressBar bar = new ProgressBar(0.0f);
layout.addComponent(bar);

layout.addComponent(new Button("Increase",
    new ClickListener() {
        @Override
        public void buttonClick(ClickEvent event) {
            float current = bar.getValue();
            if (current < 1.0f)
                bar.setValue(current + 0.10f);
        }
    }));
}
```

### Indeterminate Mode

In the indeterminate mode, a non-progressive indicator is displayed continuously. The indeterminate indicator is a circular wheel in the built-in themes. The progress value has no meaning in the indeterminate mode.

```
ProgressBar bar = new ProgressBar();
bar.setIndeterminate(true);
```

**Figure 5.58. Indeterminate Progress Bar**

## Doing Heavy Computation

The progress indicator is often used to display the progress of a heavy server-side computation task, often running in a background thread. The UI, including the progress bar, can be updated either with polling or by using server push. When doing so, you must ensure thread-safety, most easily by updating the UI inside a `UI.access()` call in a `Runnable`, as described in Section 11.16.3, “Accessing UI from Another Thread”.

In the following example, we create a thread in the server to do some “heavy work” and use polling to update the UI. All the thread needs to do is to set the value of the progress bar with `setValue()` and the current progress is displayed automatically when the browser polls the server.

```
HorizontalLayout barbar = new HorizontalLayout();
layout.addComponent(barbar);

// Create the indicator, disabled until progress is started
final ProgressBar progress = new ProgressBar(new Float(0.0));
progress.setEnabled(false);
barbar.addComponent(progress);

final Label status = new Label("not running");
barbar.addComponent(status);

// A button to start progress
final Button button = new Button("Click to start");
layout.addComponent(button);

// A thread to do some work
class WorkThread extends Thread {
    // Volatile because read in another thread in access()
    volatile double current = 0.0;

    @Override
    public void run() {
        // Count up until 1.0 is reached
        while (current < 1.0) {
            current += 0.01;

            // Do some "heavy work"
            try {
                sleep(50); // Sleep for 50 milliseconds
            } catch (InterruptedException e) {}

            // Update the UI thread-safely
            UI.getCurrent().access(new Runnable() {
                @Override
                public void run() {
                    progress.setValue(new Float(current));
                    if (current < 1.0)
                        status.setValue(" " +
                }
            });
        }
    }
}
```

```

        ((int)(current*100)) + "% done");
    else
        status.setValue("all done");
}
});

}

// Show the "all done" for a while
try {
    sleep(2000); // Sleep for 2 seconds
} catch (InterruptedException e) {}

// Update the UI thread-safely
UI.getCurrent().access(new Runnable() {
    @Override
    public void run() {
        // Restore the state to initial
        progress.setValue(new Float(0.0));
        progress.setEnabled(false);

        // Stop polling
        UI.getCurrent().setPollInterval(-1);

        button.setEnabled(true);
        status.setValue("not running");
    }
});
}

}

// Clicking the button creates and runs a work thread
button.addClickListener(new Button.ClickListener() {
    public void buttonClick(ClickEvent event) {
        final WorkThread thread = new WorkThread();
        thread.start();

        // Enable polling and set frequency to 0.5 seconds
        UI.getCurrent().setPollInterval(500);

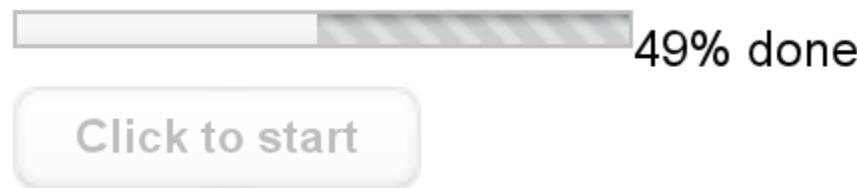
        // Disable the button until the work is done
        progress.setEnabled(true);
        button.setEnabled(false);

        status.setValue("running...");
    }
});
}

```

The example is illustrated in Figure 5.59, “Doing Heavy Work”.

**Figure 5.59. Doing Heavy Work**



## CSS Style Rules

```
.v-progressbar, v-progressbar-indeterminate {}  
.v-progressbar-wrapper {}  
.v-progressbar-indicator {}
```

The progress bar has a `v-progressbar` base style. The animation is the background of the element with `v-progressbar-wrapper` style, by default an animated GIF image. The progress is an element with `v-progressbar-indicator` style inside the wrapper, and therefore displayed on top of it. When the progress element grows, it covers more and more of the animated background.

In the indeterminate mode, the top element also has the `v-progressbar-indeterminate` style. The built-in themes simply display the animated GIF in the top element and have the inner elements disabled.

## 5.26. Slider

The **Slider** is a vertical or horizontal bar that allows setting a numeric value within a defined range by dragging a bar handle with the mouse. The value is shown when dragging the handle.

**Slider** has a number of different constructors that take a combination of the caption, *minimum* and *maximum* value, *resolution*, and the *orientation* of the slider.

```
// Create a vertical slider  
final Slider vertslider = new Slider(1, 100);  
vertslider.setOrientation(SliderOrientation.VERTICAL);
```

### Slider Properties

*min*

Minimum value of the slider range. The default is 0.0.

*max*

Maximum value of the slider range. The default is 100.0.

*resolution*

The number of digits after the decimal point. The default is 0.

*orientation*

The orientation can be either horizontal (`SliderOrientation.HORIZONTAL`) or vertical (`SliderOrientation.VERTICAL`). The default is horizontal.

As the **Slider** is a field component, you can handle value changes with a **ValueChangeListener**. The value of the **Slider** field is a **Double** object.

```
// Shows the value of the vertical slider  
final Label vertvalue = new Label();  
vertvalue.setSizeUndefined();  
  
// Handle changes in slider value.  
vertslider.addValueChangeListener(  
    new Property.ValueChangeListener() {  
        public void valueChange(ValueChangeEvent event) {  
            double value = (Double) vertslider.getValue();  
        }  
    }  
>);
```

```
// Use the value
box.setHeight((float) value, Sizeable.UNITS_PERCENTAGE);
vertvalue.setValue(String.valueOf(value));
}
});

// The slider has to be immediate to send the changes
// immediately after the user drags the handle.
vertslider.setImmediate(true);
```

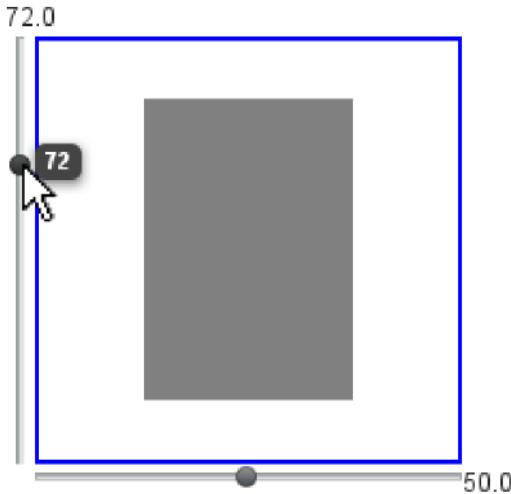
You can set the value with the `setValue()` method defined in **Slider** that takes the value as a native double value. The setter can throw a **ValueOutOfBoundsException**, which you must handle.

```
// Set the initial value. This has to be set after the
// listener is added if we want the listener to handle
// also this value change.
try {
    vertslider.setValue(50.0);
} catch (ValueOutOfBoundsException e) {
}
```

Alternatively, you can use the regular `setValue(Object)`, which does not do bounds checking.

Figure 5.60, “The **Slider** Component” shows both vertical (from the code examples) and horizontal sliders that control the size of a box. The slider values are displayed also in separate labels.

### Figure 5.60. The Slider Component



## CSS Style Rules

```
.v-slider {}
.v-slider-base {}
.v-slider-handle {}
```

The enclosing style for the **Slider** is `v-slider`. The slider bar has style `v-slider-base`. Even though the handle is higher (for horizontal slider) or wider (for vertical slider) than the bar, the handle element is nevertheless contained within the slider bar element. The appearance of the handle comes from a background image defined in the `background` CSS property.

## 5.27. Calendar

The **Calendar** component allows organizing and displaying calendar events. The main features of the calendar include:

- Monthly, weekly, and daily views
- Two types of events: all-day events and events with a time range
- Add events directly, from a **Container**, or with an event provider
- Control the range of the visible dates
- Selecting and editing date or time range by dragging
- Drag and drop events to calendar
- Support for localization and timezones

User interaction with the calendar elements, such as date and week captions as well as events, is handled with event listeners. Also date/time range selections, event dragging, and event resizing can be listened by the server. The weekly view has navigation buttons to navigate forward and backward in time. These actions are also listened by the server. Custom navigation can be implemented using event handlers, as described in Section 5.27.10, “Customizing the Calendar”.

The data source of a calendar can be practically anything, as its events are queried dynamically by the component. You can bind the calendar to a Vaadin container, or to any other data source by implementing an *event provider*.

The **Calendar** has undefined size by default and you usually want to give it a fixed or relative size, for example as follows.

```
Calendar cal = new Calendar("My Calendar");
cal.setWidth("600px");
cal.setHeight("300px");
```

After creating the calendar, you need to set a time range for it, which also controls the view mode, and set up the data source for calendar events.

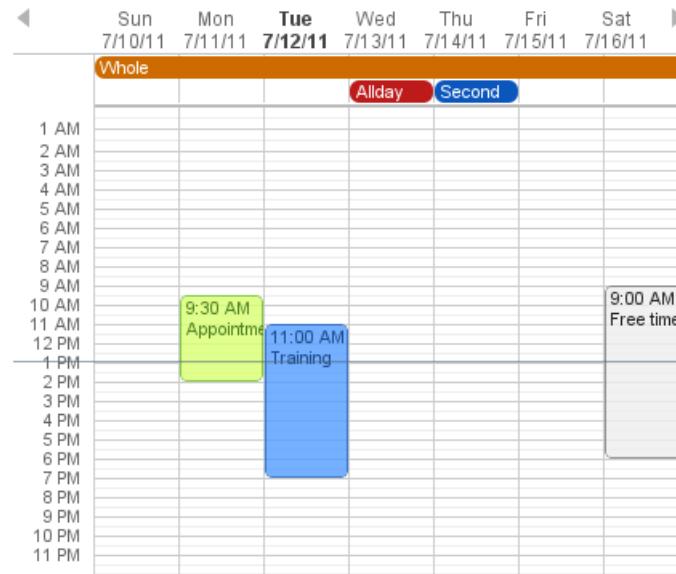
### 5.27.1. Date Range and View Mode

The Vaadin Calendar has two types of views that are shown depending on the date range of the calendar. The *weekly view* displays a week by default. It can show anything between one to seven days a week, and is also used as a single-day view. The view mode is determined from the *date range* of the calendar, defined by a start and an end date. Calendar will be shown in a *monthly view* when the date range is over than one week (seven days) long. The date range is always calculated in an accuracy of one millisecond.

The monthly view, shown in Figure 5.61, “Monthly view with All-Day and Normal Events”, can easily be used to control all types of events, but it is best suited for events that last for one or more days. You can drag the events to move them. In the figure, you can see two longer events that are highlighted with a blue and green background color. Other markings are shorter day events that last less than a 24 hours. These events can not be moved by dragging in the monthly view.

**Figure 5.61. Monthly view with All-Day and Normal Events**

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	1 Jul	2
27						
28	3	4	5	6	7	8
29	10	11	12	13	14	15
Whole week						
	9:30 AM App	11:00 AM Tra	All day event	Second allday		9:00 AM Free
17	18	19	20	21	22	23
30	24	25	26	27	28	29
31	31	1 Aug	2	3	4	5
32						6

**Figure 5.62. Weekly View**

In Figure 5.62, “Weekly View”, you can see four normal day events and also all-day events at the top of the time line grid.

In the following, we set the calendar to show only one day, which is the current day.

```
cal.setStartDate(new Date());
cal.setEndDate(new Date());
```

Notice that although the range we set above is actually zero time long, the calendar still renders the time from 00:00 to 23:59. This is normal, as the Vaadin Calendar is guaranteed to render at least the date range provided, but may expand it. This behaviour is important to notice when we implement our own event providers.

## 5.27.2. Calendar Events

All occurrences in a calendar are represented as *events*. You have three ways to manage the calendar events:

- Add events directly to the **Calendar** object using the `addEvent()`
- Use a **Container** as a data source
- Use the *event provider* mechanism

You can add events with `addEvent()` and remove them with the `removeEvent()`. These methods will use the underlying event provider to write the modifications to the data source.

### Event Interfaces and Providers

Events are handled through the **CalendarEvent** interface. The concrete class of the event depends on the specific **CalendarEventProvider** used in the calendar.

By default, **Calendar** uses a **BasicEventProvider** to provide events, which uses **BasicEvent** instances.

Calendar does not depend on any particular data source implementation. Events are queried by the **Calendar** from the provider that just has to implement the **CalendarEventProvider** interface. It is up to the event provider that **Calendar** gets the correct events.

You can bind any Vaadin **Container** to a calendar, in which case a **ContainerEventProvider** is used transparently. The container must be ordered by start date and time of the events. See Section 8.5, “Collecting Items in Containers” for basic information about containers.

### Event Types

A calendar event requires a start time and an end time. These are the only mandatory properties. In addition, an event can also be set as an all-day event by setting the `all-day` property of the event. You can also set the description of an event, which is displayed as a tooltip in the user interface.

If the `all-day` field of the event is `true`, then the event is always rendered as an all-day event. In the monthly view, this means that no start time is displayed in the user interface and the event has an colored background. In the weekly view, all-day events are displayed in the upper part of the screen, and rendered similarly to the monthly view. In addition, when the time range of an event is 24 hours or longer, it is rendered as an all-day event in the monthly view.

When the time range of an event is equal or less than 24 hours, with the accuracy of one millisecond, the event is considered as a normal day event. Normal event has a start and end times that may be on different days.

## Basic Events

The easiest way to add and manage events in a calendar is to use the *basic event* management API. Calendar uses by default a **BasicEventProvider**, which keeps the events in memory in an internal representation.

For example, the following adds a two-hour event starting from the current time. The standard Java **GregorianCalendar** provides various ways to manipulate date and time.

```
// Add a two-hour event
GregorianCalendar start = new GregorianCalendar();
GregorianCalendar end   = new GregorianCalendar();
end.add(java.util.Calendar.HOUR, 2);
calendar.addEvent(new BasicEvent("Calendar study",
    "Learning how to use Vaadin Calendar",
    start.getTime(), end.getTime()));
```

This adds a new event that lasts for 3 hours. As the **BasicEventProvider** and **BasicEvent** implement some optional event interfaces provided by the calendar package, there is no need to refresh the calendar. Just create events, set their properties and add them to the Event Provider.

### 5.27.3. Getting Events from a Container

You can use any Vaadin Container that implements the **Indexed** interface as the data source for calendar events. The **Calendar** will listen to change events from the container as well as write changes to the container. You can attach a container to a **Calendar** with **setContainerDataSource()**.

In the following example, we bind a **BeanItemContainer** that contains built-in **BasicEvent** events to a calendar.

```
// Create the calendar
Calendar calendar = new Calendar("Bound Calendar");

// Use a container of built-in BasicEvents
final BeanItemContainer<BasicEvent> container =
    new BeanItemContainer<BasicEvent>(BasicEvent.class);

// Create a meeting in the container
container.addBean(new BasicEvent("The Event", "Single Event",
    new GregorianCalendar(2012,1,14,12,00).getTime(),
    new GregorianCalendar(2012,1,14,14,00).getTime()));

// The container must be ordered by the start time. You
// have to sort the BIC every time after you have added
// or modified events.
container.sort(new Object[]{"start"}, new boolean[]{true});

calendar.setContainerDataSource(container, "caption",
    "description", "start", "end", "styleName");
```

The container must either use the default property IDs for event data, as defined in the **CalendarEvent** interface, or provide them as parameters for the **setContainerDataSource()** method, as we did in the example above.

## Keeping the Container Ordered

The events in the container *must* be kept ordered by their start date/time. Failing to do so may and will result in the events not showing in the calendar properly.

Ordering depends on the container. With some containers, such as **BeanItemContainer**, you have to sort the container explicitly every time after you have added or modified events, usually with the `sort()` method, as we did in the example above. Some container, such as **JPACContainer**, keep the in container automatically order if you provide a sorting rule.

For example, you could order a **JPACContainer** by the following rule, assuming that the start date/time is held in the `startDate` property:

```
// The container must be ordered by start date. For JPACContainer
// we can just set up sorting once and it will stay ordered.
container.sort(new String[]{"startDate"}, new boolean[]{true});
```

## Delegation of Event Management

Setting a container as the calendar data source with `setContainerDataSource()` automatically switches to **ContainerEventProvider**. You can manipulate the event data through the API in **Calendar** and the user can move and resize event through the user interface. The event provider delegates all such calendar operations to the container.

If you add events through the **Calendar** API, notice that you may be unable to create events of the type held in the container or adding them requires some container-specific operations. In such case, you may need to customize the `addEvent()` method.

For example, **JPACContainer** requires adding new items with `addEntity()`. You could first add the entity to the container or entity manager directly and then pass it to the `addEvent()`. That does not, however, work if the entity class does not implement `CalendarEvent`. This is actually the case always if the property names differ from the ones defined in the interface. You could handle creating the underlying entity objects in the `addEvent()` as follows:

```
// Create a JPACContainer
final JPACContainer<MyCalendarEvent> container =
    JPACContainerFactory.make(MyCalendarEvent.class,
        "book-examples");

// Customize the event provider for adding events
// as entities
ContainerEventProvider cep =
    new ContainerEventProvider(container) {
        @Override
        public void addEvent(CalendarEvent event) {
            MyCalendarEvent entity = new MyCalendarEvent(
                event.getCaption(), event.getDescription(),
                event.getStart(), event.getEnd(),
                event.getStyleName());
            container.addEntity(entity);
        }
    }

// Set the container as the data source
calendar.setEventProvider(cep);

// Now we can add events to the database through the calendar
```

```
BasicEvent event = new BasicEvent("The Event", "Single Event",
    new GregorianCalendar(2012,1,15,12,00).getTime(),
    new GregorianCalendar(2012,1,15,14,00).getTime());
calendar.addEvent(event);
```

## 5.27.4. Implementing an Event Provider

If the two simple ways of storing and managing events for a calendar are not enough, you may need to implement a custom event provider. It is the most flexible way of providing events. You need to attach the event provider to the **Calendar** using the `setEventProvider()` method.

Event queries are done by asking the event provider for all the events between two given dates. The range of these dates is guaranteed to be at least as long as the start and end dates set for the component. The component can, however, ask for a longer range to ensure correct rendering. In particular, all start dates are expanded to the start of the day, and all end dates are expanded to the end of the day.

## Custom Events

An event provider could use the built-in **BasicEvent**, but it is usually more proper to define a custom event type that is bound directly to the data source. Custom events may be useful for some other purposes as well, such as when you need to add extra information to an event or customize how it is acquired.

Custom events must implement the `CalendarEvent` interface or extend an existing event class. The built-in **BasicEvent** class should serve as a good example of implementing simple events. It keeps the data in member variables.

```
public class BasicEvent
    implements CalendarEventEditor, EventChangeNotifier {
    ...

    public String getCaption() {
        return caption;
    }

    public String getDescription() {
        return description;
    }

    public Date getEnd() {
        return end;
    }

    public Date getStart() {
        return start;
    }

    public String getStyleName() {
        return styleName;
    }

    public boolean isAllDay() {
        return isAllDay;
    }

    public void setCaption(String caption) {
        this.caption = caption;
    }
}
```

```
        fireEventChange();
    }

    public void setDescription(String description) {
        this.description = description;
        fireEventChange();
    }

    public void setEnd(Date end) {
        this.end = end;
        fireEventChange();
    }

    public void setStart(Date start) {
        this.start = start;
        fireEventChange();
    }

    public void setStyleName(String styleName) {
        this.styleName = styleName;
        fireEventChange();
    }

    public void setAllDay(boolean isAllDay) {
        this.isAllDay = isAllDay;
        fireEventChange();
    }

    public void addEventChangeListener(
        EventChangeListener listener) {
        ...
    }

    public void removeListener(EventChangeListener listener) {
        ...
    }

    protected void fireEventChange() {...}
}
```

You may have noticed that there was some additional code in the **BasicEvent** that was not in the **CalendarEvent** interface. Namely **BasicEvent** also implements two additional interfaces:

**CalendarEditor**

This interface defines setters for all the fields, and is required for some of the default handlers to work.

**EventChangeNotifier**

This interface adds the possibility to listen for changes in the event, and enables the **Calendar** to render the changes immediately.

The start time and end time are mandatory, but caption, description, and style name are not. The style name is used as a part of the CSS class name for the HTML DOM element of the event.

In addition to the basic event interfaces, you can enhance the functionality of your event and event provider classes by using the **EventChange** and **EventSetChange** events. They let the **Calendar** component to know about changes in events and update itself accordingly. The **Ba-**

**sicEvent** and **BasicEventProvider** examples given earlier include a simple implementation of these interfaces.

## Implementing the Event Provider

An event provider needs to implement the `CalendarEventProvider` interface. It has only one method to be implemented. Whenever the calendar is painted, `getEvents(Date, Date)` method is called and it must return a list of events between the given start and end time.

The following example implementation returns only one example event. The event starts from the current time and is five hours long.

```
public class MyEventProvider implements CalendarEventProvider{
    public List<Event> getEvents(Date startDate, Date endDate){
        List<Event> events = new ArrayList<Event>();
        GregorianCalendar cal = new GregorianCalendar();
        cal.setTime(new Date());

        Date start = cal.getTime();
        cal.add(GregorianCalendar.HOUR, 5);
        Date end = cal.getTime();
        BasicEvent event = new BasicEvent();
        event.setCaption("My Event");
        event.setDescription("My Event Description");
        event.setStart(start);
        event.setEnd(end);
        events.add(event);

        return events;
    }
}
```

It is important to notice that the **Calendar** may query for dates beyond the range defined by start date and end date. Particularly, it may expand the date range to make sure the user interface is rendered correctly.

### 5.27.5. Styling a Calendar

Configuring the appearance of the Vaadin Calendar component is one of the basic tasks. At the least, you need to consider its sizing in your user interface. You also quite probably want to use some color or colors for events.

#### Sizing

The Calendar supports component sizing as usual for defined (fixed or relative) sizes. When using an undefined size for the calendar, all the sizes come from CSS. In addition, when the height is undefined, a scrollbar is displayed in the weekly view to better fit the cells to the user interface.

Below is a list of style rules that define the size of a Calendar with undefined size (these are the defaults):

```
.v-calendar-month-sizedheight .v-calendar-month-day {
    height: 100px;
}

.v-calendar-month-sizedwidth .v-calendar-month-day {
```

```
width: 100px;
}

.v-calendar-header-month-Hsized .v-calendar-header-day {
width: 101px;
}

/* for IE */
.v-ie6 .v-calendar-header-month-Hsized .v-calendar-header-day {
width: 104px;
}

/* for others */
.v-calendar-header-month-Hsized td:first-child {
padding-left: 21px;
}

.v-calendar-header-day-Hsized {
width: 200px;
}

.v-calendar-week-numbers-Vsized .v-calendar-week-number {
height: 100px;
line-height: 100px;
}

.v-calendar-week-wrapper-Vsized {
height: 400px;
overflow-x: hidden !important;
}

.v-calendar-times-Vsized .v-calendar-time {
height: 38px;
}

.v-calendar-times-Hsized .v-calendar-time {
width: 42px;
}

.v-calendar-day-times-Vsized .v-slot,.v-calendar-day-times-Vsized .v-slot-even {
height: 18px;
}

.v-calendar-day-times-Hsized, .v-calendar-day-times-Hsized .v-slot,.v-calendar-
day-times-Hsized .v-slot-even {
width: 200px;
}
```

## Event Style

Events can be styled with CSS by setting them a *style name suffix*. The suffix is retrieved with the `getStyleName()` method in `CalendarEvent`. If you use **BasicEvent** events, you can set the suffix with `setStyleName()`.

```
BasicEvent event = new BasicEvent("Wednesday Wonder", ... );
event.setStyleName("mycolor");
calendar.addEvent(event);
```

Suffix `mycolor` would create `v-calendar-event-mycolor` class for regular events and `v-calendar-event-mycolor-add-day` for all-day events. You could style the events with the following rules:

```
.v-calendar .v-calendar-event-mycolor {}
.v-calendar .v-calendar-event-mycolor-all-day {}
.v-calendar .v-calendar-event-mycolor .v-calendar-event-caption {}
.v-calendar .v-calendar-event-mycolor .v-calendar-event-content {}
```

## 5.27.6. Visible Hours and Days

As we saw in Section 5.27.1, “Date Range and View Mode”, you can set the range of dates that are shown by the Calendar. But what if you wanted to show the entire month but hide the weekends? Or show only hours from 8 to 16 in the weekly view? The `setVisibleDays()` and `setVisibleHours()` methods allow you to do that.

```
calendar.setVisibleDays(1,5); // Monday to Friday
calendar.setVisibleHours(0,15); // Midnight until 4 pm
```

After the above settings, only weekdays from Monday to Friday would be shown. And when the calendar is in the weekly view, only the time range from 00:00 to 16:00 would be shown.

Note that the excluded times are never shown so you should take care when setting the date range. If the date range contains only dates / times that are excluded, nothing will be displayed. Also note that even if a date is not rendered because these settings, the event provider may still be queried for events for that date.

## 5.27.7. Drag and Drop

Vaadin Calendar can act as a drop target for drag and drop, described in Section 11.12, “Drag and Drop”. With the functionality, the user could drag events, for example, from a table to a calendar.

To support dropping, a **Calendar** must have a drop handler. When the drop handler is set, the days in the monthly view and the time slots in the weekly view can receive drops. Other locations, such as day names in the weekly view, can not currently receive drops.

Calendar uses its own implementation of `TargetDetails`: **CalendarTargetdetails**. It holds information about the the drop location, which in the context of **Calendar** means the date and time. The drop target location can be retrieved via the `getDropTime()` method. If the drop is done in the monthly view, the returned date does not have exact time information. If the drop happened in the weekly view, the returned date also contains the start time of the slot.

Below is a short example of creating a drop handler and using the drop information to create a new event:

```
private Calendar createDDCalendar() {
    Calendar calendar = new Calendar();
    calendar.setDropHandler(new DropHandler() {
        public void drop(DragAndDropEvent event) {
            CalendarTargetDetails details =
                (CalendarTargetDetails) event.getTargetDetails();

            TableTransferable transferable =
                (TableTransferable) event.getTransferable();

            createEvent(details, transferable);
        }
    });
}
```

```
removeTableRow(transferable);
}

public AcceptCriterion getAcceptCriterion() {
    return AcceptAll.get();
}

});

return calendar;
}

protected void createEvent(CalendarTargetDetails details,
    TableTransferable transferable) {
    Date dropTime = details.getDropTime();
    java.util.Calendar timeCalendar = details.getTargetCalendar()
        .getInternalCalendar();
    timeCalendar.setTime(dropTime);
    timeCalendar.add(java.util.Calendar.MINUTE, 120);
    Date endTime = timeCalendar.getTime();

    Item draggedItem = transferable.getSourceComponent().
        getItem(transferable.getItemId());

    String eventType = (String)draggedItem.
        getItemProperty("type").getValue();

    String eventDescription = "Attending: "
        + getParticipantString(
            (String[]) draggedItem.
                getItemProperty("participants").getValue()));

    BasicEvent newEvent = new BasicEvent();
    newEvent.setAllDay(!details.hasDropTime());
    newEvent.setCaption(eventType);
    newEvent.setDescription(eventDescription);
    newEvent.setStart(dropTime);
    newEvent.setEnd(endTime);

    BasicEventProvider ep = (BasicEventProvider) details
        .getTargetCalendar().getEventProvider();
    ep.addEvent(newEvent);
}
```

### 5.27.8. Using the Context Menu

Vaadin Calendar allows the use of context menu (mouse right-click) to manage events. As in other context menus in Vaadin, the menu items are handled in Vaadin as *actions* by an *action handler*. To enable a context menu, you have to implement a Vaadin Action.Handler and add it to the calendar with addActionHandler().

An action handler must implement two methods: `getActions()` and `handleAction()`. The `getActions()` is called for each day displayed in the calendar view. It should return a list of allowed actions for that day, that is, the items of the context menu. The `target` parameter is the context of the click - a **CalendarDateRange** that spans over the day. The `sender` is the **Calendar** object.

The `handleActions()` receives the target context in the `target`. If the context menu was opened on an event, the target is the `Event` object, otherwise it is a **CalendarDateRange**.

## 5.27.9. Localization and Formatting

### Setting the Locale and Time Zone

Month and weekday names are shown in the language of the locale setting of the **Calendar**. The translations are acquired from the standard Java locale data. By default, **Calendar** uses the system default locale for its internal calendar, but you can change it with `setLocale(Locale locale)`. Setting the locale will update also other location specific date and time settings, such as the first day of the week, time zone, and time format. However, time zone and time format can be overridden by settings in the **Calendar**.

For example, the following would set the language to US English:

```
cal.setLocale(Locale.US);
```

The locale defines the default time zone. You can change it with the `setTimeZone()` method, which takes a `java.util.TimeZone` object as its parameter. Setting `timezone` to null will reset `timezone` to the locale default.

For example, the following would set the Finnish time zone, which is EET

```
cal.setTimeZone(TimeZone.getTimeZone("Europe/Helsinki"));
```

### Time and Date Caption Format

The time may be shown either in 24 or 12 hour format. The default format is defined by the locale, but you can change it with the `setTimeFormat()` method. Giving a null setting will reset the time format to the locale default.

```
cal.setTimeFormat(TimeFormat.Format12H);
```

You can change the format of the date captions in the week view with the `setWeeklyCaptionFormat(String dateFormatPattern)` method. The date format pattern should follow the format of the standard Java `java.text.SimpleDateFormat` class.

For example:

```
cal.setWeeklyCaptionFormat("dd-MM-yyyy");
```

## 5.27.10. Customizing the Calendar

In this section, we give a tutorial for how to make various basic customizations of the Vaadin Calendar. The event provider and styling was described earlier, so now we concentrate on other features of the Calendar API.

### Overview of Handlers

Most of the handlers related to calendar events have sensible default handlers. These are found in the `com.vaadin.ui.handler` package. The default handlers and their functionalities are described below.

- **BasicBackwardHandler**. Handles clicking the back-button of the weekly view so that the viewed month is changed to the previous one.

- **BasicForwardHandler**. Handles clicking the forward-button of the weekly view so that the viewed month is changed to the next one.
- **BasicWeekClickHandler**. Handles clicking the week numbers int the monthly view so that the viewable date range is changed to the clicked week.
- **BasicDateClickHandler**. Handles clicking the dates on both the monthly view and the weekly view. Changes the viewable date range so that only the clicked day is visible.
- **BasicEventMoveHandler**. Handles moving the events in both monthly view and the weekly view. Events can be moved and their start and end dates are changed correctly, but only if the event implements **CalendarEventEditor** (implemented by **BasicEvent**).
- **BasicEventResizeHandler**. Handles resizing the events in the weekly view. Events can be resized and their start and end dates are changed correctly, but only if the event implements **CalendarEventEditor** (implemented by the **BasicEvent**).

All of these handlers are automatically set when creating a new **Calendar**. If you wish to disable some of the default functionality, you can simply set the corresponding handler to `null`. This will prevent the functionality from ever appearing on the user interface. For example, if you set the **EventMoveHandler** to `null`, the user will be unable to move events in the browser.

## Creating a Calendar

Let us first create a new **Calendar** instance. Here we use our own event provider, the **MyEventProvider** described in the section called “Implementing the Event Provider”.

```
Calendar cal = new Calendar(new MyEventProvider());
```

This initializes the Calendar. To customize the viewable date range, we must set a start and end date to it.

There is only one visible event in the timeline, starting from the current time. That is what our event provider passes to the client.

It would be nice to also be able to control the navigation forward and backward. The default navigation is provided by the default handlers, but perhaps we want to restrict the users so they can only navigate dates in the current year. Maybe we also want to pose some other restrictions to the clicking week numbers and dates.

These restrictions and other custom logic can be defined with custom handlers. You can find the handlers in the `com.vaadin.addon.calendar.ui.handler` package and they can be easily extended. Note that if you don not want to extend the default handlers, you are free to implement your own. The interfaces are described in `CalendarComponentEvents`.

### 5.27.11. Backward and Forward Navigation

Vaadin Calendar has only limited built-in navigation support. The weekly view has navigation buttons in the top left and top right corners.

You can handle backward and forward navigation with a `BackwardListener` and `ForwardListener`.

```
cal.setHandler(new BasicBackwardHandler() {  
    protected void setDates(BackwardEvent event,  
                           Date start, Date end) {
```

```
java.util.Calendar calendar = event.getComponent()
    .getInternalCalendar();
if (isThisYear(calendar, end)
    && isThisYear(calendar, start)) {
    super.setDates(event, start, end);
}
});
```

The forward navigation handler can be implemented in the same way. The example handler restricts the dates to the current year.

## 5.27.12. Date Click Handling

By default, clicking a date either in month or week view switches to single-day view. The date click event is handled by a `DateClickHandler`.

The following example handles click events so that when the user clicks the date header in the weekly view, it will switch to single-day view, and in the single-day view switch back to the weekly view.

```
cal.setHandler(new BasicDateClickHandler() {
    public void dateClick(DateClickEvent event) {
        Calendar cal = event.getComponent();
        long currentCalDateRange = cal.getEndDate().getTime()
            - cal.getStartDate().getTime();

        if (currentCalDateRange < VCalendar.DAYINMILLIS) {
            // Change the date range to the current week
            cal.setStartDate(cal.getFirstDateForWeek(event.getDate()));
            cal.setEndDate(cal.getLastDateForWeek(event.getDate()));

        } else {
            // Default behaviour, change date range to one day
            super.dateClick(event);
        }
    }
});
```

## 5.27.13. Handling Week Clicks

The monthly view displays week numbers for each week row on the left side of the date grid. The week number are clickable and you can handle the click events by setting a `WeekClickHandler` for the `Calendar` object. The default handler changes the date range to be the clicked week.

In the following example, we add a week click handler that changes the date range of the calendar to one week only if the start and end dates of the week are in the current month.

```
cal.setHandler(new BasicWeekClickHandler() {
    protected void setDates(WeekClick event,
                           Date start, Date end) {
        java.util.Calendar calendar = event.getComponent()
            .getInternalCalendar();
        if (isThisMonth(calendar, start)
            && isThisMonth(calendar, end)) {
            super.setDates(event, start, end);
        }
    }
});
```

```
}); }
```

### 5.27.14. Handling Event Clicks

The calendar events in all views are are clickable. There is no default handler. Just like the date and week click handlers, event click handling is enabled by setting an `EventClickHandler` for the `Calendar` object.

You can get hold of the clicked event by the `getCalendarEvent()` method in the `EventClick` object passed to the handler, as shown in the following example.

```
cal.setHandler(new EventClickHandler() {
    public void eventClick(EventClick event) {
        BasicEvent e = (BasicEvent) event.getCalendarEvent();

        // Do something with it
        new Notification("Event clicked: " + e.getCaption(),
                         e.getDescription()).show(Page.getCurrent());
    }
});
```

### 5.27.15. Event Dragging

The user can drag an event to change its position in time. The default handler sets the start and end time of the event accordingly. You can do many things with a custom move handler, such as restrict moving events.

In the following example, we add a `EventMoveHandler` to a `Calendar`. The event handler updates the new position to the datasource, but only if the new dates are in the current month. This requires making some changes to the event provider class.

```
cal.setHandler(new BasicEventMoveHandler() {
    private java.util.Calendar javaCalendar;

    public void eventMove(MoveEvent event) {
        javaCalendar = event.getComponent().getInternalCalendar();
        super.eventMove(event);
    }

    protected void setDates(CalendarEventEditor event,
                           Date start, Date end) {
        if (isThisMonth(javaCalendar, start)
            && isThisMonth(javaCalendar, end)) {
            super.setDates(event, start, end);
        }
    }
});
```

For the above example to work, the example event provider presented earlier needs to be changed slightly so that it doesn't always create a new event when `getEvents()` is called.

```
public static class MyEventProvider
    implements CalendarEventProvider {
    private List<CalendarEvent> events =
        new ArrayList<CalendarEvent>();

    public MyEventProvider() {
```

```
events = new ArrayList<CalendarEvent>();
GregorianCalendar cal = new GregorianCalendar();
cal.setTime(new Date());

Date start = cal.getTime();
cal.add(GregorianCalendar.HOUR, 5);
Date end = cal.getTime();
BasicEvent event = new BasicEvent();
event.setCaption("My Event");
event.setDescription("My Event Description");
event.setStart(start);
event.setEnd(end);
events.add(event);
}

public void addEvent(CalendarEvent BasicEvent) {
    events.add(BasicEvent);
}

public List<CalendarEvent> getEvents(Date startDate,
                                      Date endDate) {
    return events;
}
}
```

After these changes, the user can move events around as earlier, but dropping an event, the start and end dates are checked by the server. Note that as the server-side must move the event in order for it to render to the place it was dropped. The server can also reject moves by not doing anything when the event is received.

## 5.27.16. Handling Drag Selection

Drag selection works both in the monthly and weekly views. To listen for drag selection, you can add a `RangeSelectListener` to the **Calendar**. There is no default handler for range select.

In the code example below, we create a new event when any date range is selected. Drag selection opens a window where the user is asked for a caption for the new event. After confirming, the new event is passed to the event provider and calendar is updated. Note that as our example event provider and event classes do not implement the event change interface, we must refresh the **Calendar** manually after changing the events.

```
cal.setHandler(new RangeSelectHandler() {
    public void rangeSelect(RangeSelectEvent event) {
        BasicEvent calendarEvent = new BasicEvent();
        calendarEvent.setStart(event.getStart());
        calendarEvent.setEnd(event.getEnd());

        // Create popup window and add a form in it.
        VerticalLayout layout = new VerticalLayout();
        layout.setMargin(true);
        layout.setSpacing(true);

        final Window w = new Window(null, layout);
        ...

        // Wrap the calendar event to a BeanItem
        // and pass it to the form
        final BeanItem<CalendarEvent> item =
```

```
        new BeanItem<CalendarEvent>(myEvent);

    final Form form = new Form();
    form.setItemDataSource(item);
    ...

    layout.addComponent(form);

    HorizontalLayout buttons = new HorizontalLayout();
    buttons.setSpacing(true);
    buttons.addComponent(new Button("OK", new ClickListener() {

        public void buttonClick(ClickEvent event) {
            form.commit();

            // Update event provider's data source
            provider.addEvent(item.getBean());

            UI.getCurrent().removeWindow(w);
        }
    }));
    ...

});
```

### 5.27.17. Resizing Events

The user can resize an event by dragging from both ends to change its start or end time. This offers a convenient way to change event times without the need to type anything. The default resize handler sets the start and end time of the event according to the resize.

In the example below, we set a custom handler for resize events. The handler prevents any event to be resized over 12 hours in length. Note that this does not prevent the user from resizing an event over 12 hours in the client. The resize will just be corrected by the server.

```
cal.setHandler(new BasicEventResizeHandler() {
    private static final long twelveHoursInMs = 12*60*60*1000;

    protected void setDates(CalendarEventEditor event,
                           Date start, Date end) {
        long eventLength = end.getTime() - start.getTime();
        if (eventLength <= twelveHoursInMs) {
            super.setDates(event, start, end);
        }
    }
});
```

## 5.28. Composition with CustomComponent

The ease of making new user interface components is one of the core features of Vaadin. Typically, you simply combine existing built-in components to produce composite components. In many applications, such composite components make up the majority of the user interface.

As described earlier in Section 4.2.2, “Compositing Components”, you have two basic ways to create a composite - either by using a layout component or the **CustomComponent**, which typically wraps around a layout component. The benefit of wrapping a layout composite in **Custom-**

**Component** is mainly encapsulation - hiding the implementation details of the composition. Otherwise, a user of the composite might rely on the internal implementation details, such as the layout class.

To create a composite, you need to inherit the **CustomComponent** and set the *composition root* component in the constructor. The composition root is typically a layout component that contains other components.

For example:

```
class MyComposite extends CustomComponent {  
    public MyComposite(String message) {  
        // A layout structure used for composition  
        Panel panel = new Panel("My Custom Component");  
        panel.setContent(new VerticalLayout());  
  
        // Compose from multiple components  
        Label label = new Label(message);  
        label.setSizeUndefined(); // Shrink  
        panel.addComponent(label);  
        panel.addComponent(new Button("Ok"));  
  
        // Set the size as undefined at all levels  
        panel.getContent().setSizeUndefined();  
        panel.setSizeUndefined();  
        setSizeUndefined();  
  
        // The composition root MUST be set  
        setCompositionRoot(panel);  
    }  
}
```

Take note of the sizing when trying to make a customcomponent that shrinks to fit the contained components. You have to set the size as undefined at all levels; the sizing of the composite component and the composition root are separate.

You can use the component as follows:

```
MyComposite mycomposite = new MyComposite("Hello");
```

The rendered component is shown in Figure 5.63, “A Custom Composite Component”.

### Figure 5.63. A Custom Composite Component



You can also inherit any other components, such as layouts, to attain similar composition. Even further, you can create entirely new low-level components, by integrating pure client-side components or by extending the client-side functionality of built-in components. Development of new components is covered in Chapter 16, *Integrating with the Server-Side*.

## 5.29. Composite Fields with **CustomField**

The **CustomField** is a way to create composite components like with **CustomComponent**, except that it implements the **Field** interface and inherit **AbstractField**, described in Section 5.4, “Field Components”. A field allows editing a property value in the Vaadin data model, and can be bound to data with field groups, as described in Section 8.4, “Creating Forms by Binding Fields to Items”. The field values are buffered and can be validated with validators.

A composite field class must implement the `getType()` and `initContent()` methods. The latter should return the content composite of the field. It is typically a layout component, but can be any component.

It is also possible to override `validate()`, `setInternalValue()`, `commit()`, `setPropertyDataSource()`, `isEmpty()` and other methods to implement different functionalities in the field. Methods overriding `setInternalValue()` should call the superclass method.

## 5.30. Embedded Resources

You can embed images in Vaadin UIs with the **Image** component, Adobe Flash graphics with **Flash**, and other web content with **BrowserFrame**. There is also a generic **Embedded** component for embedding other object types. The embedded content is referenced as *resources*, as described in Section 4.4, “Images and Other Resources”.

The following example displays an image as a class resource loaded with the class loader:

```
Image image = new Image("Yes, logo:",
    new ClassResource("vaadin-logo.png"));
main.addComponent(image);
```

The caption can be given as null to disable it. An empty string displays an empty caption which takes a bit space. The caption is managed by the containing layout.

You can set an alternative text for an embedded resource with `setAlternateText()`, which can be shown if images are disabled in the browser for some reason. The text can be used for accessibility purposes, such as for text-to-speech generation.

### 5.30.1. Embedded Image

The **Image** component allows embedding an image resource in a Vaadin UI.

```
// Serve the image from the theme
Resource res = new ThemeResource("img/myimage.png");

// Display the image without caption
Image image = new Image(null, res);
layout.addComponent(image);
```

The **Image** component has by default undefined size in both directions, so it will automatically fit the size of the embedded image. If you want scrolling with scroll bars, you can put the image inside a **Panel** that has a defined size to enable scrolling, as described in Section 6.6.1, “Scrolling the Panel Content”. You can also put it inside some other component container and set the `overflow: auto` CSS property for the container element in a theme to enable automatic scrollbars.

## Generating and Reloading Images

You can also generate the image content dynamically using a **StreamResource**, as described in Section 4.4.5, “Stream Resources”, or with a **RequestHandler**.

If the image changes, the browser needs to reload it. Simply updating the stream resource is not enough. Because of how caching is handled in some browsers, you can cause a reload easiest by renaming the filename of the resource with a unique name, such as one including a timestamp. You should set cache time to zero with `setCacheTime()` for the resource object when you create it.

```
// Create the stream resource with some initial filename
StreamResource imageResource =
    new StreamResource(imageSource, "initial-filename.png");

// Instruct browser not to cache the image
imageResource.setCacheTime(0);

// Display the image
Image image = new Image(null, imageResource);
```

When refreshing, you also need to call `markAsDirty()` for the **Image** object.

```
// This needs to be done, but is not sufficient
image.markAsDirty();

// Generate a filename with a timestamp
SimpleDateFormat df = new SimpleDateFormat("yyyyMMddHHmmssSSS");
String filename = "myfilename-" + df.format(new Date()) + ".png";

// Replace the filename in the resource
imageResource.setFilename(makeImageFilename());
```

### 5.30.2. Adobe Flash Graphics

The **Flash** component allows embedding Adobe Flash animations in Vaadin UIs.

```
Flash flash = new Flash(null,
    new ThemeResource("img/vaadin_spin.swf"));
layout.addComponent(flash);
```

You can set Flash parameters with `setParameter()`, which takes a parameter's name and value as strings. You can also set the `codeBase`, `archive`, and `standBy` attributes for the Flash object element in HTML.

### 5.30.3. BrowserFrame

The **BrowserFrame** allows embedding web content inside an HTML `<iframe>` element. You can refer to an external URL with **ExternalResource**.

As the **BrowserFrame** has undefined size by default, it is critical that you define a meaningful size for it, either fixed or relative.

```
BrowserFrame browser = new BrowserFrame("Browser",
    new ExternalResource("http://demo.vaadin.com/sampler/"));
browser.setWidth("600px");
browser.setHeight("400px");
layout.addComponent(browser);
```

Notice that web pages can prevent embedding them in an <iframe>.

#### 5.30.4. Generic Embedded Objects

The generic **Embedded** component allows embedding all sorts of objects, such as SVG graphics, Java applets, and PDF documents, in addition to the images, Flash graphics, and browser frames which you can embed with the specialized components.

For example, to display a Flash animation:

```
// A resource reference to some object
Resource res = new ThemeResource("img/vaadin_spin.swf");

// Display the object
Embedded object = new Embedded("My Object", res);
layout.addComponent(object);
```

Or an SVG image:

```
// A resource reference to some object
Resource res = new ThemeResource("img/reindeer.svg");

// Display the object
Embedded object = new Embedded("My SVG", res);
object.setMimeType("image/svg+xml"); // Unnecessary
layout.addComponent(object);
```

The MIME type of the objects is usually detected automatically from the filename extension with the **FileTypeResolver** utility in Vaadin. If not, you can set it explicitly with `setMimeType()`, as was done in the example above (where it was actually unnecessary).

Some embeddable object types may require special support in the browser. You should make sure that there is a proper fallback mechanism if the browser does not support the embedded type.



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# Chapter 6

# Managing Layout

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Ever since the ancient xeroxians invented graphical user interfaces, programmers have wanted to make GUI programming ever easier for themselves. Solutions started simple. When GUIs appeared on PC desktops, practically all screens were of the VGA type and fixed into 640x480 size. Mac or X Window System on UNIX were not much different. Everyone was so happy with such awesome graphics resolutions that they never thought that an application would have to work on a radically different screen size. At worst, screens could only grow, they thought, giving more space for more windows. In the 80s, the idea of having a computer screen in your pocket was simply not realistic. Hence, the GUI APIs allowed placing UI components using screen coordinates. Visual Basic and some other systems provided an easy way for the designer to drag and drop components on a fixed-sized window. One would have thought that at least translators would have complained about the awkwardness of such a solution, but apparently they were not,

as non-engineers, heard or at least cared about. At best, engineers could throw at them a resource editor that would allow them to resize the UI components by hand. Such was the spirit back then.

After the web was born, layout design was doomed to change for ever. At first, layout didn't matter much, as everyone was happy with plain headings, paragraphs, and a few hyperlinks here and there. Designers of HTML wanted the pages to run on any screen size. The screen size was actually not pixels but rows and columns of characters, as the baby web was really just *hypertext*, not graphics. That was soon to be changed. The first GUI-based browser, NCSA Mosaic, launched a revolution that culminated in Netscape Navigator. Suddenly, people who had previously been doing advertisement brochures started writing HTML. This meant that layout design had to be easy not just for programmers, but also allow the graphics designer to do his or her job without having to know a thing about programming. The W3C committee designing web standards came up with the CSS (Cascading Style Sheet) specification, which allowed trivial separation of appearance from content. Later versions of HTML followed, XHTML and HTML 5 appeared, as did countless other standards.

Page description and markup languages are a wonderful solution for static presentations, such as books and most web pages. Real applications, however, need to have more control. They need to be able to change the state of user interface components and even their layout on the run. This creates a need to separate the presentation from content on exactly the right level.

Thanks to the attack of graphics designers, desktop applications were, when it comes to appearance, far behind web design. Sun Microsystems had come in 1995 with a new programming language, Java, for writing cross-platform desktop applications. Java's original graphical user interface toolkit, AWT (Abstract Windowing Toolkit), was designed to work on multiple operating systems as well as embedded in web browsers. One of the special aspects of AWT was the layout manager, which allowed user interface components to be flexible, growing and shrinking as needed. This made it possible for the user to resize the windows of an application flexibly and also served the needs of localization, as text strings were not limited to some fixed size in pixels. It became even possible to resize the pixel size of fonts, and the rest of the layout adapted to the new size.

Layout management of Vaadin is a direct successor of the web-based concept for separation of content and appearance and of the Java AWT solution for binding the layout and user interface components into objects in programs. Vaadin layout components allow you to position your UI components on the screen in a hierarchical fashion, much like in conventional Java UI toolkits such as AWT, Swing, or SWT. In addition, you can approach the layout from the direction of the web with the **CustomLayout** component, which you can use to write your layout as a template in HTML that provides locations of any contained components. The **AbsoluteLayout** allows the old-style pixel-position based layouting, but it also supports percentual values, which makes it usable for scalable layouts. It is also useful as an area on which the user can position items with drag and drop.

The moral of the story is that, because Vaadin is intended for web applications, appearance is of high importance. The solutions have to be the best of both worlds and satisfy artists of both kind: code and graphics. On the API side, the layout is controlled by UI components, particularly the layout components. On the visual side, it is controlled by themes. Themes can contain any HTML, Sass, CSS, and JavaScript that you or your web artists create to make people feel good about your software.

## 6.1. Overview

The user interface components in Vaadin can roughly be divided in two groups: components that the user can interact with and layout components for placing the other components to specific

places in the user interface. The layout components are identical in their purpose to layout managers in regular desktop frameworks for Java and you can use plain Java to accomplish sophisticated component layouting.

You start by creating a content layout for the UI and then add other layout components hierarchically, and finally the interaction components as the leaves of the component tree.

```
// Set the root layout for the UI
VerticalLayout content = new VerticalLayout();
setContent(content);

// Add the topmost component.
content.addComponent(new Label("The Ultimate Cat Finder"));

// Add a horizontal layout for the bottom part.
HorizontalLayout bottom = new HorizontalLayout();
content.addComponent(bottom);

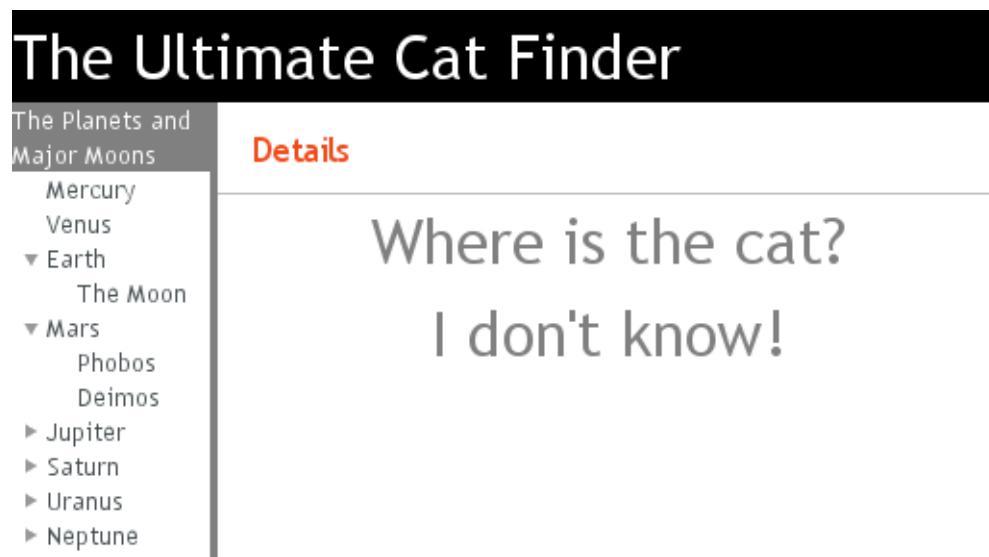
bottom.addComponent(new Tree("Major Planets and Their Moons"));
bottom.addComponent(new Panel());
...
```

You will usually need to tune the layout components a bit by setting sizes, expansion ratios, alignments, spacings, and so on. The general settings are described in Section 6.13, “Layout Formatting”.

Layouts are coupled with themes that specify various layout features, such as backgrounds, borders, text alignment, and so on. Definition and use of themes is described in Chapter 7, *Themes*

You can see a finished version of the above example in Figure 6.1, “Layout Example”.

**Figure 6.1. Layout Example**



The alternative for using layout components is to use the special **CustomLayout** that allows using HTML templates. This way, you can let the web page designers take responsibility of component layouting using their own set of tools. What you lose is the ability to manage the layout dynamically.



### The Visual Editor

While you can always program the layout by hand, the Vaadin plugin for the Eclipse IDE includes a visual (WYSIWYG) editor that you can use to create user interfaces visually. The editor generates the code that creates the user interface and is useful for rapid application development and prototyping. It is especially helpful when you are still learning the framework, as the generated code, which is designed to be as reusable as possible, also works as an example of how you create user interfaces with Vaadin. You can find more about the editor in Chapter 10, *Visual User Interface Design with Eclipse*.

## 6.2. UI, Window, and Panel Content

The **UI**, **Window**, and its superclass **Panel** all have a single content component, which you need to set with `setContent()`. The content is usually a layout component, although any component is allowed.

```
Panel panel = new Panel("This is a Panel");
VerticalLayout panelContent = new VerticalLayout();
panelContent.addComponent(new Label("Hello!"));
panel.setContent(panelContent);

// Set the panel as the content of the UI
setContent(panel);
```

The size of the content is the default size of the particular layout component, for example, a **VerticalLayout** has 100% width and undefined height by default (this coincides with the defaults for **Panel** and **Label**). If such a layout with undefined height grows higher than the browser window, it will flow out of the view and scrollbars will appear. In many applications, you want to use the full area of the browser view. Setting the components contained inside the content layout to full size is not enough, and would actually lead to an invalid state if the height of the content layout is undefined.

```
// First set the root content for the UI
VerticalLayout content = new VerticalLayout();
setContent(content);

// Set the content size to full width and height
content.setSizeFull();

// Add a title area on top of the screen. This takes
// just the vertical space it needs.
content.addComponent(new Label("My Application"));

// Add a menu-view area that takes rest of vertical space
HorizontalLayout menuvieew = new HorizontalLayout();
menuvieew.setSizeFull();
content.addComponent(menuvieew);
```

See Section 6.13.1, “Layout Size” for more information about setting layout sizes.

## 6.3. VerticalLayout and HorizontalLayout

**VerticalLayout** and **HorizontalLayout** are ordered layouts for laying components out either vertically or horizontally, respectively. They both extend from **AbstractOrderedLayout**, together

with the **FormLayout**. These are the two most important layout components in Vaadin, and typically you have a **VerticalLayout** as the root content component of the **UI**.

**VerticalLayout** has 100% default width and undefined height, so it fills the containing layout (or UI) horizontally, and fits its content vertically. **HorizontalLayout** has undefined size in both dimensions.

Typical use of the layouts goes as follows:

```
VerticalLayout vertical = new VerticalLayout ();
vertical.addComponent(new TextField("Name"));
vertical.addComponent(new TextField("Street address"));
vertical.addComponent(new TextField("Postal code"));
layout.addComponent(vertical);
```

The component captions are placed above the component, so the layout will look as follows:

Name	<input type="text"/>
Street address	<input type="text"/>
Postal code	<input type="text"/>

Using **HorizontalLayout** gives the following layout:

Name	Street address	Postal code
<input type="text"/>	<input type="text"/>	<input type="text"/>

### 6.3.1. Spacing in Ordered Layouts

The ordered layouts can have spacing between the horizontal or vertical cells. The spacing can be enabled with `setSpacing(true)`.

The spacing as a default height or width, which can be customized in CSS. You need to set the height or width for spacing elements with `v-spacing` style. You also need to specify an enclosing rule element in a CSS selector, such as `v-verticallayout` for a **VerticalLayout** or `v-hori-zontallayout` for a **HorizontalLayout**. You can also use `v-vertical` and `v-horizontal` for all vertically or horizontally ordered layouts, such as **FormLayout**.

For example, the following sets the amount of spacing for all **VerticalLayouts**, as well as **FormLayout**, in the UI:

```
.v-vertical > .v-spacing {
    height: 30px;
}
```

Or for **HorizontalLayout**:

```
.v-horizontal > .v-spacing {
    width: 50px;
}
```

### 6.3.2. Sizing Contained Components

The components contained within an ordered layout can be laid out in a number of different ways depending on how you specify their height or width in the primary direction of the layout component.

**Figure 6.2. Component Widths in `HorizontalLayout`**

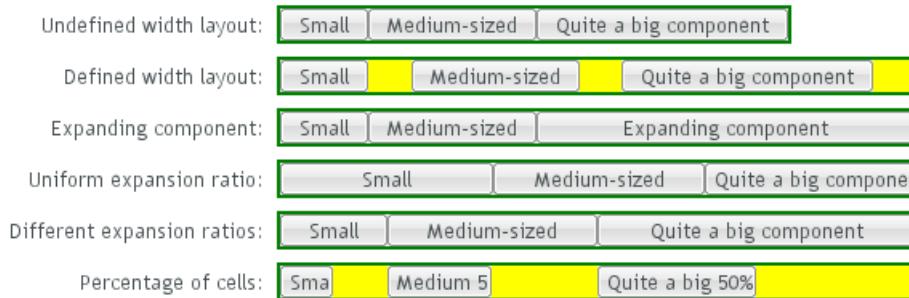


Figure 6.2, “Component Widths in `HorizontalLayout`” above gives a summary of the sizing options for a `HorizontalLayout`. The figure is broken down in the following subsections.

#### Layout with Undefined Size

If a `VerticalLayout` has undefined height or `HorizontalLayout` undefined width, the layout will shrink to fit the contained components so that there is no extra space between them.

```
HorizontalLayout fittingLayout = new HorizontalLayout();
fittingLayout.setWidth(Sizeable.SIZE_UNDEFINED, 0); // Default
fittingLayout.addComponent(new Button("Small"));
fittingLayout.addComponent(new Button("Medium-sized"));
fittingLayout.addComponent(new Button("Quite a big component"));
parentLayout.addComponent(fittingLayout);
```



The both layouts actually have undefined height by default and `HorizontalLayout` has also undefined width, while `VerticalLayout` has 100% relative width.

If such a vertical layout with undefined height continues below the bottom of a window (a `Window` object), the window will pop up a vertical scroll bar on the right side of the window area. This way, you get a "web page". The same applies to `Panel`.



**A layout that contains components with percentual size must have a defined size!**

If a layout has undefined size and a contained component has, say, 100% size, the component would fill the space given by the layout, while the layout would shrink to fit the space taken by the component, which would be a paradox. This requirement holds for height and width separately. The debug window allows detecting such invalid cases; see Section 11.3.5, “Inspecting Component Hierarchy”.

An exception to the above rule is a case where you have a layout with undefined size that contains a component with a fixed or undefined size together with one or more components with relative size. In this case, the contained component with fixed (or undefined) size in a sense defines the

size of the containing layout, removing the paradox. That size is then used for the relatively sized components.

The technique can be used to define the width of a **VerticalLayout** or the height of a **HorizontalLayout**.

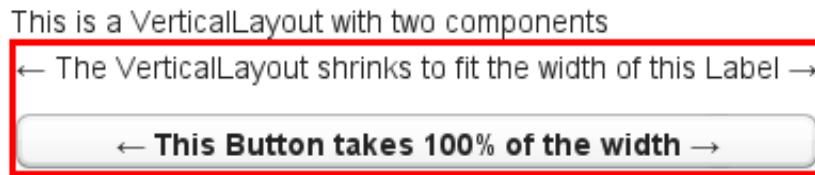
```
// Vertical layout would normally have 100% width
VerticalLayout vertical = new VerticalLayout();

// Shrink to fit the width of contained components
vertical.setWidth(Sizeable.SIZE_UNDEFINED, 0);

// Label has normally 100% width, but we set it as
// undefined so that it will take only the needed space
Label label =
    new Label("\u2190 The VerticalLayout shrinks to fit "+
              "the width of this Label \u2192");
label.setWidth(Sizeable.SIZE_UNDEFINED, 0);
vertical.addComponent(label);

// Button has undefined width by default
Button butt = new Button("\u2190 This Button takes 100% "+
                        "of the width \u2192");
butt.setWidth("100%");
vertical.addComponent(butt);
```

**Figure 6.3. Defining the Size with a Component**



## Layout with Defined Size

If you set a **HorizontalLayout** to a defined size horizontally or a **VerticalLayout** vertically, and there is space left over from the contained components, the extra space is distributed equally between the component cells. The components are aligned within these cells according to their alignment setting, top left by default, as in the example below.

```
fixedLayout.setWidth("400px");
```



Using percentual sizes for components contained in a layout requires answering the question, "Percentage of what?" There is no sensible default answer for this question in the current implementation of the layouts, so in practice, you may not define "100%" size alone.

## Expanding Components

Often, you want to have one component that takes all the available space left over from other components. You need to set its size as 100% and set it as *expanding* with `setExpandRatio()`. The second parameter for the method is an expansion ratio, which is relevant if there are more than one expanding component, but its value is irrelevant for a single expanding component.

```
HorizontalLayout layout = new HorizontalLayout();
layout.setWidth("400px");

// These buttons take the minimum size.
layout.addComponent(new Button("Small"));
layout.addComponent(new Button("Medium-sized"));

// This button will expand.
Button expandButton = new Button("Expanding component");

// Use 100% of the expansion cell's width.
expandButton.setWidth("100%");

// The component must be added to layout before setting the ratio.
layout.addComponent(expandButton);

// Set the component's cell to expand.
layout.setExpandRatio(expandButton, 1.0f);

parentLayout.addComponent(layout);
```



Notice that you must call `setExpandRatio()` *after* `addComponent()`, because the layout can not operate on a component that it doesn't (yet) include.

## Expand Ratios

If you specify an expand ratio for multiple components, they will all try to use the available space according to the ratio.

```
HorizontalLayout layout = new HorizontalLayout();
layout.setWidth("400px");

// Create three equally expanding components.
String[] captions = { "Small", "Medium-sized",
                     "Quite a big component" };
for (int i = 1; i <= 3; i++) {
    Button button = new Button(captions[i-1]);
    button.setWidth("100%");
    layout.addComponent(button);

    // Have uniform 1:1:1 expand ratio.
    layout.setExpandRatio(button, 1.0f);
}
```



As the example used the same ratio for all components, the ones with more content may have the content cut. Below, we use differing ratios:

```
// Expand ratios for the components are 1:2:3.
layout.setExpandRatio(button, i * 1.0f);
```



If the size of the expanding components is defined as a percentage (typically "100%"), the ratio is calculated from the *overall* space available for the relatively sized components. For example, if you have a 100 pixels wide layout with two cells with 1.0 and 4.0 respective expansion ratios, and both the components in the layout are set as `setWidth("100%)`, the cells will have respective widths of 20 and 80 pixels, regardless of the minimum size of the components.

However, if the size of the contained components is undefined or fixed, the expansion ratio is of the *excess* available space. In this case, it is the excess space that expands, not the components.

```
for (int i = 1; i <= 3; i++) {
    // Button with undefined size.
    Button button = new Button(captions[i - 1]);

    layout4.addComponent(button);

    // Expand ratios are 1:2:3.
    layout4.setExpandRatio(button, i * 1.0f);
}
```



It is not meaningful to combine expanding components with percentually defined size and components with fixed or undefined size. Such combination can lead to a very unexpected size for the percentually sized components.

## Percentage of Cells

A percentual size of a component defines the size of the component *within its cell*. Usually, you use "100%", but a smaller percentage or a fixed size (smaller than the cell size) will leave an empty space in the cell and align the component within the cell according to its alignment setting, top left by default.

```
HorizontalLayout layout50 = new HorizontalLayout();
layout50.setWidth("400px");

String[] captions1 = { "Small 50%", "Medium 50%",
                      "Quite a big 50%" };
for (int i = 1; i <= 3; i++) {
    Button button = new Button(captions1[i-1]);
    button.setWidth("50%");
    layout50.addComponent(button);

    // Expand ratios for the components are 1:2:3.
    layout50.setExpandRatio(button, i * 1.0f);
}
parentLayout.addComponent(layout50);
```



## 6.4. GridLayout

**GridLayout** container lays components out on a grid, defined by the number of columns and rows. The columns and rows of the grid serve as coordinates that are used for laying out com-

ponents on the grid. Each component can use multiple cells from the grid, defined as an area (x1,y1,x2,y2), although they typically take up only a single grid cell.

The grid layout maintains a cursor for adding components in left-to-right, top-to-bottom order. If the cursor goes past the bottom-right corner, it will automatically extend the grid downwards by adding a new row.

The following example demonstrates the use of **GridLayout**. The `addComponent` takes a component and optional coordinates. The coordinates can be given for a single cell or for an area in x,y (column,row) order. The coordinate values have a base value of 0. If coordinates are not given, the cursor will be used.

```
// Create a 4 by 4 grid layout.
GridLayout grid = new GridLayout(4, 4);
grid.addStyleName("example-gridlayout");

// Fill out the first row using the cursor.
grid.addComponent(new Button("R/C 1"));
for (int i = 0; i < 3; i++) {
    grid.addComponent(new Button("Col " + (grid.getCursorX() + 1)));
}

// Fill out the first column using coordinates.
for (int i = 1; i < 4; i++) {
    grid.addComponent(new Button("Row " + i), 0, i);
}

// Add some components of various shapes.
grid.addComponent(new Button("3x1 button"), 1, 1, 3, 1);
grid.addComponent(new Label("1x2 cell"), 1, 2, 1, 3);
InlineDateField date = new InlineDateField("A 2x2 date field");
date.setResolution(DateField.RESOLUTION_DAY);
grid.addComponent(date, 2, 2, 3, 3);
```

The resulting layout will look as follows. The borders have been made visible to illustrate the layout cells.

**Figure 6.4. The Grid Layout Component**

R/C 1	Col 1	Col 2	Col 3																																											
Row 1	3x1 button																																													
Row 2	1x2 cell	A 2x2 date field November 2007 <table border="1"> <thead> <tr> <th>Sun</th><th>Mon</th><th>Tue</th><th>Wed</th><th>Thu</th><th>Fri</th><th>Sat</th></tr> </thead> <tbody> <tr> <td></td><td></td><td></td><td></td><td>1</td><td>2</td><td>3</td></tr> <tr> <td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr> <tr> <td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr> <tr> <td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr> <tr> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td></td></tr> </tbody> </table>			Sun	Mon	Tue	Wed	Thu	Fri	Sat					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Sun	Mon	Tue	Wed	Thu	Fri	Sat																																								
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18	19	20	21	22	23	24																																								
25	26	27	28	29	30																																									
Row 3																																														

A component to be placed on the grid must not overlap with existing components. A conflict causes throwing a **GridLayout.OverlapsException**.

## 6.4.1. Sizing Grid Cells

You can define the size of both a grid layout and its components in either fixed or percentual units, or leave the size undefined altogether, as described in Section 5.3.9, “Sizing Components”. Section 6.13.1, “Layout Size” gives an introduction to sizing of layouts.

The size of the **GridLayout** component is undefined by default, so it will shrink to fit the size of the components placed inside it. In most cases, especially if you set a defined size for the layout but do not set the contained components to full size, there will be some unused space. The position of the non-full components within the grid cells will be determined by their *alignment*. See Section 6.13.3, “Layout Cell Alignment” for details on how to align the components inside the cells.

The components contained within a **GridLayout** layout can be laid out in a number of different ways depending on how you specify their height or width. The layout options are similar to **HorizontalLayout** and **VerticalLayout**, as described in Section 6.3, “**VerticalLayout** and **HorizontalLayout**”.



**A layout that contains components with percentual size must have a defined size!**

If a layout has undefined size and a contained component has, say, 100% size, the component would fill the space given by the layout, while the layout would shrink to fit the space taken by the component, which is a paradox. This requirement holds for height and width separately. The debug mode allows detecting such invalid cases; see Section 11.3.1, “Enabling the Debug Mode”.

Often, you want to have one or more rows or columns that take all the available space left over from non-expanding rows or columns. You need to set the rows or columns as *expanding* with `setRowExpandRatio()` and `setColumnExpandRatio()`. The first parameter for these methods is the index of the row or column to set as expanding. The second parameter for the methods is an expansion ratio, which is relevant if there are more than one expanding row or column, but its value is irrelevant if there is only one. With multiple expanding rows or columns, the ratio parameter sets the relative portion how much a specific row/column will take in relation with the other expanding rows/columns.

```
GridLayout grid = new GridLayout(3,2);

// Layout containing relatively sized components must have
// a defined size, here is fixed size.
grid.setWidth("600px");
grid.setHeight("200px");

// Add some content
String labels [] = {
    "Shrinking column<br/>Shrinking row",
    "Expanding column (1:)<br/>Shrinking row",
    "Expanding column (5:)<br/>Shrinking row",
    "Shrinking column<br/>Expanding row",
    "Expanding column (1:)<br/>Expanding row",
    "Expanding column (5:)<br/>Expanding row"
};
for (int i=0; i<labels.length; i++) {
    Label label = new Label(labels[i], ContentMode.HTML);
    label.setWidth(null); // Set width as undefined
    grid.addComponent(label);
```

```

}

// Set different expansion ratios for the two columns
grid.setColumnExpandRatio(1, 1);
grid.setColumnExpandRatio(2, 5);

// Set the bottom row to expand
grid.setRowExpandRatio(1, 1);

// Align and size the labels.
for (int col=0; col<grid.getColumns(); col++) {
    for (int row=0; row<grid.getRows(); row++) {
        Component c = grid.getComponent(col, row);
        grid.setComponentAlignment(c, Alignment.TOP_CENTER);

        // Make the labels high to illustrate the empty
        // horizontal space.
        if (col != 0 || row != 0)
            c.setHeight("100%");
    }
}

```

**Figure 6.5. Expanding Rows and Columns in GridLayout**

Shrinking column Shrinking row	Expanding column (1:) Shrinking row	Expanding column (5:) Shrinking row
Shrinking column Expanding row	Expanding column (1:) Expanding row	Expanding column (5:) Expanding row

If the size of the contained components is undefined or fixed, the expansion ratio is of the excess space, as in Figure 6.5, “Expanding Rows and Columns in **GridLayout**” (excess horizontal space is shown in white). However, if the size of the all the contained components in the expanding rows or columns is defined as a percentage, the ratio is calculated from the *overall* space available for the percentually sized components. For example, if we had a 100 pixels wide grid layout with two columns with 1.0 and 4.0 respective expansion ratios, and all the components in the grid were set as `setWidth("100%")`, the columns would have respective widths of 20 and 80 pixels, regardless of the minimum size of their contained components.

## CSS Style Rules

```
.v-gridlayout {}
.v-gridlayout-margin {}
```

The `v-gridlayout` is the root element of the **GridLayout** component. The `v-gridlayout-margin` is a simple element inside it that allows setting a padding between the outer element and the cells.

For styling the individual grid cells, you should style the components inserted in the cells. The implementation structure of the grid can change, so depending on it, as is done in the example below, is not generally recommended. Normally, if you want to have, for example, a different color for a certain cell, just make set the component inside it `setSizeFull()`, and add a style

name for it. Sometimes you may need to use a layout component between a cell and its actual component just for styling.

The following example shows how to make the grid borders visible, as in Figure 6.5, “Expanding Rows and Columns in **GridLayout**”.

```
.v-gridlayout-gridexpandratio {  
    background: blue; /* Creates a "border" around the grid. */  
    margin:     10px; /* Empty space around the layout. */  
}  
  
/* Add padding through which the background color shows. */  
.v-gridlayout-gridexpandratio .v-gridlayout-margin {  
    padding: 2px;  
}  
  
/* Add cell borders and make the cell backgrounds white.  
 * Warning: This depends heavily on the HTML structure. */  
.v-gridlayout-gridexpandratio > div > div > div {  
    padding: 2px; /* Layout background will show through. */  
    background: white; /* The cells will be colored white. */  
}  
  
/* Components inside the layout are a safe way to style cells. */  
.v-gridlayout-gridexpandratio .v-label {  
    text-align: left;  
    background: #fffffc0; /* Pale yellow */  
}
```

You should beware of `margin`, `padding`, and `border` settings in CSS as they can mess up the layout. The dimensions of layouts are calculated in the Client-Side Engine of Vaadin and some settings can interfere with these calculations. For more information on margins and spacing, see Section 6.13.4, “Layout Cell Spacing” and Section 6.13.5, “Layout Margins”

## 6.5. FormLayout

**FormLayout** lays the components and their captions out in two columns, with optional indicators for required fields and errors that can be shown for each field. The field captions can have an icon in addition to the text. **FormLayout** is an ordered layout and much like **VerticalLayout**. For description of margins, spacing, and other features in ordered layouts, see Section 6.3, “**VerticalLayout** and **HorizontalLayout**”.

The following example shows typical use of **FormLayout** in a form:

```
// A FormLayout used outside the context of a Form  
FormLayout fl = new FormLayout();  
  
// Make the FormLayout shrink to its contents  
fl.setSizeUndefined();  
  
TextField tf = new TextField("A Field");  
fl.addComponent(tf);  
  
// Mark the first field as required  
tf.setRequired(true);  
tf.setRequiredError("The Field may not be empty.");  
  
TextField tf2 = new TextField("Another Field");
```

```
f1.addComponent(tf2);

// Set the second field straining to error state with a message.
tf2.setComponentError(
    new UserError("This is the error indicator of a Field."));
```

The resulting layout will look as follows. The error message shows in a tooltip when you hover the mouse pointer over the error indicator.

**Figure 6.6. A FormLayout Layout for Forms**



## CSS Style Rules

```
.v-formlayout {}
.v-formlayout .v-caption {}

/* Columns in a field row. */
.v-formlayout-contentcell {} /* Field content. */
.v-formlayout-captioncell {} /* Field caption. */
.v-formlayout-errorcell {} /* Field error indicator. */

/* Overall style of field rows. */
.v-formlayout-row {}
.v-formlayout-firstrow {}
.v-formlayout-lastrow {}

/* Required field indicator. */
.v-formlayout .v-required-field-indicator {}
.v-formlayout-captioncell .v-caption
    .v-required-field-indicator {}

/* Error indicator. */
.v-formlayout-cell .v-errorindicator {}
.v-formlayout-error-indicator .v-errorindicator {}
```

The top-level element of **FormLayout** has the `v-formlayout` style. The layout is tabular with three columns: the caption column, the error indicator column, and the field column. These can be styled with `v-formlayout-captioncell`, `v-formlayout-errorcell`, and `v-formlayout-contentcell`, respectively. While the error indicator is shown as a dedicated column, the indicator for required fields is currently shown as a part of the caption column.

For information on setting margins and spacing, see also Section 6.3.1, “Spacing in Ordered Layouts” and Section 6.13.5, “Layout Margins”.

## 6.6. Panel

**Panel** is a single-component container with a frame around the content. It has an optional caption and an icon which are handled by the panel itself, not its containing layout. The panel itself does not manage the caption of its contained component. You need to set the content with `setContent()`.

**Panel** has 100% width and undefined height by default. This corresponds with the default sizing of **VerticalLayout**, which is perhaps most commonly used as the content of a **Panel**. If the width or height of a panel is undefined, the content must have a corresponding undefined or fixed size in the same direction to avoid a sizing paradox.

```
Panel panel = new Panel("Astronomy Panel");
panel.addStyleName("mypanalexample");
panel.setSizeUndefined(); // Shrink to fit content
layout.addComponent(panel);

// Create the content
FormLayout content = new FormLayout();
content.addStyleName("mypanelcontent");
content.addComponent(new TextField("Participant"));
content.addComponent(new TextField("Organization"));
content.setSizeUndefined(); // Shrink to fit
content.setMargin(true);
panel.setContent(content);
```

The resulting layout is shown in Figure 6.7, “A Panel”.

**Figure 6.7. A Panel**



### 6.6.1. Scrolling the Panel Content

Normally, if a panel has undefined size in a direction, as it has by default vertically, it will fit the size of the content and grow as the content grows. However, if it has a fixed or percentual size and its content becomes too big to fit in the content area, a scroll bar will appear for the particular direction. Scroll bars in a **Panel** are handled natively by the browser with the `overflow: auto` property in CSS.

In the following example, we have a 300 pixels wide and very high **Image** component as the panel content.

```
// Display an image stored in theme
Image image = new Image(null,
    new ThemeResource("img/Ripley_Scroll-300px.jpg"));

// To enable scrollbars, the size of the panel content
// must not be relative to the panel size
image.setSizeUndefined(); // Actually the default
```

```
// The panel will give it scrollbars.  
Panel panel = new Panel("Scroll");  
panel.setWidth("300px");  
panel.setHeight("300px");  
panel.setContent(image);  
  
layout.addComponent(panel);
```

The result is shown in Figure 6.8, “Panel with Scroll Bars”. Notice that also the horizontal scrollbar has appeared even though the panel has the same width as the content (300 pixels) - the 300px width for the panel includes the panel border and vertical scrollbar.

**Figure 6.8. Panel with Scroll Bars**



## Programmatic Scrolling

Panel implements the `Scrollable` interface to allow programmatic scrolling. You can set the scroll position in pixels with `setScrollTop()` and `setScrollLeft()`. You can also get the scroll position set previously, but scrolling the panel in the browser does not update the scroll position to the server-side.

## CSS Style Rules

```
.v-panel {}  
.v-panel-caption {}  
.v-panel-nocaption {}  
.v-panel-content {}  
.v-panel-deco {}
```

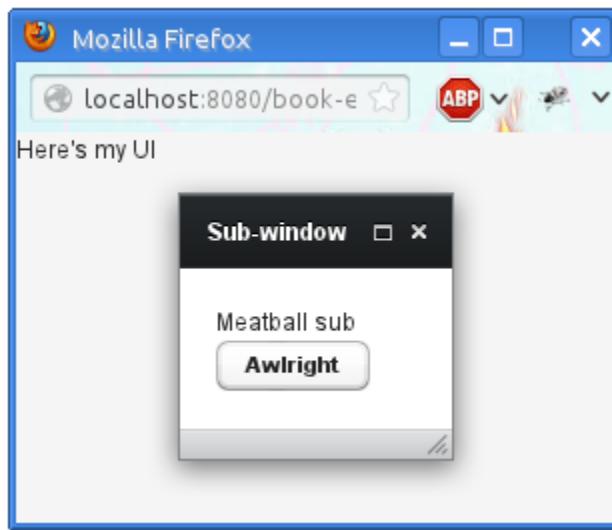
The entire panel has `v-panel` style. A panel consists of three parts: the caption, content, and bottom decorations (shadow). These can be styled with `v-panel-caption`, `v-panel-content`, and `v-panel-deco`, respectively. If the panel has no caption, the caption element will have the style `v-panel-nocaption`.

The built-in `light` style in the Reindeer and Runo themes has no borders or border decorations for the **Panel**. You can use the `Reindeer.PANEL_LIGHT` and `Runo.PANEL_LIGHT` constants to add the style to a panel. Other themes may also provide the light and other styles for **Panel** as well.

## 6.7. Sub-Windows

*Sub-windows* are floating panels within a native browser window. Unlike native browser windows, sub-windows are managed by the client-side runtime of Vaadin using HTML features. Vaadin allows opening, closing, resizing, maximizing and restoring sub-windows, as well as scrolling the window content.

**Figure 6.9. A Sub-Window**



Sub-windows are typically used for *Dialog Windows* and *Multiple Document Interface* applications. Sub-windows are by default not modal; you can set them modal as described in Section 6.7.4, “Modal Sub-Windows”.

### 6.7.1. Opening and Closing Sub-Windows

You can open a new sub-window by creating a new **Window** object and adding it to the UI with `addWindow()`, typically in some event listener. A sub-window needs a content component, which is typically a layout.

In the following, we display a sub-window immediately when a UI opens:

```
public static class SubWindowUI extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        // Some other UI content  
        setContent(new Label("Here's my UI"));  
  
        // Create a sub-window and set the content  
        Window subWindow = new Window("Sub-window");  
        VerticalLayout subContent = new VerticalLayout();  
        subContent.setMargin(true);  
        subWindow.setContent(subContent);  
    }  
}
```

```
// Put some components in it
subContent.addComponent(new Label("Meatball sub"));
subContent.addComponent(new Button("Awlright"));

// Center it in the browser window
subWindow.center();

// Open it in the UI
addWindow(subWindow);
}
}
```

The result was shown in Figure 6.9, “A Sub-Window”. Sub-windows by default have undefined size in both dimensions, so they will shrink to fit the content.

The user can close a sub-window by clicking the close button in the upper-right corner of the window. The button is controlled by the `closable` property, so you can disable it with `setClosable(false)`.

You close a sub-window also programmatically by calling the `close()` for the sub-window, typically in a click listener for an **OK** or **Cancel** button. You can also call `removeWindow()` for the current **UI**.

## Sub-Window Management

Usually, you would extend the **Window** class for your specific sub-window as follows:

```
// Define a sub-window by inheritance
class MySub extends Window {
    public MySub() {
        super("Subs on Sale"); // Set window caption
        center();

        // Some basic content for the window
        VerticalLayout content = new VerticalLayout();
        content.addComponent(new Label("Just say it's OK!"));
        content.setMargin(true);
        setContent(content);

        // Disable the close button
        setClosable(false);

        // Trivial logic for closing the sub-window
        Button ok = new Button("OK");
        ok.addClickListener(new ClickListener() {
            public void buttonClick(ClickEvent event) {
                close(); // Close the sub-window
            }
        });
        content.addComponent(ok);
    }
}
```

You could open the window as follows:

```
// Some UI logic to open the sub-window
final Button open = new Button("Open Sub-Window");
open.addClickListener(new ClickListener() {
```

```
public void buttonClick(ClickEvent event) {  
    MySub sub = new MySub();  
  
    // Add it to the root component  
    UI.getCurrent().addWindow(sub);  
}  
});
```

## 6.7.2. Window Positioning

When created, a sub-window will have an undefined default size and position. You can specify the size of a window with `setHeight()` and `setWidth()` methods. You can set the position of the window with `setPositionX()` and `setPositionY()` methods.

```
// Create a new sub-window  
mywindow = new Window("My Dialog");  
  
// Set window size.  
mywindow.setHeight("200px");  
mywindow.setWidth("400px");  
  
// Set window position.  
mywindow.setPositionX(200);  
mywindow.setPositionY(50);  
  
UI.getCurrent().addWindow(mywindow);
```

## 6.7.3. Scrolling Sub-Window Content

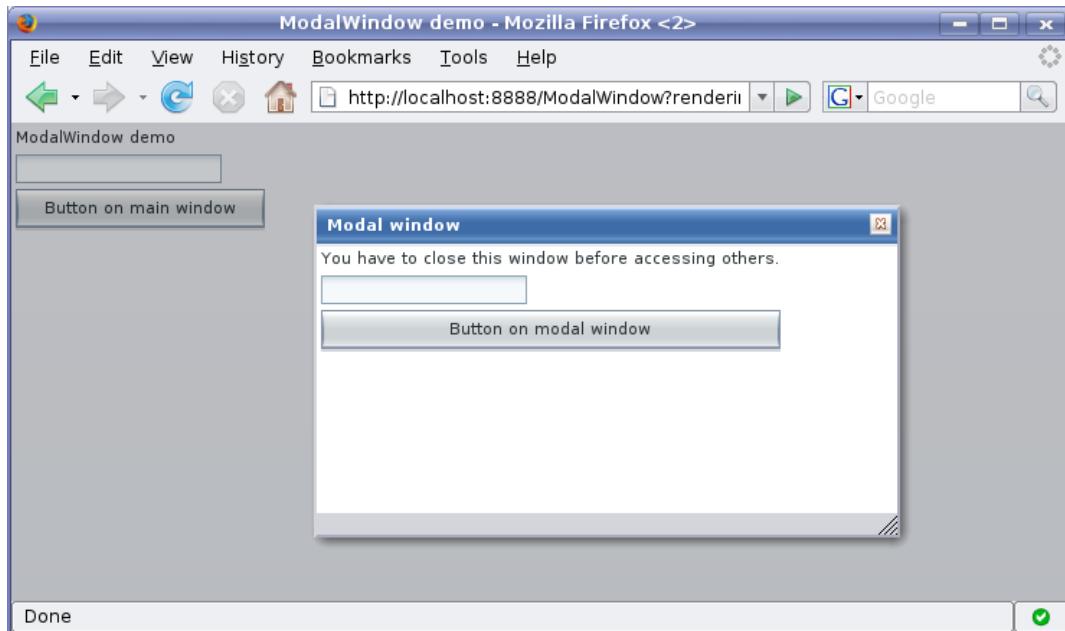
If a sub-window has a fixed or percentual size and its content becomes too big to fit in the content area, a scroll bar will appear for the particular direction. On the other hand, if the sub-window has undefined size in the direction, it will fit the size of the content and never get a scroll bar. Scroll bars in sub-windows are handled with regular HTML features, namely `overflow: auto` property in CSS.

As `Window` extends `Panel`, windows are also `Scrollable`. Note that the interface defines *programmatic scrolling*, not scrolling by the user. Please see Section 6.6, “[Panel](#)”.

## 6.7.4. Modal Sub-Windows

A modal window is a sub-window that prevents interaction with the other UI. Dialog windows, as illustrated in Figure 6.10, “Modal Sub-Window”, are typical cases of modal windows. The advantage of modal windows is limiting the scope of user interaction to a sub-task, so changes in application state are more limited. The disadvantage of modal windows is that they can restrict workflow too much.

You can make a sub-window modal with `setModal(true)`.

**Figure 6.10. Modal Sub-Window**

Depending on the theme, the parent window may be grayed when the modal window is open.



#### Security Warning

Modality of child windows is purely a client-side feature and can be circumvented with client-side attack code. You should not trust in the modality of child windows in security-critical situations such as login windows.

## 6.8. HorizontalSplitPanel and VerticalSplitPanel

**HorizontalSplitPanel** and **VerticalSplitPanel** are a two-component containers that divide the available space into two areas to accomodate the two components. **HorizontalSplitPanel** makes the split horizontally with a vertical splitter bar, and **VerticalSplitPanel** vertically with a horizontal splitter bar. The user can drag the bar to adjust its position.

You can set the two components with the `setFirstComponent()` and `setSecondComponent()` methods, or with the regular `addComponent()` method.

```
// Have a panel to put stuff in
Panel panel = new Panel("Split Panels Inside This Panel");

// Have a horizontal split panel as its content
HorizontalSplitPanel hsplit = new HorizontalSplitPanel();
panel.setContent(hsplit);

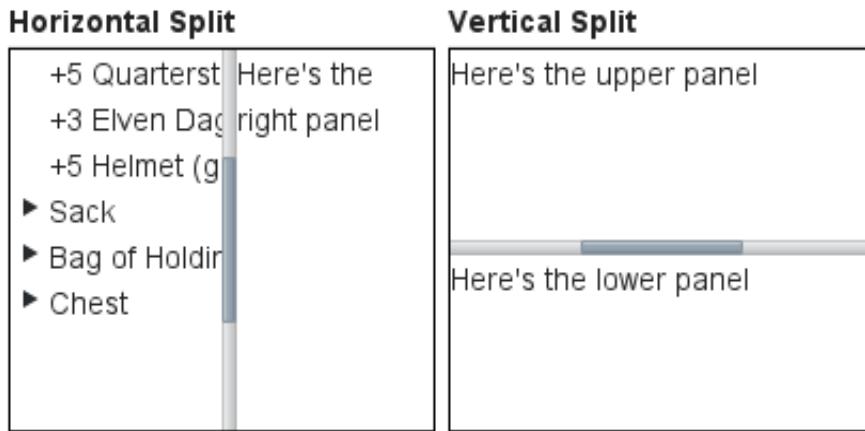
// Put a component in the left panel
Tree tree = new Tree("Menu", TreeExample.createTreeContent());
hsplit.setFirstComponent(tree);

// Put a vertical split panel in the right panel
VerticalSplitPanel vsplit = new VerticalSplitPanel();
hsplit.setSecondComponent(vsplit);
```

```
// Put other components in the right panel
vsplit.addComponent(new Label("Here's the upper panel"));
vsplit.addComponent(new Label("Here's the lower panel"));
```

The result is shown in Figure 6.11, “**HorizontalSplitPanel** and **VerticalSplitPanel**”. Observe that the tree is cut horizontally as it can not fit in the layout. If its height exceeds the height of the panel, a vertical scroll bar will appear automatically. If horizontal scroll bar is necessary, you could put the content in a **Panel**, which can have scroll bars in both directions.

**Figure 6.11. HorizontalSplitPanel and VerticalSplitPanel**



You can set the split position with `setSplitPosition()`. It accepts any units defined in the **Sizeable** interface, with percentual size relative to the size of the component.

```
// Have a horizontal split panel
HorizontalSplitPanel hsplit = new HorizontalSplitPanel();
hsplit.setFirstComponent(new Label("75% wide panel"));
hsplit.setSecondComponent(new Label("25% wide panel"));

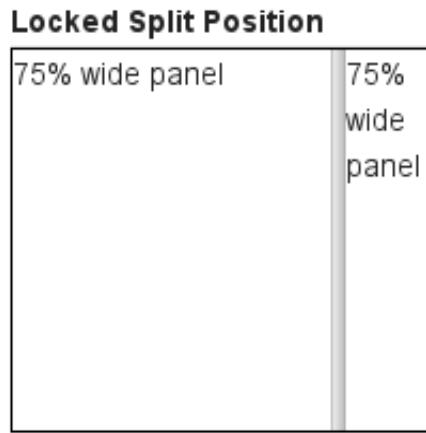
// Set the position of the splitter as percentage
hsplit.setSplitPosition(75, Sizeable.UNITS_PERCENTAGE);
```

Another version of the `setSplitPosition()` method allows leaving out the unit, using the same unit as previously. The method also has versions take a boolean parameter, `reverse`, which allows defining the size of the right or bottom panel instead of the left or top panel.

The split bar allows the user to adjust the split position by dragging the bar with mouse. To lock the split bar, use `setLocked(true)`. When locked, the move handle in the middle of the bar is disabled.

```
// Lock the splitter
hsplit.setLocked(true);
```

Setting the split position programmatically and locking the split bar is illustrated in Figure 6.12, “A Layout With Nested SplitPanels”.

**Figure 6.12. A Layout With Nested SplitPanels**

Notice that the size of a split panel must not be undefined in the split direction.

## CSS Style Rules

```
/* For a horizontal SplitPanel. */
.v-splitpanel-horizontal {}
.v-splitpanel-hsplitter {}
.v-splitpanel-hsplitter-locked {}

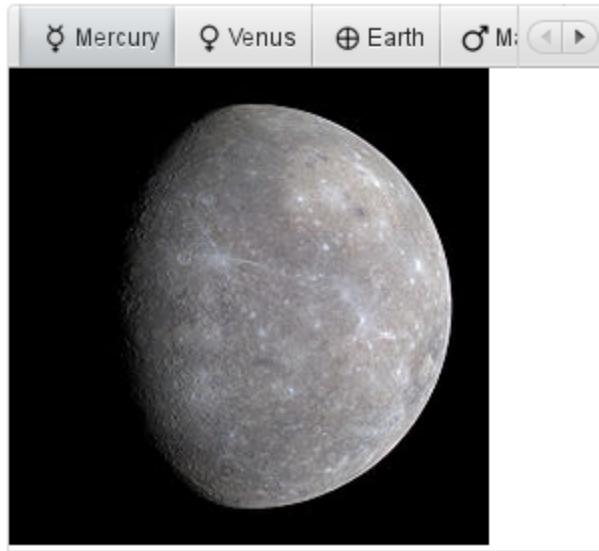
/* For a vertical SplitPanel. */
.v-splitpanel-vertical {}
.v-splitpanel-vsplitter {}
.v-splitpanel-vsplitter-locked {}

/* The two container panels. */
.v-splitpanel-first-container {} /* Top or left panel. */
.v-splitpanel-second-container {} /* Bottom or right panel. */
```

The entire split panel has the style `v-splitpanel-horizontal` or `v-splitpanel-vertical`, depending on the panel direction. The split bar or *splitter* between the two content panels has either the `...-splitter` or `...-splitter-locked` style, depending on whether its position is locked or not.

## 6.9. TabSheet

The **TabSheet** is a multicomponent container that allows switching between the components with "tabs". The tabs are organized as a tab bar at the top of the tab sheet. Clicking on a tab opens its contained component in the main display area of the layout. If there are more tabs than fit in the tab bar, navigation buttons will appear.

**Figure 6.13. A Simple TabSheet Layout**

### 6.9.1. Adding Tabs

You add new tabs to a tab sheet with the `addTab()` method. The simple version of the method takes as its parameter the root component of the tab. You can use the root component to retrieve its corresponding **Tab** object. Typically, you put a layout component as the root component.

You can also give the caption and the icon as parameters for the `addTab()` method. The following example demonstrates the creation of a simple tab sheet, where each tab shows a different **Label** component. The tabs have an icon, which are (in this example) loaded as Java class loader resources from the application.

```
TabSheet tabsheet = new TabSheet();
layout.addComponent(tabsheet);

// Create the first tab
VerticalLayout tab1 = new VerticalLayout();
tab1.addComponent(new Embedded(null,
    new ThemeResource("img/planets/Mercury.jpg")));
tabsheet.addTab(tab1, "Mercury",
    new ThemeResource("img/planets/Mercury_symbol.png"));

// This tab gets its caption from the component caption
VerticalLayout tab2 = new VerticalLayout();
tab2.addComponent(new Embedded(null,
    new ThemeResource("img/planets/Venus.jpg")));
tab2.setCaption("Venus");
tabsheet.addTab(tab2).setIcon(
    new ThemeResource("img/planets/Venus_symbol.png"));
...
```

### 6.9.2. Tab Objects

Each tab in a tab sheet is represented as a **Tab** object, which manages the tab caption, icon, and attributes such as hidden and visible. You can set the caption with `setCaption()` and the icon with `setIcon()`. If the component added with `addTab()` has a caption or icon, it is used

as the default for the **Tab** object. However, changing the attributes of the root component later does not affect the tab, but you must make the setting through the **Tab** object. The `addTab()` returns the new **Tab** object, so you can easily set an attribute using the reference.

```
// Set an attribute using the returned reference  
tabsheet.addTab(myTab).setCaption("My Tab");
```

## Disabling and Hiding Tabs

A tab can be disabled by setting `setEnabled(false)` for the **Tab** object, thereby disallowing selecting it.

A tab can be made invisible by setting `setVisible(false)` for the **Tab** object. The `hideTabs()` method allows hiding the tab bar entirely. This can be useful in tabbed document interfaces (TDI) when there is only one tab.

**Figure 6.14. A TabSheet with Hidden and Disabled Tabs**



### 6.9.3. Tab Change Events

Clicking on a tab selects it. This fires a **TabSheet.SelectedTabChangeEvent**, which you can handle by implementing the **TabSheet.SelectedTabChangeListener** interface. You can access the tabsheet of the event with `getTabSheet()`, and find the new selected tab with `getSelectedTab()`.

You can programmatically select a tab with  `setSelectedTab()`, which also fires the **SelectedTabChangeEvent** (beware of recursive events). Reselecting the currently selected tab does not fire the event.

Notice that when the first tab is added, it is selected and the change event is fired, so if you want to catch that, you need to add your listener before adding any tabs.

### Creating Tab Content Dynamically

In the following example, we create the tabs as empty content layouts, and add the tab content dynamically when a tab is selected:

```
TabSheet tabsheet = new TabSheet();  
  
// Create tab content dynamically when tab is selected  
tabsheet.addSelectedTabChangeListener(  
    new TabSheet.SelectedTabChangeListener() {  
        public void selectedTabChange(SelectedTabChangeEvent event) {  
            // Find the tabsheet  
            TabSheet tabsheet = event.getTabSheet();  
  
            // Find the tab (here we know it's a layout)  
            Layout tab = (Layout) tabsheet.getSelectedTab();  
  
            // Get the tab caption from the tab object  
            String caption = tabsheet.getTab(tab).getCaption();  
        }  
    }  
>);
```

```

        // Fill the tab content
        tab.removeAllComponents();
        tab.addComponent(new Image(null,
            new ThemeResource("img/planets/" + caption + ".jpg")));
    }
});

// Have some tabs
String[] tabs = {"Mercury", "Venus", "Earth", "Mars"};
for (String caption: tabs)
    tabsheet.addTab(new VerticalLayout(), caption,
        new ThemeResource("img/planets/" + caption + "_symbol.png"));

```

#### 6.9.4. Enabling and Handling Closing Tabs

You can enable a close button for individual tabs with the `closable` property in the **TabSheet.Tab** objects.

```
// Enable closing the tab
tabsheet.getTab(tabComponent).setClosable(true);
```

**Figure 6.15. TabSheet with Closable Tabs**



#### Handling Tab Close Events

You can handle closing tabs by implementing a custom **TabSheet.CloseHandler**. The default implementation simply calls `removeTab()` for the tab to be closed, but you can prevent the close by not calling it. This allows, for example, opening a dialog window to confirm the close.

```

tabsheet.setCloseHandler(new CloseHandler() {
    @Override
    public void onTabClose(TabSheet tabsheet,
                           Component tabContent) {
        Tab tab = tabsheet.getTab(tabContent);
        Notification.show("Closing " + tab.getCaption());

        // We need to close it explicitly in the handler
        tabsheet.removeTab(tab);
    }
});
```

#### CSS Style Rules

```
.
.v-tabsheets { }
.v-tabsheets-tabs { }
.v-tabsheets-content { }
.v-tabsheets-deco { }
.v-tabsheets-tabcontainer { }
.v-tabsheets-tabsheetpanel { }
```

```
.v-tabsheetshidetabs {}

.v-tabsheetscroller {}
.v-tabsheetscrollerPrev {}
.v-tabsheetscrollerNext {}
.v-tabsheetscrollerPrev-disabled{}
.v-tabsheetscrollerNext-disabled{}

.v-tabsheettabitem {}
.v-tabsheettabitem-selected {}
.v-tabsheettabitemcell {}
.v-tabsheettabitemcell-first {}

.v-tabsheets tabs td {}
.v-tabsheetspacertd {}
```

The entire tabsheet has the `v-tabsheets` style. A tabsheet consists of three main parts: the tabs on the top, the main content pane, and decorations around the tabsheet.

The tabs area at the top can be styled with `v-tabsheets tabs`, `v-tabsheets tabcontainer` and `v-tabsheets tabitem*`.

The style `v-tabsheetspacertd` is used for any empty space after the tabs. If the tabsheet has too little space to show all tabs, scroller buttons enable browsing the full tab list. These use the styles `v-tabsheetscroller*`.

The content area where the tab contents are shown can be styled with `v-tabsheets content`, and the surrounding decoration with `v-tabsheets deco`.

## 6.10. Accordion

**Accordion** is a multicomponent container similar to **TabSheet**, except that the "tabs" are arranged vertically. Clicking on a tab opens its contained component in the space between the tab and the next one. You can use an **Accordion** identically to a **TabSheet**, which it actually inherits. See Section 6.9, "**TabSheet**" for more information.

The following example shows how you can create a simple accordion. As the **Accordion** is rather naked alone, we put it inside a **Panel** that acts as its caption and provides it a border.

```
// Create the Accordion.
Accordion accordion = new Accordion();

// Have it take all space available in the layout.
accordion.setSizeFull();

// Some components to put in the Accordion.
Label l1 = new Label("There are no previously saved actions.");
Label l2 = new Label("There are no saved notes.");
Label l3 = new Label("There are currently no issues.");

// Add the components as tabs in the Accordion.
accordion.addTab(l1, "Saved actions", null);
accordion.addTab(l2, "Notes", null);
accordion.addTab(l3, "Issues", null);

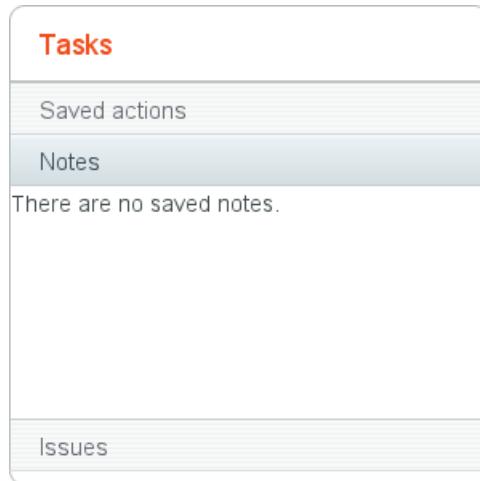
// A container for the Accordion.
Panel panel = new Panel("Tasks");
panel.setWidth("300px");
```

```
panel.setHeight("300px");
panel.setContent(accordion);

// Trim its layout to allow the Accordion take all space.
panel.getLayout().setSizeFull();
panel.getLayout().setMargin(false);
```

Figure 6.16, “An Accordion” shows what the example would look like with the default theme.

**Figure 6.16. An Accordion**



## CSS Style Rules

```
.v-accordion {}
.v-accordion-item {}
.v-accordion-item-open {}
.v-accordion-item-first {}
.v-accordion-item-caption {}
.v-accordion-item-caption .v-caption {}
.v-accordion-item-content {}
```

The top-level element of **Accordion** has the `v-accordion` style. An **Accordion** consists of a sequence of item elements, each of which has a `caption` element (the tab) and a content area element.

The selected item (tab) has also the `v-accordion-open` style. The content area is not shown for the closed items.

## 6.11. AbsoluteLayout

**AbsoluteLayout** allows placing components in arbitrary positions in the layout area. The positions are specified in the `addComponent()` method with horizontal and vertical coordinates relative to an edge of the layout area. The positions can include a third depth dimension, the `z-index`, which specifies which components are displayed in front and which behind other components.

The positions are specified by a CSS absolute position string, using the `left`, `right`, `top`, `bottom`, and `z-index` properties known from CSS. In the following example, we have a 300 by 150 pixels large layout and position a text field 50 pixels from both the left and the top edge:

```
// A 400x250 pixels size layout
AbsoluteLayout layout = new AbsoluteLayout();
layout.setWidth("400px");
layout.setHeight("250px");

// A component with coordinates for its top-left corner
TextField text = new TextField("Somewhere someplace");
layout.addComponent(text, "left: 50px; top: 50px");
```

The `left` and `top` specify the distance from the left and top edge, respectively. The `right` and `bottom` specify the distances from the right and bottom edge.

```
// At the top-left corner
Button button = new Button("left: 0px; top: 0px;");
layout.addComponent(button, "left: 0px; top: 0px");

// At the bottom-right corner
Button buttCorner = new Button("right: 0px; bottom: 0px;");
layout.addComponent(buttCorner, "right: 0px; bottom: 0px");

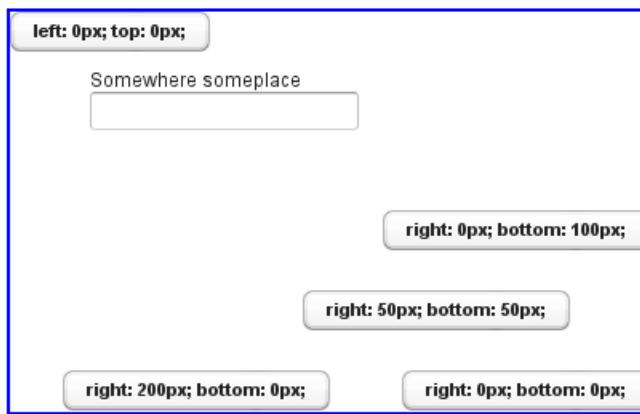
// Relative to the bottom-right corner
Button buttBrRelative = new Button("right: 50px; bottom: 50px;");
layout.addComponent(buttBrRelative, "right: 50px; bottom: 50px");

// On the bottom, relative to the left side
Button buttBottom = new Button("left: 50px; bottom: 0px;");
layout.addComponent(buttBottom, "left: 50px; bottom: 0px");

// On the right side, up from the bottom
Button buttRight = new Button("right: 0px; bottom: 100px");
layout.addComponent(buttRight, "right: 0px; bottom: 100px");
```

The result of the above code examples is shown in Figure 6.17, “Components Positioned Positioned Relative to Various Edges”.

### Figure 6.17. Components Positioned Relative to Various Edges

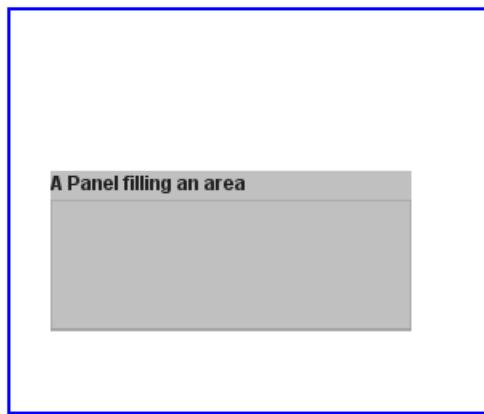


In the above examples, we had components of undefined size and specified the positions of components by a single pair of coordinates. The other possibility is to specify an area and let the component fill the area by specifying a proportional size for the component, such as "100%". Normally, you use `setSizeFull()` to take the entire area given by the layout.

```
// Specify an area that a component should fill
Panel panel = new Panel("A Panel filling an area");
panel.setSizeFull(); // Fill the entire given area
layout.addComponent(panel, "left: 25px; right: 50px; " +
    "top: 100px; bottom: 50px;");
```

The result is shown in Figure 6.18, “Component Filling an Area Specified by Coordinates”

**Figure 6.18. Component Filling an Area Specified by Coordinates**

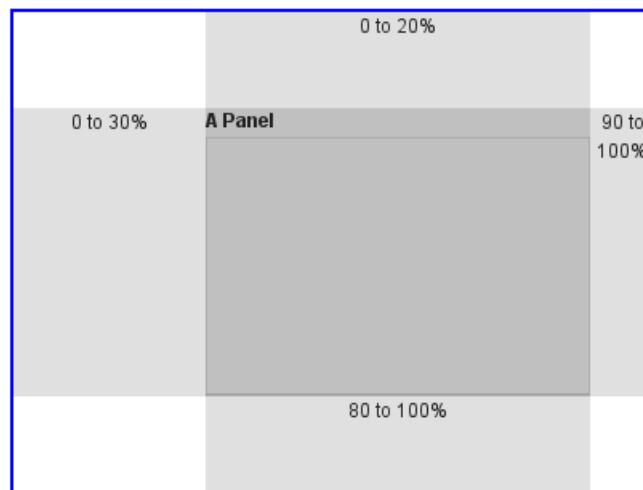


You can also use proportional coordinates to specify the coordinates:

```
// A panel that takes 30% to 90% horizontally and
// 20% to 80% vertically
Panel panel = new Panel("A Panel");
panel.setSizeFull(); // Fill the specified area
layout.addComponent(panel, "left: 30%; right: 10%;" +
    "top: 20%; bottom: 20%;");
```

The result is shown in Figure 6.19, “Specifying an Area by Proportional Coordinates”

**Figure 6.19. Specifying an Area by Proportional Coordinates**



Drag and drop is very useful for moving the components contained in an **AbsoluteLayout**. Check out the example in Section 11.12.6, “Dropping on a Component”.

## Styling with CSS

```
.v-absolutelayout {}  
.v-absolutelayout-wrapper {}
```

The **AbsoluteLayout** component has `v-absolutelayout` root style. Each component in the layout is contained within an element that has the `v-absolutelayout-wrapper`. The component captions are outside the wrapper elements, in a separate element with the usual `v-caption` style.

## 6.12. CssLayout

**CssLayout** allows strong control over styling of the components contained inside the layout. The components are contained in a simple DOM structure consisting of `<div>` elements. By default, the contained components are laid out horizontally and wrap naturally when they reach the width of the layout, but you can control this and most other behaviour with CSS. You can also inject custom CSS for each contained component. As **CssLayout** has a very simple DOM structure and no dynamic rendering logic, relying purely on the built-in rendering logic of the browsers, it is the fastest of the layout components.

The basic use of **CssLayout** is just like with any other layout component:

```
CssLayout layout = new CssLayout();  
  
// Component with a layout-managed caption and icon  
TextField tf = new TextField("A TextField");  
tf.setIcon(new ThemeResource("icons/user.png"));  
layout.addComponent(tf);  
  
// Labels are 100% wide by default so must unset width  
Label label = new Label("A Label");  
label.setWidth(Sizeable.SIZE_UNDEFINED, 0);  
layout.addComponent(label);  
  
layout.addComponent(new Button("A Button"));
```

The result is shown in Figure 6.20, “Basic Use of **CssLayout**”. Notice that the default spacing and alignment of the layout is quite crude and CSS styling is nearly always needed.

**Figure 6.20. Basic Use of CssLayout**



The `display` attribute of **CssLayout** is `inline-block` by default, so the components are laid out horizontally following another. **CssLayout** has 100% width by default. If the components reach the width of the layout, they are wrapped to the next "line" just as text would be. If you add a component with 100% width, it will take an entire line by wrapping before and after the component.

### 6.12.1. CSS Injection

Overriding the `getCss()` method allows injecting custom CSS for each component. The CSS returned by the method is inserted in the `style` attribute of the `<div>` element of the component, so it will override any style definitions made in CSS files.

```
CssLayout layout = new CssLayout() {
    @Override
    protected String getCss(Component c) {
        if (c instanceof Label) {
            // Color the boxes with random colors
            int rgb = (int) (Math.random()*(1<<24));
            return "background: #" + Integer.toHexString(rgb);
        }
        return null;
    }
}
layout.setWidth("400px"); // Causes to wrap the contents

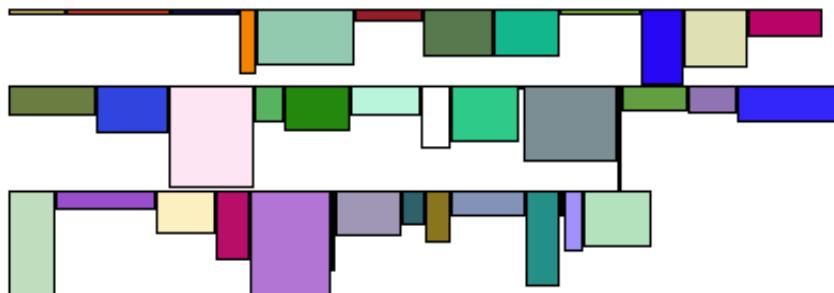
// Add boxes of various sizes
for (int i=0; i<40; i++) {
    Label box = new Label("&nbsp;", ContentMode.HTML);
    box.addStyleName("flowbox");
    box.setWidth((float) Math.random()*50,
                Sizeable.UNITS_PIXELS);
    box.setHeight((float) Math.random()*50,
                  Sizeable.UNITS_PIXELS);
    layout.addComponent(box);
}
```

The style name added to the components allows making common styling in a CSS file:

```
.v-label-flowbox {
    border: thin black solid;
}
```

Figure 6.21, “Use of `getCss()` and line wrap” shows the rendered result.

**Figure 6.21. Use of `getCss()` and line wrap**



## 6.12.2. Browser Compatibility

The strength of the **CssLayout** is also its weakness. Much of the logic behind the other layout components is there to give nice default behaviour and to handle the differences in different browsers. Some browsers, no need to say which, are notoriously incompatible with the CSS standards, so they require a lot of custom CSS. You may need to make use of the browser-specific style classes in the root element of the application. Some features in the other layouts are not even solvable in pure CSS, at least in all browsers.

## Styling with CSS

```
.v-csslayout {}
.v-csslayout-margin {}
.v-csslayout-container {}
```

The **CssLayout** component has `v-csslayout` root style. The margin element with `v-csslayout-margin` style is always enabled. The components are contained in an element with `v-csslayout-container` style.

For example, we could style the basic **CssLayout** example shown earlier as follows:

```
/* Have the caption right of the text box, bottom-aligned */
.csslayoutexample .mylayout .v-csslayout-container {
    direction: rtl;
    line-height: 24px;
    vertical-align: bottom;
}

/* Have some space before and after the caption */
.csslayoutexample .mylayout .v-csslayout-container .v-caption {
    padding-left: 3px;
    padding-right: 10px;
}
```

The example would now be rendered as shown in Figure 6.22, “Styling **CssLayout**”.

**Figure 6.22. Styling CssLayout**



Captions and icons that are managed by the layout are contained in an element with `v-caption` style. These caption elements are contained flat at the same level as the actual component elements. This may cause problems with wrapping in `inline-block` mode, as wrapping can occur between the caption and its corresponding component element just as well as between components. Such use case is therefore not feasible.

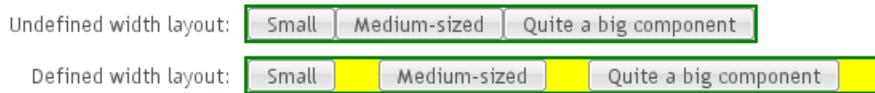
## 6.13. Layout Formatting

While the formatting of layouts is mainly done with style sheets, just as with other components, style sheets are not ideal or even possible to use in some situations. For example, CSS does not allow defining the spacing of table cells, which is done with the `cellspacing` attribute in HTML.

Moreover, as many layout sizes are calculated dynamically in the Client-Side Engine of Vaadin, some CSS settings can fail altogether.

### 6.13.1. Layout Size

The size of a layout component can be specified with the `setWidth()` and `setHeight()` methods defined in the **Sizeable** interface, just like for any component. It can also be undefined, in which case the layout shrinks to fit the component(s) inside it. Section 5.3.9, “Sizing Components” gives details on the interface.

**Figure 6.23. HorizontalLayout with Undefined vs Defined size**

Many layout components take 100% width by default, while they have the height undefined.

The sizes of components inside a layout can also be defined as a percentage of the space available in the layout, for example with `setWidth("100%")`; or with the (most commonly used method) `setSizeFull()` that sets 100% size in both directions. If you use a percentage in a **HorizontalLayout**, **VerticalLayout**, or **GridLayout**, you will also have to set the component as *expanding*, as noted below.



### Warning

*A layout that contains components with percentual size must have a defined size!*

If a layout has undefined size and a contained component has, say, 100% size, the component will try to fill the space given by the layout, while the layout will shrink to fit the space taken by the component, which is a paradox. This requirement holds for height and width separately. The debug mode allows detecting such invalid cases; see Section 11.3.5, “Inspecting Component Hierarchy”.

For example:

```
// This takes 100% width but has undefined height.
VerticalLayout layout = new VerticalLayout();

// A button that takes all the space available in the layout.
Button button = new Button("100%x100% button");
button.setSizeFull();
layout.addComponent(button);

// We must set the layout to a defined height vertically, in
// this case 100% of its parent layout, which also must
// not have undefined size.
layout.setHeight("100%");
```

If you have a layout with undefined height, such as **VerticalLayout**, in a **UI**, **Window**, or **Panel**, and put enough content in it so that it extends outside the bottom of the view area, scrollbars will appear. If you want your application to use all the browser view, nothing more or less, you should use `setSizeFull()` for the root layout.

```
// Create the UI content
VerticalLayout content = new VerticalLayout();

// Use entire view area
content.setSizeFull();

setContent(content);
```

## 6.13.2. Expanding Components

If you set a **HorizontalLayout** to a defined size horizontally or a **VerticalLayout** vertically, and there is space left over from the contained components, the extra space is distributed equally

between the component cells. The components are aligned within these cells, according to their alignment setting, top left by default, as in the example below.



Often, you don't want such empty space, but want one or more components to take all the leftover space. You need to set such a component to 100% size and use `setExpandRatio()`. If there is just one such expanding component in the layout, the ratio parameter is irrelevant.



If you set multiple components as expanding, the expand ratio dictates how large proportion of the available space (overall or excess depending on whether the components are sized as a percentage or not) each component takes. In the example below, the buttons have 1:2:3 ratio for the expansion.



**GridLayout** has corresponding method for both of its directions, `setRowExpandRatio()` and `setColumnExpandRatio()`.

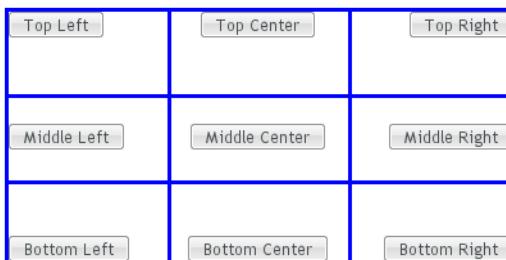
Expansion is dealt in detail in the documentation of the layout components that support it. See Section 6.3, “**VerticalLayout** and **HorizontalLayout**” and Section 6.4, “**GridLayout**” for details on components with relative sizes.

### 6.13.3. Layout Cell Alignment

You can set the alignment of the component inside a specific layout cell with the `setComponentAlignment()` method. The method takes as its parameters the component contained in the cell to be formatted, and the horizontal and vertical alignment.

Figure 6.24, “Cell Alignments” illustrates the alignment of components within a **GridLayout**.

**Figure 6.24. Cell Alignments**



The easiest way to set alignments is to use the constants defined in the **Alignment** class. Let us look how the buttons in the top row of the above **GridLayout** are aligned with constants:

```
// Create a grid layout
final GridLayout grid = new GridLayout(3, 3);

grid.setWidth(400, Sizeable.UNITS_PIXELS);
grid.setHeight(200, Sizeable.UNITS_PIXELS);

Button topleft = new Button("Top Left");
grid.addComponent(topleft, 0, 0);
grid.setComponentAlignment(topleft, Alignment.TOP_LEFT);
```

```

Button topcenter = new Button("Top Center");
grid.addComponent(topcenter, 1, 0);
grid.setComponentAlignment(topcenter, Alignment.TOP_CENTER);

Button topright = new Button("Top Right");
grid.addComponent(topright, 2, 0);
grid.setComponentAlignment(topright, Alignment.TOP_RIGHT);
...

```

The following table lists all the **Alignment** constants by their respective locations:

**Table 6.1. Alignment Constants**

<i>TOP_LEFT</i>	<i>TOP_CENTER</i>	<i>TOP_RIGHT</i>
<i>MIDDLE_LEFT</i>	<i>MIDDLE_CENTER</i>	<i>MIDDLE_RIGHT</i>
<i>BOTTOM_LEFT</i>	<i>BOTTOM_CENTER</i>	<i>BOTTOM_RIGHT</i>

Another way to specify the alignments is to create an **Alignment** object and specify the horizontal and vertical alignment with separate constants. You can specify either of the directions, in which case the other alignment direction is not modified, or both with a bitmask operation between the two directions.

```

Button middleleft = new Button("Middle Left");
grid.addComponent(middleleft, 0, 1);
grid.setComponentAlignment(middleleft,
    new Alignment(Bits.ALIGNMENT_VERTICAL_CENTER |
        Bits.ALIGNMENT_LEFT));

Button middlecenter = new Button("Middle Center");
grid.addComponent(middlecenter, 1, 1);
grid.setComponentAlignment(middlecenter,
    new Alignment(Bits.ALIGNMENT_VERTICAL_CENTER |
        Bits.ALIGNMENT_HORIZONTAL_CENTER));

Button middleright = new Button("Middle Right");
grid.addComponent(middleright, 2, 1);
grid.setComponentAlignment(middleright,
    new Alignment(Bits.ALIGNMENT_VERTICAL_CENTER |
        Bits.ALIGNMENT_RIGHT));

```

Obviously, you may combine only one vertical bitmask with one horizontal bitmask, though you may leave either one out. The following table lists the available alignment bitmask constants:

**Table 6.2. Alignment Bitmasks**

Horizontal	<i>Bits.ALIGNMENT_LEFT</i>
	<i>Bits.ALIGNMENT_HORIZONTAL_CENTER</i>
	<i>Bits.ALIGNMENT_RIGHT</i>
Vertical	<i>Bits.ALIGNMENT_TOP</i>
	<i>Bits.ALIGNMENT_VERTICAL_CENTER</i>
	<i>Bits.ALIGNMENT_BOTTOM</i>

You can determine the current alignment of a component with `getComponentAlignment()`, which returns an **Alignment** object. The class provides a number of getter methods for decoding the alignment, which you can also get as a bitmask value.

## Size of Aligned Components

You can only align a component that is smaller than its containing cell in the direction of alignment. If a component has 100% width, as many components have by default, horizontal alignment does not have any effect. For example, **Label** is 100% wide by default and can not therefore be horizontally aligned as such. The problem can be hard to notice, as the text inside a **Label** is left-aligned.

You usually need to set either a fixed size, undefined size, or less than a 100% relative size for the component to be aligned - a size that is smaller than the containing layout has.

For example, assuming that a **Label** has short content that is less wide than the containing **VerticalLayout**, you could center it as follows:

```
VerticalLayout layout = new VerticalLayout(); // 100% default width
Label label = new Label("Hello"); // 100% default width
label.setSizeUndefined();
layout.addComponent(label);
layout.setComponentAlignment(label, Alignment.MIDDLE_CENTER);
```

If you set the size as undefined and the component itself contains components, make sure that the contained components also have either undefined or fixed size. For example, if you set the size of a **Form** as undefined, its containing layout **FormLayout** has 100% default width, which you also need to set as undefined. But then, any components inside the **FormLayout** must have either undefined or fixed size.

### 6.13.4. Layout Cell Spacing

The **VerticalLayout**, **HorizontalLayout**, and **GridLayout** layouts offer a `setSpacing()` method to enable spacing between the cells of the layout.

For example:

```
VerticalLayout layout = new VerticalLayout();
layout.setSpacing(true);
layout.addComponent(new Button("Component 1"));
layout.addComponent(new Button("Component 2"));
layout.addComponent(new Button("Component 3"));
```

The effect of spacing in **VerticalLayout** and **HorizontalLayout** is illustrated in Figure 6.25, “Layout Spacings”.

**Figure 6.25. Layout Spacings**

		No spacing:	Vertical spacing:
No spacing:	Component 1   Component 2   Component 3	Component 1 Component 2 Component 3	Component 1 Component 2 Component 3
Horizontal spacing:	Component 1        Component 2        Component 3		Component 1 Component 2 Component 3

The exact amount of spacing is defined in CSS. If the default is not suitable, you can customize it in a custom theme.

In the Valo theme, you can specify the spacing with the `$v-layout-spacing-vertical` and `$v-layout-spacing-horizontal` parameters, as described in Section 7.6.2, “Common Settings”. The spacing defaults to the `$v-unit-size` measure.

When adjusting spacing in other themes, you should note that it is implemented in a bit different ways in different layouts. In the ordered layouts, it is done with spacer elements, while in the **GridLayout** it has special handling. Please see the sections on the individual components for more details.

### 6.13.5. Layout Margins

Most layout components do not have any margin around them by default. The ordered layouts, as well as **GridLayout**, support enabling a margin with `setMargin()`. This enables CSS classes for each margin in the HTML element of the layout component.

In the Valo theme, the margin sizes default to `$v-unit-size`. You can customize them with `$v-layout-margin-top`, `right`, `bottom`, and `left`. See Section 7.6.2, “Common Settings” for a description of the parameters.

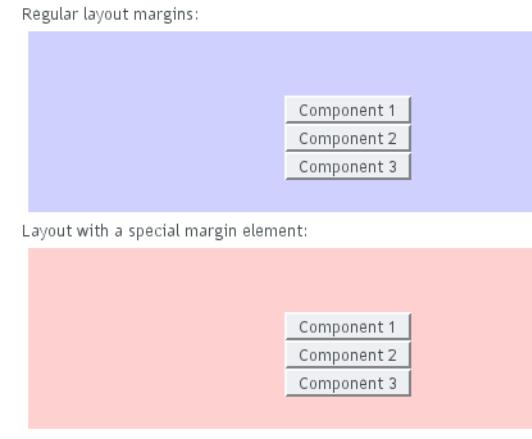
To customize the default margins in other themes, you can define each margin with the `padding` property in CSS. You may want to have a custom CSS class for the layout component to enable specific customization of the margins, as is done in the following with the `mymargins` class:

```
.mymargins.v-margin-left {padding-left: 10px;}  
.mymargins.v-margin-right {padding-right: 20px;}  
.mymargins.v-margin-top {padding-top: 40px;}  
.mymargins.v-margin-bottom {padding-bottom: 80px;}
```

You can enable only specific margins by passing a **MarginInfo** to the `setMargin()`. The margins are specified in clockwise order for top, right, bottom, and left margin. The following would enable the left and right margins:

```
layout.setMargin(new MarginInfo(false, true, false, true));
```

The resulting margins are shown in Figure 6.26, “Layout Margins” below. The two ways produce identical margins.

**Figure 6.26. Layout Margins**

## 6.14. Custom Layouts

While it is possible to create almost any typical layout with the standard layout components, it is sometimes best to separate the layout completely from code. With the **CustomLayout** component, you can write your layout as a template in HTML that provides locations of any contained components. The layout template is included in a theme. This separation allows the layout to be designed separately from code, for example using WYSIWYG web designer tools such as Adobe Dreamweaver.

A template is a HTML file located under `layouts` folder under a theme folder under the `WebContent/VAADIN/themes/` folder, for example, `WebContent/VAADIN/themes/themename/layouts/mylayout.html`. (Notice that the root path `WebContent/VAADIN/themes/` for themes is fixed.) A template can also be provided dynamically from an **InputStream**, as explained below. A template includes `<div>` elements with a *location* attribute that defines the location identifier. All custom layout HTML-files must be saved using UTF-8 character encoding.

```

<table width="100%" height="100%">
  <tr height="100%">
    <td>
      <table align="center">
        <tr>
          <td align="right">User&nbsp;name:</td>
          <td><div location="username"></div></td>
        </tr>
        <tr>
          <td align="right">Password:</td>
          <td><div location="password"></div></td>
        </tr>
      </table>
    </td>
  </tr>
  <tr>
    <td align="right" colspan="2">
      <div location="okbutton"></div>
    </td>
  </tr>
</table>

```

The client-side engine of Vaadin will replace contents of the location elements with the components. The components are bound to the location elements by the location identifier given to `addComponent()`, as shown in the example below.

```
// Have a Panel where to put the custom layout.  
Panel panel = new Panel("Login");  
panel.setSizeUndefined();  
main.addComponent(panel);  
  
// Create custom layout from "layoutname.html" template.  
CustomLayout custom = new CustomLayout("layoutname");  
custom.addStyleName("customlayoutexample");  
  
// Use it as the layout of the Panel.  
panel.setContent(custom);  
  
// Create a few components and bind them to the location tags  
// in the custom layout.  
TextField username = new TextField();  
custom.addComponent(username, "username");  
  
TextField password = new TextField();  
custom.addComponent(password, "password");  
  
Button ok = new Button("Login");  
custom.addComponent(ok, "okbutton");
```

The resulting layout is shown below in Figure 6.27, “Example of a Custom Layout Component”.

**Figure 6.27. Example of a Custom Layout Component**



You can use `addComponent()` also to replace an existing component in the location given in the second parameter.

In addition to a static template file, you can provide a template dynamically with the **CustomLayout** constructor that accepts an **InputStream** as the template source. For example:

```
new CustomLayout(new ByteArrayInputStream("<b>Template</b>".getBytes()));
```

or

```
new CustomLayout(new FileInputStream(file));
```



---

# Chapter 7

# Themes

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This chapter provides details about using and creating *themes* that control the visual look of web applications. Themes are created using Sass, which is an extension of CSS (Cascading Style Sheets), or with plain CSS. We provide an introduction to CSS, especially concerning the styling of HTML by element classes.

## 7.1. Overview

Vaadin separates the appearance of the user interface from its logic using *themes*. Themes can include Sass or CSS style sheets, custom HTML layouts, and any necessary graphics. Theme resources can also be accessed from application code as **ThemeResource** objects.

Custom themes are placed under the VAADIN/themes/ folder of the web application (under WebContent in Eclipse or src/main/webapp in Maven projects). This location is fixed -- the VAADIN folder contains static resources that are served by the Vaadin servlet. The servlet augments the files stored in the folder by resources found from corresponding VAADIN folders contained in JARs in the class path. For example, the built-in themes are stored in the vaadin-themes.jar.

Figure 7.1, “Contents of a Theme” illustrates the contents of a theme.

## Figure 7.1. Contents of a Theme



The name of a theme folder defines the name of the theme. The name is used in the `@Theme` annotation that sets the theme. A theme must contain either a `styles.scss` for Sass themes, or `styles.css` stylesheet for plain CSS themes, but other contents have free naming. We recommend that you have the actual theme content in a SCSS file named after the theme, such as `mytheme.scss`, to make the names more unique.

We also suggest a convention for naming the folders as `img` for images, `layouts` for custom layouts, and `css` for additional stylesheets.

Custom themes need to extend a base theme, as described in Section 7.4, “Creating and Using Themes”. Copying and modifying an existing theme is also possible, but it is not recommended, as it may need more work to maintain if the modifications are small.

You use a theme by specifying it with the `@Theme` annotation for the UI class of the application as follows:

```

@Theme( "mytheme" )
public class MyUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        ...
    }
}
  
```

A theme can contain alternate styles for user interface components, which can be changed as needed.

In addition to style sheets, a theme can contain HTML templates for custom layouts used with `CustomLayout`. See Section 6.14, “Custom Layouts” for details.

Resources provided in a theme can also be accessed using the **ThemeResource** class, as described in Section 4.4.4, “Theme Resources”. This allows displaying theme resources in component icons, in the **Image** component, and other such uses.

## 7.2. Introduction to Cascading Style Sheets

Cascading Style Sheets or CSS is the basic technique to separate the appearance of a web page from the content represented in HTML. In this section, we give an introduction to CSS and look how they are relevant to software development with Vaadin.

### CSS Information Sources

As we can only give a short instruction in this book, we encourage you to refer to the rich literature on CSS and the many resources available in the web. You can find the authoritative specifications of CSS standards from the W3C website and other literature, references, and tutorials from the Open Directory Project page on CSS, as well as from other sources.

#### 7.2.1. Applying CSS to HTML

Let us consider the following HTML document that contains various markup elements for formatting text. Vaadin UIs work in essentially similar documents, even though they use somewhat different elements to draw the user interface.

```
<html>
  <head>
    <title>My Page</title>
    <link rel="stylesheet" type="text/css"
          href="mystylesheet.css" />
  </head>
  <body>
    <p>This is a paragraph</p>
    <p>This is another paragraph</p>
    <table>
      <tr>
        <td>This is a table cell</td>
        <td>This is another table cell</td>
      </tr>
    </table>
  </body>
</html>
```

The HTML elements that will be styled later by matching CSS rules are emphasized above.

The `<link>` element in the HTML header defines the used CSS stylesheet. The definition is automatically generated by Vaadin in the HTML page that loads the UI of the application. A stylesheet can also be embedded in the HTML document itself, as is done when optimizing their loading in Vaadin TouchKit, for example.

#### 7.2.2. Basic CSS Rules

A stylesheet contains a set of *rules* that can match the HTML elements in the page. Each rule consists of one or more *selectors*, separated with commas, and a *declaration block* enclosed in curly braces. A declaration block contains a list of *property* statements. Each property has a label and a value, separated with a colon. A property statement ends with a semicolon.

Let us look at an example that matches certain elements in the simple HTML document given in the previous section:

```
p, td {  
    color: blue;  
}  
  
td {  
    background: yellow;  
    font-weight: bold;  
}
```

The `p` and `td` are element type selectors that match with `<p>` and `<td>` elements in HTML, respectively. The first rule matches with both elements, while the second matches only with `<td>` elements. Let us assume that you have saved the above style sheet with the name `mystylesheet.css` and consider the following HTML file located in the same folder.

## Figure 7.2. Simple Styling by Element Type

This is a paragraph.  
This is another paragraph.  

This is a table cell	This is another table cell
----------------------	----------------------------

## Style Inheritance in CSS

CSS has *inheritance* where contained elements inherit the properties of their parent elements. For example, let us change the above example and define it instead as follows:

```
table {  
    color: blue;  
    background: yellow;  
}
```

All elements contained in the `<table>` element would have the same properties. For example, the text in the contained `<td>` elements would be in blue color.

## HTML Element Types

HTML has a number of element types, each of which accepts a specific set of properties. The `<div>` elements are generic elements that can be used to create almost any layout and formatting that can be created with a specific HTML element type. Vaadin uses `<div>` elements extensively to draw the UI, especially in layout components.

Matching elements by their type as shown above is, however, rarely if ever used in style sheets for Vaadin applications. We used it above, because it is the normal way in regular HTML documents that use the various HTML elements for formatting text, but it is not applicable in Vaadin UIs that consist mostly of `<div>` elements. Instead, you need to match by element class, as described next.

### 7.2.3. Matching by Element Class

Matching HTML elements by the `class` attribute is the most common form of matching in Vaadin stylesheets. It is also possible to match with the `identifier` of a unique HTML element.

The class of an HTML element is defined with the `class` attribute as follows:

```
<html>
  <body>
    <p class="normal">This is the first paragraph</p>

    <p class="another">This is the second paragraph</p>

    <table>
      <tr>
        <td class="normal">This is a table cell</td>
        <td class="another">This is another table cell</td>
      </tr>
    </table>
  </body>
</html>
```

The class attributes of HTML elements can be matched in CSS rules with a selector notation where the class name is written after a period following the element name. This gives us full control of matching elements by their type and class.

```
p.normal {color: red;}
p.another {color: blue;}
td.normal {background: pink;}
td.another {background: yellow;}
```

The page would look as shown below:

**Figure 7.3. Matching HTML Element Type and Class**

This is a paragraph with "normal" class

This is a paragraph with "another" class

This is a table cell with "normal" class This is a table cell with "another" class

We can also match solely by the class by using the universal selector `*` for the element name, for example `*.normal`. The universal selector can also be left out altogether so that we use just the class name following the period, for example `.normal`.

```
.normal {
  color: red;
}

.another {
  background: yellow;
}
```

In this case, the rule will match with all elements of the same class regardless of the element type. The result is shown in Figure 7.4, “Matching Only HTML Element Class”. This example illustrates a technique to make style sheets compatible regardless of the exact HTML element used in drawing a component.

#### Figure 7.4. Matching Only HTML Element Class

```
This is a paragraph with "normal" class
This is a paragraph with "another" class
This is a table cell with "normal" class This is a table cell with "another" class
```

To ensure future compatibility, we recommend that you use only matching based on the classes and *do not* match for specific HTML element types in CSS rules, because Vaadin may change the exact HTML implementation how components are drawn in the future. For example, Vaadin earlier used `<div>` element to draw **Button** components, but later it was changed to use the special-purpose `<button>` element in HTML. Because of using the `v-button` style class in the CSS rules for the button, styling it has changed only very little.

#### 7.2.4. Matching by Descendant Relationship

CSS allows matching HTML by their containment relationship. For example, consider the following HTML fragment:

```
<body>
  <p class="mytext">Here is some text inside a
    paragraph element</p>
  <table class="mytable">
    <tr>
      <td class="mytext">Here is text inside
        a table and inside a td element.</td>
    </tr>
  </table>
</body>
```

Matching by the class name `.mytext` alone would match both the `<p>` and `<td>` elements. If we want to match only the table cell, we could use the following selector:

```
.mytable .mytext {color: blue;}
```

To match, a class listed in a rule does not have to be an immediate descendant of the previous class, but just a descendant. For example, the selector `".v-panel .v-button"` would match all elements with class `.v-button` somewhere inside an element with class `.v-panel`.

#### 7.2.5. Importance of Cascading

CSS or Cascading Stylesheets are, as the name implies, about *cascading* stylesheets, which means applying the stylesheet rules according to their origin, importance, scope, specificity, and order.

For exact rules for cascading in CSS, see the section Cascading in the CSS specification.

#### Importance

Declarations in CSS rules can be made override declarations with otherwise higher priority by annotating them as `!important`. For example, an inline style setting made in the `style` attribute of an HTML element has a higher specificity than any rule in a CSS stylesheet.

```
<div class="v-button" style="height: 20px;">...
```

You can override the higher specificity with the `!important` annotation as follows:

```
.v-button {height: 30px !important;}
```

## Specificity

A rule that specifies an element with selectors more closely overrides ones that specify it less specifically. With respect to the element class selectors most commonly used in Vaadin themes, the specificity is determined by the number of class selectors in the selector.

```
.v-button {}  
.v-verticallayout .v-button {}  
.v-app .v-verticallayout .v-button {}
```

In the above example, the last rule would have the highest specificity and would match.

As noted earlier, style declarations given in the style attribute of a HTML element have higher specificity than declarations in a CSS rule, except if the `!important` annotation is given.

See the CSS3 selectors module specification for details regarding how the specificity is computed.

## Order

CSS rules given later have higher priority than ones given earlier. For example, in the following, the latter rule overrides the former and the color will be black:

```
.v-button {color: white}  
.v-button {color: black}
```

As specificity has a higher cascading priority than order, you could make the first rule have higher priority by adding specificity as follows:

```
.v-app .v-button {color: white}  
.v-button {color: black}
```

The order is important to notice in certain cases, because Vaadin does not guarantee the order in which CSS stylesheets are loaded in the browser, which can in fact be random and result in very unexpected behavior. This is not relevant for Sass stylesheets, which are compiled to a single stylesheet. For plain CSS stylesheets, such as add-on or TouchKit stylesheets, the order can be relevant.

### 7.2.6. Style Class Hierarchy of a Vaadin UI

Let us give a real case in a Vaadin UI by considering a simple Vaadin UI with a label and a button inside a vertical layout:

```
// UI has v-ui style class  
@Theme("mytheme")  
public class HelloWorld extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        // VerticalLayout has v-verticallayout style  
        VerticalLayout content = new VerticalLayout();  
        setContent(content);  
  
        // Label has v-label style  
        content.addComponent(new Label("Hello World!"));  
  
        // Button has v-button style  
        content.addComponent(new Button("Push Me!"),
```

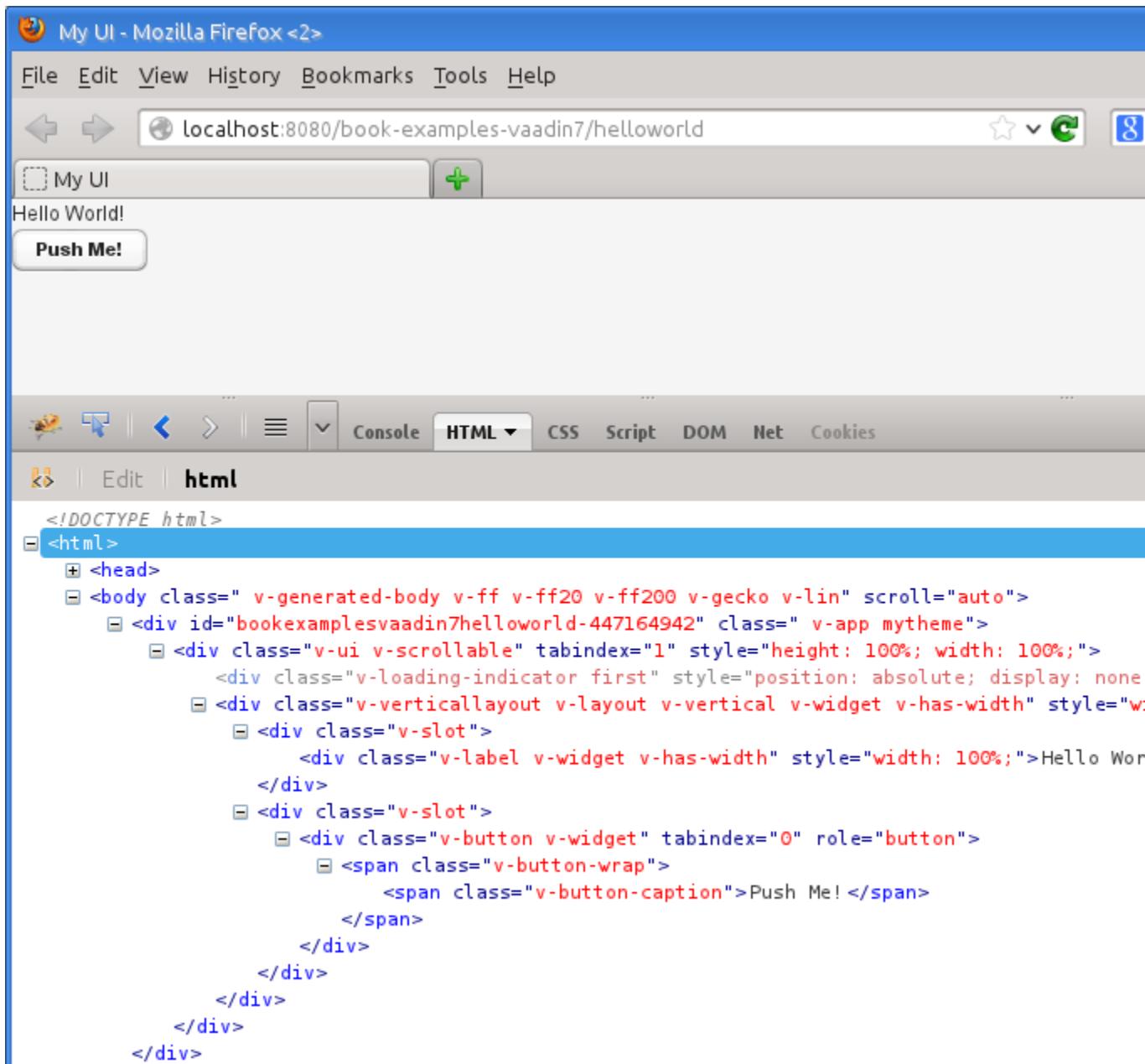
```

        new Button.ClickListener() {
            @Override
            public void buttonClick(ClickEvent event) {
                Notification.show("Pushed!");
            }
        });
    }
}

```

The UI will look by default as shown in Figure 7.5, “An Unthemed Vaadin UI”. By using a HTML inspector such as Firebug, you can view the HTML tree and the element classes and applied styles for each element.

**Figure 7.5. An Unthemed Vaadin UI**



Now, let us look at the HTML element class structure of the UI, as we can see it in the HTML inspector:

```
<body class="v-generated-body v-ff v-ff20 v-ff200 v-gecko v-lin"
      scroll="auto">
<div id="bookexamplesvaadin7helloworld-447164942"
      class="v-app mytheme">
<div class="v-ui v-scrollable"
      tabindex="1" style="height: 100%; width: 100%;">
<div class="v-loading-indicator first"
      style="position: absolute; display: none;"></div>
<div class="v-verticallayout v-layout v-vertical
v-widget v-has-width"
      style="width: 100%;">
<div class="v-slot">
<div class="v-label v-widget v-has-width"
      style="width: 100%;">Hello World!</div>
</div>
<div class="v-slot">
<div class="v-button v-widget"
      tabindex="0" role="button">
<span class="v-button-wrap">
<span class="v-button-caption">Push Me!</span>
</span>
</div>
</div>
</div>
</div>
...
</body>
```

Now, consider the following theme where we set the colors and margins of various elements. The theme is actually a Sass theme.

```
@import "../reindeer/reindeer.scss";

@mixin mytheme {
  @include reindeer;

  /* White background for the entire UI */
  .v-ui {
    background: white;
  }

  /* All labels have white text on black background */
  .v-label {
    background: black;
    color: white;
    font-size: 24pt;
    line-height: 24pt;
    padding: 5px;
  }

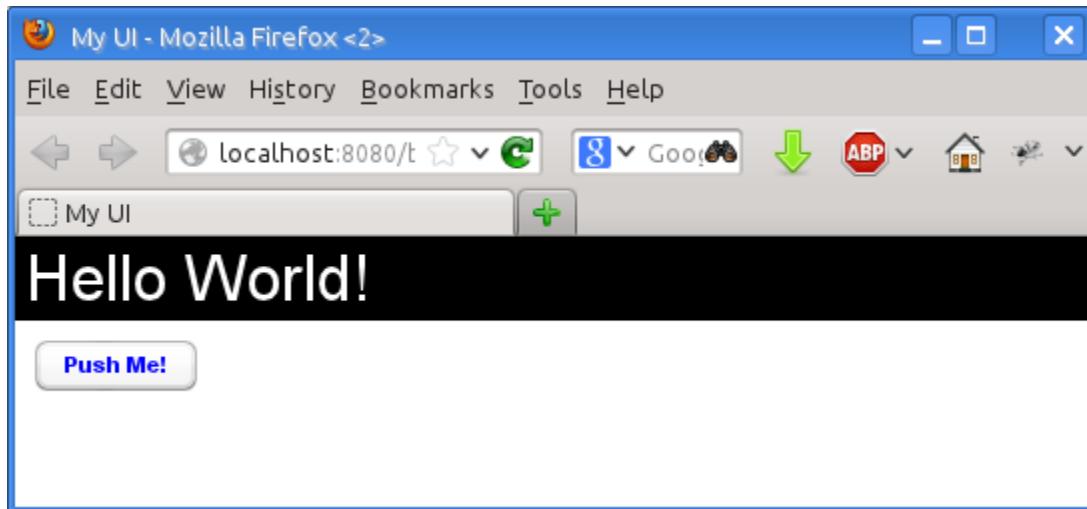
  /* All buttons have blue caption and some margin */
  .v-button {
    margin: 10px;

    /* A nested selector to increase specificity */
  }
}
```

```
.v-button-caption {
    color: blue;
}
}
```

The look has changed as shown in Figure 7.6, “Themed Vaadin UI”.

**Figure 7.6. Themed Vaadin UI**



An element can have multiple classes separated with a space. With multiple classes, a CSS rule matches an element if any of the classes match. This feature is used in many Vaadin components to allow matching based on the state of the component. For example, when the mouse is over a **Link** component, `over` class is added to the component. Most of such styling is a feature of Google Web Toolkit.

### 7.2.7. Notes on Compatibility

CSS is a standard continuously under development. It was first proposed in 1994. The specification of CSS is maintained by the CSS Working Group of World Wide Web Consortium (W3C). Versioned with backward-compatible "levels", CSS Level 1 was published in 1996, Level 2 in 1998, and the ongoing development of CSS Level 3 started in 1998. CSS3 is divided into a number of separate modules, each developed and progressing separately, and many of the modules are already Level 4.

While the support for CSS has been universal in all graphical web browsers since at least 1995, the support has been very incomplete at times and there still exists an unfortunate number of incompatibilities between browsers. While we have tried to take these incompatibilities into account in the built-in themes in Vaadin, you need to consider them while developing your own themes. Compatibility issues are detailed in various CSS handbooks.

## 7.3. Syntactically Awesome Stylesheets (Sass)

Vaadin uses Sass for stylesheets. Sass is an extension of CSS3 that adds nested rules, variables, mixins, selector inheritance, and other features to CSS. Sass supports two formats for stylesheet: Vaadin themes are written in SCSS (`.scss`), which is a superset of CSS3, but Sass also allows a more concise indented format (`.sass`).

Sass can be used in two basic ways in Vaadin applications, either by compiling SCSS files to CSS or by doing the compilation on the fly. The latter way is possible if the development mode is enabled for the Vaadin servlet, as described in Section 4.8.6, “Other Servlet Configuration Parameters”.

### 7.3.1. Sass Overview

#### Variables

Sass allows defining variables that can be used in the rules.

```
$textcolor: blue;

.v-button-caption {
  color: $textcolor;
}
```

The above rule would be compiled to CSS as:

```
.v-button-caption {
  color: blue;
}
```

Also mixins can have variables as parameters, as explained later.

#### Nesting

Sass supports nested rules, which are compiled into inside-selectors. For example:

```
.v-app {
  background: yellow;

  .mybutton {
    font-style: italic;

    .v-button-caption {
      color: blue;
    }
  }
}
```

is compiled as:

```
.v-app {
  background: yellow;
}

.v-app .mybutton {
  font-style: italic;
}

.v-app .mybutton .v-button-caption {
  color: blue;
}
```

## Mixins

Mixins are rules that can be included in other rules. You define a mixin rule by prefixing it with the `@mixin` keyword and the name of the mixin. You can then use `@include` to apply it to another rule. You can also pass parameters to it, which are handled as local variables in the mixin.

For example:

```
@mixin my mixin {
    background: yellow;
}

@mixin other mixin($param) {
    margin: $param;
}

.v-button-caption {
    @include my mixin;
    @include other mixin(10px);
}
```

The above SCSS would translated to the following CSS:

```
.v-button-caption {
    background: yellow;
    margin: 10px;
}
```

You can also have nested rules in a mixin, which makes them especially powerful. Mixing in rules is used when extending Vaadin themes, as described in Section 7.4.1, “Sass Themes”.

Vaadin themes are defined as mixins to allow for certain uses, such as different themes for different portlets in a portal.

### 7.3.2. Sass Basics with Vaadin

We are not going to give in-depth documentation of Sass and refer you to its excellent documentation at <http://sass-lang.com/>. In the following, we give just basic introduction to using it with Vaadin.

You can create a new Sass-based theme with the Eclipse plugin, as described in Section 7.5, “Creating a Theme in Eclipse”.

### 7.3.3. Compiling Sass Themes

#### Compiling On the Fly

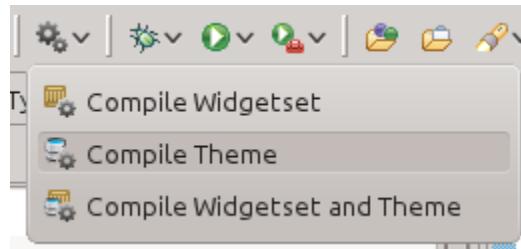
The easiest way to use Sass themes is to let the Vaadin servlet compile them on the run. In this case, the SCSS source files are placed in the theme folder. Compilation is done each time the `styles.css` is requested from the server.

The on-the-fly compilation takes a bit time, so it is only available when the Vaadin servlet is in the development mode, as described in Section 4.8.6, “Other Servlet Configuration Parameters”. Also, it requires the theme compiler and all its dependencies to be in the class path of the servlet. For production, you should compile the theme to CSS, as described next.

## Compiling in Eclipse

If using Eclipse and the Vaadin Plugin for Eclipse, its project wizard creates a Sass theme. It includes **Compile Theme** command in the toolbar to compile the project theme to CSS. Another command compiles also the widget set.

**Figure 7.7. Compiling Sass Theme**



The WebContent/VAADIN/mytheme/styles.scss and any Sass sources included by it are compiled to styles.css.

## Compiling with Maven

To compile the themes with Maven, you need to include the built-in themes as a dependency:

```
...
<dependencies>
  ...
  <dependency>
    <groupId>com.vaadin</groupId>
    <artifactId>vaadin-themes</artifactId>
    <version>${vaadin.version}</version>
  </dependency>
</dependencies>
...
```

This is automatically included at least in the `vaadin-archetype-application` archetype for Vaadin applications. The actual theme compilation is most conveniently done by the Vaadin Maven Plugin with `update-theme` and `compile-theme` goals.

```
...
<plugin>
  <groupId>com.vaadin</groupId>
  <artifactId>vaadin-maven-plugin</artifactId>
  ...
  <executions>
    <execution>
      ...
      <goals>
        <goal>clean</goal>
        <goal>resources</goal>
        <goal>update-theme</goal>
        <goal>update-widgetset</goal>
        <goal>compile-theme</goal>
        <goal>compile</goal>
      </goals>
    </execution>
  </executions>
</plugin>
```

Once these are in place, the theme is compiled as part of relevant lifecycle phases, such as package.

```
mvn package
```

You can also compile just the theme with the compile-theme goal:

```
mvn vaadin:compile-theme
```

## Compiling in Command-line

You can compile Sass style sheets to CSS either with the Vaadin Sass compiler or the standard one. The `styles.css` of a custom theme should be the compilation target. When compiled before deployment, the source files do not need to be in the theme folder.

You can run the Vaadin Sass compiler in a theme folder as follows:

```
java -cp '../../../../../WEB-INF/lib/*' com.vaadin.sass.SassCompiler styles.scss  
styles.css
```

The `-cp` parameter should point to the class path where the Vaadin Sass Compiler and theme JARs are located. In the above example, they are assumed to be located in the `WEB-INF/lib` folder of the web application. If you have loaded the Vaadin libraries using Ivy, as is the case with projects created with the Vaadin Plugin for Eclipse, the Vaadin libraries are stored in Ivy's local repository. Its folder hierarchy is somewhat scattered, so we recommend that you retrieve the libraries to a single folder. We recommend using an Ant script as is described next.

## Compiling with Ant

With Apache Ant, you can easily resolve the dependencies with Ivy and compile the theme with the Theme Compiler included in Vaadin as follows. This build step can be conveniently included in a WAR build script.

Start with the following configuration:

```
<project xmlns:ivy="antlib:org.apache.ivy.ant"  
        name="My Project" basedir="../"  
        default="package-war">  
  
    <target name="configure">  
        <!-- Where project source files are located -->  
        <property name="src-location" value="src" />  
  
        ... other project build definitions ...  
  
        <!-- Name of the theme -->  
        <property name="theme" value="book-examples"/>  
  
        <!-- Compilation result directory -->  
        <property name="result" value="build/result"/>  
    </target>  
  
    <!-- Initialize build -->  
    <target name="init" depends="configure">  
        <!-- Construct and check classpath -->  
        <path id="compile.classpath">  
            <!-- Source code to be compiled -->  
            <pathelement path="${src-location}" />
```

```
<!-- Vaadin libraries and dependencies -->
<fileset dir="${result}/lib">
    <include name="*.jar"/>
</fileset>
</path>

<mkdir dir="${result}"/>
</target>
```

You should first resolve all Vaadin libraries to a single directory, which you can use for deployment, but also for theme compilation.

```
<target name="resolve" depends="init">
    <ivy:retrieve
        pattern="${result}/lib/[module]-[type]-[artifact]-[revision].[ext]" />
</target>
```

Then, you can compile the theme as follows:

```
<!-- Compile theme -->
<target name="compile-theme"
    depends="init, resolve">
    <delete dir="${result}/VAADIN/themes/${theme}" />
    <mkdir dir="${result}/VAADIN/themes/${theme}" />

    <java classname="com.vaadin.sass.SassCompiler"
        fork="true">
        <classpath>
            <path refid="compile.classpath" />
        </classpath>
        <arg value="WebContent/VAADIN/themes/${theme}/styles.scss" />
        <arg value="${result}/VAADIN/themes/${theme}/styles.css" />
    </java>

    <!-- Copy theme resources -->
    <copy todir="${result}/VAADIN/themes/${theme}">
        <fileset dir="WebContent/VAADIN/themes/${theme}">
            <exclude name="**/*.scss" />
        </fileset>
    </copy>
</target>
</project>
```

## 7.4. Creating and Using Themes

Custom themes are placed in the `VAADIN/themes` folder of the web application, in an Eclipse project under the `WebContent` folder or `src/main/webapp` in Maven projects, as was illustrated in Figure 7.1, “Contents of a Theme”. This location is fixed. You need to have a theme folder for each theme you use in your application, although applications rarely need more than a single theme.

### 7.4.1. Sass Themes

You can use Sass themes in Vaadin in two ways, either by compiling them to CSS by yourself or by letting the Vaadin servlet compile them for you on-the-fly when the theme CSS is requested by the browser, as described in Section 7.3.3, “Compiling Sass Themes”.

To define a Sass theme with the name `mytheme`, you must place a file with name `styles.scss` in the theme folder `VAADIN/themes/mytheme`. If no `styles.css` exists in the folder, the Sass file is compiled on-the-fly when the theme is requested by a browser.

We recommend that you organize the theme in at least two SCSS files so that you import the actual theme from a Sass file that is named more uniquely than the `styles.scss`, to make it distinguishable in the editor. This organization is how the Vaadin Plugin for Eclipse creates a new theme.

If you use Vaadin add-ons that contain themes, Vaadin Plugin for Eclipse and Maven automatically add them to the `addons.scss` file.

## Theme SCSS

We recommend that the rules in a theme should be prefixed with a selector for the theme name. You can do the prefixing in Sass by enclosing the rules in a nested rule with a selector for the theme name.

Themes are defined as Sass mixins, so after you import the mixin definitions, you can `@include` them in the theme rule as follows:

```
@import "addons.scss";
@import "mytheme.scss";

.mytheme {
  @include addons;
  @include mytheme;
}
```

However, this is mainly necessary if you use the UI in portlets, each of which can have its own theme, or in the special circumstance that the theme has rules that use empty parent selector & to refer to the theme name.

Otherwise, you can safely leave the nested theme selector out as follows:

```
@import "addons.scss";
@import "mytheme.scss";

@include addons;
@include mytheme;
```

The actual theme should be defined as follows, as a mixin that includes the base theme.

```
@import "../reindeer/reindeer.scss";

@mixin mytheme {
  @include reindeer;

  /* An actual theme rule */
  .v-button {
    color: blue;
```

```
    }
```

## 7.4.2. Plain Old CSS Themes

In addition to Sass themes, you can create plain old CSS themes. CSS theme are more restricted than Sass styles - an application can only have one CSS theme while you can have multiple Sass themes.

A CSS theme is defined in a `styles.css` file in the `VAADIN/themes/mytheme` folder. You need to import the `legacy-styles.css` of the built-in theme as follows:

```
@import "../reindeer/legacy-styles.css";  
  
.v-app {  
    background: yellow;  
}
```

## 7.4.3. Styling Standard Components

Each user interface component in Vaadin has a CSS style class that you can use to control the appearance of the component. Many components have additional sub-elements that also allow styling. You can add context-specific stylenames with `addStyleName()`. Notice that `getStyleNames()` returns only the custom stylenames, not the built-in stylenames for the component.

Please see the section on each component for a description of its styles. Most of the stylenames are determined in the client-side widget of each component. The easiest way to find out the styles of the elements is to use a HTML inspector such as FireBug.

Some client-side components or component styles can be shared by different server-side components. For example, `v-textfield` style is used for all text input boxes in components, in addition to `TextField`.

## 7.4.4. Built-in Themes

Vaadin currently includes the following built-in themes:

- `valo`, the primary theme since Vaadin 7.3
- `reindeer`, the primary theme in Vaadin 6 and 7
- `chameleon`, an easily customizable theme
- `runo`, the default theme in IT Mill Toolkit 5
- `liferay`, for Liferay portlets

In addition, there is the `base` theme, which should not be used directly, but is extended by the other built-in themes, except `valo`.

The built-in themes are provided in the respective `VAADIN/themes/<theme>/styles.scss` stylesheets in the `vaadin-themes` JAR. Also the precompiled CSS files are included, in case you want to use the themes directly.

Various constants related to the built-in themes are defined in the theme classes in `com.vaadin.ui.themes` package. These are mostly special style names for specific components.

```

@Theme( "runo" )
public class MyUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        ...
        Panel panel = new Panel("Regular Panel in the Runo Theme");
        panel.addComponent(new Button("Regular Runo Button"));

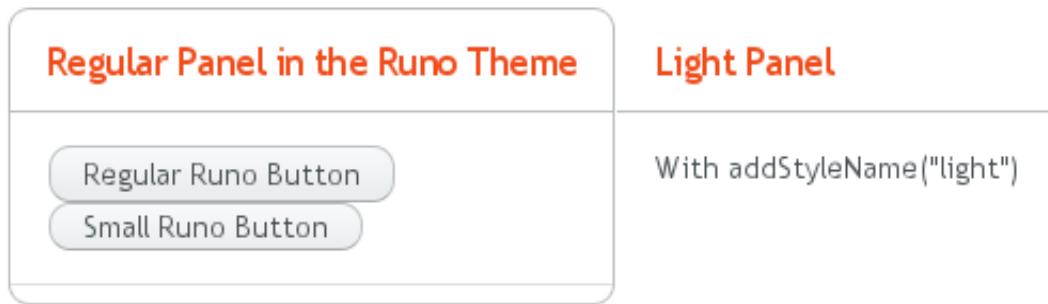
        // A button with the "small" style
        Button smallButton = new Button("Small Runo Button");
        smallButton.addStyleName(Runo.BUTTON_SMALL);

        Panel lightPanel = new Panel("Light Panel");
        lightPanel.addStyleName(Runo.PANEL_LIGHT);
        lightPanel.addComponent(
            new Label("With addStyleName(\"light\")"));
        ...
    }
}

```

The example with the Runo theme is shown in Figure 7.8, “Runo Theme”.

**Figure 7.8. Runo Theme**



The built-in themes come with a custom icon font, FontAwesome, which is used for icons in the theme, and which you can use as font icons, as described in Section 7.7, “Font Icons”.

### Serving Built-In Themes Staticly

The built-in themes included in the Vaadin library JAR are served dynamically from the JAR by the servlet. Serving themes and widget sets statically by the web server is more efficient. To do so, you need to extract the VAADIN/ directories from the JAR to the web content directory (WebContent in Eclipse or src/main/webapp in Maven projects).

```

$ cd WebContent
$ unzip path-to/vaadin-server-7.x.x.jar 'VAADIN/*'
$ unzip path-to/vaadin-themes-7.x.x.jar 'VAADIN/*'
$ unzip path-to/vaadin-client-compiled-7.x.x.jar 'VAADIN/*'

```

You can also serve static content from a front-end caching server, which reduces the load of the application server. In portals, you install the themes globally in the portal as described in Section 12.3.5, “Installing Vaadin Resources”.

Just make sure to update the static content when you upgrade to a newer version of Vaadin.

Creation of a default theme for custom GWT widgets is described in Section 16.8, “Styling a Widget”.

### 7.4.5. Add-on Themes

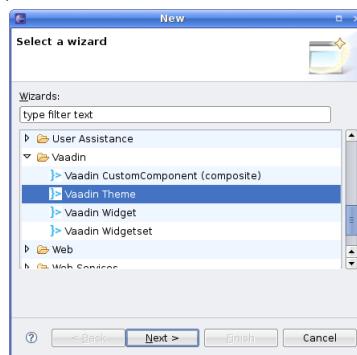
You can find more themes as add-ons from the Vaadin Directory. In addition, many component add-ons contain a theme for the components they provide.

The add-on themes need to be included in the project theme. Vaadin Plugin for Eclipse and Maven automatically include them in the `addons.scss` file in the project theme folder. It should be included by the project theme.

## 7.5. Creating a Theme in Eclipse

The Eclipse plugin automatically creates a theme stub for new Vaadin projects. It also includes a wizard for creating new custom themes. Do the following steps to create a new theme.

1. Select **File New Other...** in the main menu or right-click the **Project Explorer** and select **New Other...**. A window will open.
2. In the **Select a wizard** step, select the **Vaadin Vaadin Theme** wizard.



Click **Next** to proceed to the next step.

3. In the **Create a new Vaadin theme** step, you have the following settings:

#### **Project** (mandatory)

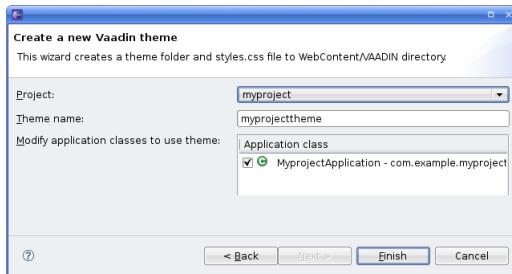
The project in which the theme should be created.

#### **Theme name** (mandatory)

The theme name is used as the name of the theme folder and in a CSS tag (prefixed with "v-theme-"), so it must be a proper identifier. Only latin alphanumerics, underscore, and minus sign are allowed.

#### **Modify application classes to use theme** (optional)

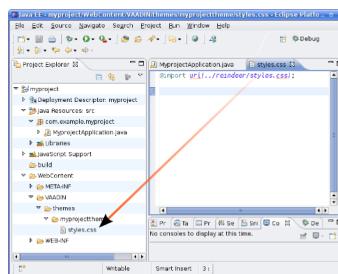
The setting allows the wizard to write a code statement that enables the theme in the constructor of the selected application (UI) class(es). If you need to control the theme with dynamic logic, you can leave the setting unchecked or change the generated line later.



Click **Finish** to create the theme.

The wizard creates the theme folder under the `WebContent/VAADIN/themes` folder and the actual style sheet as `mytheme.scss` and `styles.scss` files, as illustrated in Figure 7.9, “Newly Created Theme”.

**Figure 7.9. Newly Created Theme**



The created theme extends a built-in base theme with an `@import` statement. See the explanation of theme inheritance in Section 7.4, “Creating and Using Themes”. Notice that the `reindeer` theme is not located in the `widgetsets` folder, but in the Vaadin JAR. See Section 7.4.4, “Built-in Themes” for information for serving the built-in themes.

If you selected a UI class or classes in the **Modify application classes to use theme** in the theme wizard, the wizard will add the `@Theme` annotation to the UI class.

If you later rename the theme in Eclipse, notice that changing the name of the folder will not automatically change the `@Theme` annotation. You need to change such references to theme names in the calls manually.

## 7.6. Valo Theme

Valo is the word for light in Finnish. The Valo theme incorporates the use of light in its logic, in how it handles shades and highlights. It creates lines, borders, highlights, and shadows adaptively according to a background color, always with contrasts pleasant to human visual perception. Auxiliary colors are computed using an algorithmic color theory to blend gently with the background. The static art is complemented with responsive animations.

The true power of Valo lies in its configurability with parameters, functions, and Sass mixins. You can use the built-in definitions in your own themes or override the defaults. Detailed documentation of the available mixins, functions, and variables can be found in the Valo API documentation available at <http://vaadin.com/valo>.

## 7.6.1. Basic Use

Valo is used just like other themes. Its optional parameters must be given before the `@import` statement.

```
// Modify the base color of the theme
$v-background-color: hsl(200, 50%, 50%);

// Import valo after setting the parameters
@import "../valo/valo";

.mythemename {
    @include valo;

    // Your theme's rules go here
}
```

If you need to override mixins or function definitions in the valo theme, you must do that after the import statement, but before including the valo mixin. Also, with some configuration parameters, you can use variables defined in the theme. In this case, they need to be overridden after the import statement.

## 7.6.2. Common Settings

In the following, we describe the optional parameters that control the visual appearance of the Valo theme. In addition to the ones given here, component styles have their own parameters, listed in the sections describing the components in the other chapters.

### General Settings

`$v-background-color (default: hsl(210, 0%, 98%))`

The background color is the main control parameter for the Valo theme and it is used for computing all other colors in the theme. If the color is dark (has low luminance), light foreground colors that give high contrast with the background are automatically used.

You can specify the color in any way allowed in CSS: hexadecimal RGB color code, RGB/A value specified with `rgb()` or `rgba()`, HSL/A value specified with `hsl()` or `hsla()`. You can also use color names, but it should be avoided, as not all CSS color names are currently supported.

`$v-app-background-color (default: $v-background-color)`

Background color of the UI's root element. You can specify the color in any way allowed in CSS.

`$v-app-loading-text (default: "")`

A static text that is shown under the loading spinner while the client-side engine is being loaded and started. The text must be given in quotes. The text can not be localized currently.

`$v-app-loading-text: "Loading Resources...";`

`$v-line-height (default: 1.55)`

Base line height for all widgets. It must be given a unitless number.

`$v-line-height: 1.6;`

## Font Settings

`$v-font-size (default: 16px)`  
Base font size. It should be specified in pixels.

```
$v-font-size: 18px;
```

`$v-font-weight (default: 300)`  
Font weight for normal fonts. It should be defined with a numeric value instead of symbolic.

```
$v-font-size: 400;
```

`$v-font-color (default: computed)`  
Foreground text color, specified as any CSS color value. The default is computed from the background color so that it gives a high contrast with the background.

`$v-font-family (default: "Open Sans", sans-serif)`  
Font family and fallback fonts as a comma-separated list. Font names containing spaces must be quoted. The default font Open Sans is a web font included in the Valo theme. Other used Valo fonts must be specified in the list to enable them. See Section 7.6.4, “Valo Fonts”.

```
$v-font-family: "Source Sans Pro", sans-serif;
```

`$v-caption-font-size (default: round($v-font-size * 0.9))`  
Font size for component captions. The value should be a pixel value.

`$v-caption-font-weight (default: max(400, $v-font-weight))`  
Font weight for captions. It should be defined with a numeric value instead of symbolic.

## Layout Settings

`$v-unit-size (default: round(2.3 * $v-font-size))`  
This is the base size for various layout measures. It is directly used in some measures, such as button height and layout margins, while other measures are derived from it. The value must be specified in pixels, with a suitable range of 18-50.

```
$v-unit-size: 40px;
```

`$v-layout-margin-top, $v-layout-margin-right, $v-layout-margin-bottom, $v-layout-margin-left (default: $v-unit-size)`  
Layout margin sizes for all built-in layout components, when the margin is enabled with `setMargin()`, as described in Section 6.13.5, “Layout Margins”.

`$v-layout-spacing-vertical and $v-layout-spacing-horizontal (default: round($v-unit-size/3))`  
Amount of vertical or horizontal space when spacing is enabled for a layout with `setSpacing()`, as described in Section 6.13.4, “Layout Cell Spacing”.

## Component Features

The following settings apply to various graphical features of some components.

`$v-border (default: 1px solid (v-shade 0.7))`

Border specification for the components that have a border. The thickness measure must be specified in pixels. For the border color, you can specify any CSS color or one of the v-tint, v-shade, and v-tone keywords described later in this section.

`$v-border-radius (default: 4px)`

Corner radius for components that have a border. The measure must be specified in pixels.

`$v-border-radius: 8px;`

`$v-gradient (default: v-linear 8%)`

Color gradient style for components that have a gradient. The gradient style may use the following keywords: v-linear and v-linear-reverse. The opacity must be given as percentage between 0% and 100%.

`$v-gradient: v-linear 20%;`

`$v-bevel (default: inset 0 1px 0 v-tint, inset 0 -1px 0 v-shade)`

Inset shadow style to define how some components are "raised" from the background. The value follows the syntax of CSS box-shadow, and should be a list of insets. For the bevel color, you can specify any CSS color or one of the v-tint, v-shade, and v-tone keywords described later in this section.

`$v-bevel-depth (default: 30%)`

Specifies the "depth" of the bevel shadow, as applied to one of the color keywords for the bevel style. The actual amount of tint, shade, or tone is computed from the depth.

`$v-shadow (default: 0 2px 3px v-shade)`

Default shadow style for all components. As with \$v-bevel, the value follows the syntax of CSS box-shadow, but without the inset. For the shadow color, you can specify any CSS color or one of the v-tint or v-shade keywords described later in this section.

`$v-shadow-opacity (default: 5%)`

Specifies the opacity of the shadow, as applied to one of the color keywords for the shadow style. The actual amount of tint or shade is computed from the depth.

`$v-focus-style (default: 0 0 0 2px rgba($v-focus-color, .5))`

Box-shadow specification for the field focus indicator. The space-separated values are the horizontal shadow position in pixels, vertical shadow position in pixels, blur distance in pixels, spread distance in pixels, and the color. The color can be any CSS color. You can only specify the color, in which case defaults for the position are used. `rgba()` or `hsla()` can be used to enable transparency.

For example, the following creates a 2 pixels wide orange outline around the field:

`$v-focus-style: 0 0 0 2px orange;`

`$v-focus-color (default: valo-focus-color())`

Color for the field focus indicator. The `valo-focus-color()` function computes a high-contrast color from the context, which is usually the background color. The color can be any CSS color.

`$v-animations-enabled (default: true)`

Specifies whether various CSS animations are used.

```
$v-hover-styles-enabled (default: true)
    Specifies whether various :hover styles are used for indicating that mouse pointer
    hovers over an element.

$v-disabled-opacity (default: 0.5)
    Opacity of disabled components, as described in Section 5.3.3, “Enabled”.

$v-selection-color (default: $v-focus-color)
    Color for indicating selection in selection components.

$v-default-field-width (default: $v-unit-size * 5)
    Default width of certain field components, unless overridden with setWidth().

$v-error-indicator-color (default: #ed473b)
    Color of the component error indicator, as described in Section 4.5.1, “Error Indicator
    and Message”.

$v-required-field-indicator-color (default: $v-error-indicator-color)
    Color of the required indicator in field components, as described in Section 5.4.1, “Field
    Interface”.
```

Color specifications for \$v-border, \$v-bevel, and \$v-shadow may use, in addition to CSS colors, the following keywords:

```
v-tint
    Lighter than the background color.

v-shade
    Darker than the background color.

v-tone
    Adaptive color specification: darker on light background and lighter on dark background.
    Not usable in $v-shadow.
```

For example:

```
$v-border: 1px solid v-shade;
```

You can fine-tune the contrast by giving a weight parameter in parentheses:

```
$v-border: 1px solid (v-tint 2);
$v-border: 1px solid (v-tone 0.5);
```

## Theme Compilation and Optimization

```
$v-relative-paths (default: true)
    This flag specifies whether relative URL paths are relative to the currently parsed
    SCSS file or to the compilation root file, so that paths are correct for different resources.
    Vaadin theme compiler parses URL paths differently from the regular Sass compiler
    (Vaadin modifies relative URL paths). Use false for Ruby compiler and true for
    Vaadin Sass compiler.

$v-included-components (default: component list)
    Theme optimization parameter to specify the included component themes, as described
    in Section 7.6.6, “Theme Optimization”.
```

```
$v-included-additional-styles (default: $v-included-components)
```

Theme optimization parameter that lists the components for which the additional component stylenames should be included. See Section 7.6.5, “Component Styles” for more details.

### 7.6.3. Valo Mixins and Functions

Valo uses Sass mixins and functions heavily to compute various theme features, such as colors and shades. Also, all component styles are mixins. You can use the built-in mixins or override them. For detailed documentation of the mixins and functions, please refer to the Valo API documentation available at <http://vaadin.com/valo/api>.

### 7.6.4. Valo Fonts

Valo includes the following custom fonts:

- Open Sans
- Source Sans Pro
- Roboto
- Lato
- Lora

The used fonts must be specified with the `$v-font-family` parameter for Valo, in a fallback order. A font family is used in decreasing order of preference, in case a font with higher preference is not available in the browser. You can specify any font families and generic families that browsers may support. In addition to the primary font family, you can use also others in your application. To enable using the fonts included in Valo, you need to list them in the variable.

```
$v-font-family: 'Open Sans', sans-serif, 'Source Sans Pro';
```

Above, we specify Open Sans as the preferred primary font, with any sans-serif font that the browser supports as a fallback. In addition, we include the Source Sans Pro as an auxiliary font that we can use in custom rules as follows:

```
.v-label pre {  
    font-family: 'Source Sans Pro', monospace;  
}
```

This would specify using the font in any **Label** component with the PREFORMATTED content mode.

### 7.6.5. Component Styles

Many components have component-specific styles to make them smaller, bigger, and so forth. You can specify the component styles with `addStyleName()` using the constants defined in the **ValoTheme** enum.

```
table.addStyleName(ValoTheme.TABLE_COMPACT);
```

For a complete up-to-date list of component-specific styles, please refer to Vaadin API documentation on the **ValoTheme** enum. Some are also described in the component-specific styling sections.

## Disabling Component Styles

Component styles are optional, but all are enabled by default. They can be enabled on per-component basis with the `$v-included-additional-styles` parameter. It defaults to `$v-included-components` and can be customized in the same way, as described in Section 7.6.6, “Theme Optimization”.

## Configuration Parameters

The following variables control some common component styles:

`$v-scaling-factor--tiny` (default: 0.75)  
A scaling multiplier for TINY component styles.

`$v-scaling-factor--small` (default: 0.85)  
A scaling multiplier for SMALL component styles.

`$v-scaling-factor--large` (default: 1.2)  
A scaling multiplier for LARGE component styles.

`$v-scaling-factor--huge` (default: 1.6)  
A scaling multiplier for HUGE component styles.

### 7.6.6. Theme Optimization

Valo theme allows optimizing the size of the compiled theme CSS by including the rules for only the components actually used in the application. The included component styles can be specified in the `$v-included-components` variable, which by default includes all components. The variable should include a comma-separated list of component names in lower-case letters. Likewise, you can specify which additional component styles, as described in Section 7.6.5, “Component Styles”, should be included using the `$v-included-additional-styles` parameter and the same format. The list of additional styles defaults to `$v-included-components`.

For example, if your UI contains just **VerticalLayout**, **TextField**, and **Button** components, you could define the variable as follows:

```
$v-included-components:  
    verticallayout,  
    textfield,  
    button;
```

You can use the `remove()` function reversely to remove just some component themes from the standard selection.

For example, with the following you can remove the theme definitions for the **Calendar** component:

```
$v-included-components: remove($v-included-components, calendar);
```

Note that in this case, you need to give the statement *after* the `@import` statement for the Valo theme, because it overrides a variable by using its value that is defined in the theme.

## 7.7. Font Icons

Font icons are icons included in a font. Fonts have many advantages over bitmap images. Browsers are usually faster in rendering fonts than loading image files. Web fonts are vector graphics, so they are scalable. As font icons are text characters, you can define their color in CSS by the regular foreground color property.

### 7.7.1. Loading Icon Fonts

Vaadin currently comes with one custom icon font: FontAwesome. It is automatically enabled in the Valo theme. For other themes, you need to include it with the following line in your project theme, after importing the base theme:

```
@include fonticons;
```

If you use other icon fonts, as described in Section 7.7.5, “Custom Font Icons”, and the font is not loaded by a base theme, you need to load it with a `font` mixin in Sass, as described in Section 7.8.1, “Loading Fonts”.

### 7.7.2. Basic Use

Font icons are resources of type `FontIcon`, which implements the `Resource` interface. You can use these special resources for component icons and such, but not as embedded images, for example.

Each icon has a Unicode codepoint, by which you can use it. Vaadin includes an awesome icon font, `FontAwesome`, which comes with an enumeration of all the icons included in the font.

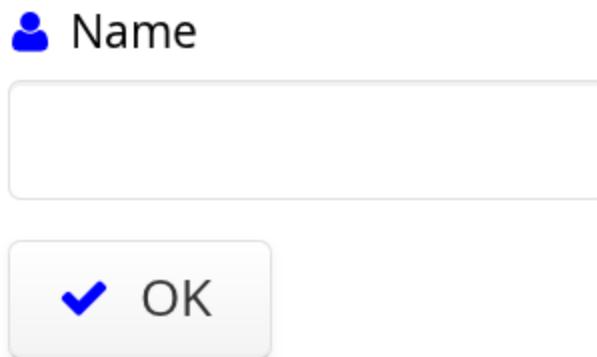
Most typically, you set a component icon as follows:

```
TextField name = new TextField( "Name" );
name.setIcon(FontAwesome.USER);
layout.addComponent(name);

// Button allows specifying icon resource in constructor
Button ok = new Button("OK", FontAwesome.CHECK);
layout.addComponent(ok);
```

The result is illustrated in Figure 7.10, “Basic Use of Font Icons”, with the color styling described next.

**Figure 7.10. Basic Use of Font Icons**



## Styling the Icons

As font icons are regular text, you can specify their color with the `color` attribute in CSS to specify the foreground text color. All HTML elements that display icons in Vaadin have the `v-icon` style name.

```
.v-icon {  
    color: blue;  
}
```

If you use the font icon resources in other ways, such as in an **Image** component, the style name will be different.

### 7.7.3. Using Font icons in HTML

You can use font icons in HTML code, such as in a **Label**, by generating the HTML to display the icon with the `getHtml()` method.

```
Label label = new Label("I " +  
    FontAwesome.HEART.getHtml() + " Vaadin",  
    ContentMode.HTML);  
label.addStyleName("redicon");  
layout.addComponent(label);
```

The HTML code has the `v-icon` style, which you can modify in CSS:

```
.redicon .v-icon {  
    color: red;  
}
```

The result is illustrated in Figure 7.11, “Using Font Icons in Label”, with the color styling described next.

**Figure 7.11. Using Font Icons in Label**



You could have set the font color in the label's HTML code as well, or for all icons in the UI.

You can easily use font icons in HTML code in other ways as well. You just need to use the correct font family and then use the hex-formatted Unicode codepoint for the icon. See for example the implementation of the `getHtml()` method in **FontAwesome**:

```
@Override  
public String getHtml() {  
    return "<span class=\"v-icon\" style=\"font-family: " +  
        getFontFamily() + ";\\">&#x" +  
        Integer.toHexString(codepoint) + ";</span>";  
}
```

## 7.7.4. Using Font Icons in Other Text

You can include a font icon in any text by its Unicode codepoint, which you can get with the `getCodePoint()` method. In such case, however, you need to use the same font for other text in the same string as well. The `FontAwesome` provided in Vaadin includes a basic character set.

```
TextField amount = new TextField("Amount (in " +
    new String(Character.toChars(
        FontAwesome.BTC.getCodepoint())) +
    " )");
amount.addStyleName("awesomecaption");
layout.addComponent(amount);
```

You need to set the font family in CSS.

```
.v-caption-awesomecaption .v-captiontext {
    font-family: FontAwesome;
}
```

## 7.7.5. Custom Font Icons

You can easily use glyphs in existing fonts as icons, or create your own.

### Creating New Icon Fonts With IcoMoon

You are free to use any of the many ways to create icons and embed them into fonts. Here, we give basic instructions for using the IcoMoon service, where you can pick icons from a large library of well-designed icons.

Font Awesome is included in IcoMoon's selection of icon libraries. Note that the codepoints of the icons are not fixed, so the `FontAwesome` enum is not compatible with such custom icon fonts.

After you have selected the icons that you want in your font, you can download them in a ZIP package. The package contains the icons in multiple formats, including WOFF, TTF, EOT, and SVG. Not all browsers support any one of them, so all are needed to support all the common browsers. Extract the `fonts` folder from the package to under your theme.

See Section 7.8.1, “Loading Fonts” for instructions for loading a custom font.

### Implementing FontIcon

You can define a font icon for any font available in the browser by implementing the `FontIcon` interface. The normal pattern for implementing it is to implement an enumeration for all the symbols available in the font. See the implementation of `FontAwesome` for more details.

You need a `FontIcon` API for the icons. In the following, we define a font icon using a normal sans-serif font built-in in the browser.

```
// Font icon definition with a single symbol
public enum MyFontIcon implements FontIcon {
    EURO(0x20AC);

    private int codepoint;

    MyFontIcon(int codepoint) {
        this.codepoint = codepoint;
```

```
}

@Override
public String getMIMEType() {
    throw new UnsupportedOperationException(
        FontIcon.class.getSimpleName()
        + " should not be used where a MIME type is needed.");
}

@Override
public String getFontFamily() {
    return "sans-serif";
}

@Override
public int getCodepoint() {
    return codepoint;
}

@Override
public String getHtml() {
    return "<span class=\"v-icon\" style=\"font-family: " +
        getFontFamily() + ";\\">>&#x" +
        Integer.toHexString(codepoint) + "</span>";
}
}
```

Then you can use it as usual:

```
TextField name = new TextField("Amount");
name.setIcon(MyFontIcon.EURO);
layout.addComponent(name);
```

You could make the implementation a class as well, instead of an enumeration, to allow other ways to specify the icons.

## 7.8. Custom Fonts

In addition to using the built-in fonts of the browser and the web fonts included in the Vaadin themes, you can use custom web fonts.

### 7.8.1. Loading Fonts

You can load web fonts with the `font` mixin as follows:

```
@include font(MyFontFamily,
    '../..../mytheme/fonts/myfontfamily');
```

The statement must be given in the `styles.scss` file *outside* the `.mytheme {}` block.

The first parameter is the name of the font family, which is used to identify the font. If the font family name contains spaces, you need to use single or double quotes around the name.

The second parameter is the base name of the font files without an extension, including a relative path. Notice that the path is relative to the base theme, where the mixin is defined, not the used theme. We recommend placing custom font files under a `fonts` folder in a theme.

Not all browsers support any single font file format, so the base name is appended with `.ttf`, `.eot`, `.woff`, or `.svg` suffix for the font file suitable for a user's browser.

## 7.8.2. Using Custom Fonts

After loaded, you can use a custom font, or actually font family, by its name in CSS and otherwise.

```
.mystyle {  
    font-family: MyFontFamily;  
}
```

Again, if the font family name contains spaces, you need to use single or double quotes around the name.

## 7.9. Responsive Themes

Vaadin includes support for responsive design which enables size range conditions in CSS selectors, allowing conditional CSS rules that respond to size changes in the browser window on the client-side. See the [Vaadin Blog article on Responsive design](#) for some additional information.

You can use the **Responsive** extension to extend either a component, typically a layout, or the entire UI. You specify the component by the static `makeResponsive()` method.

```
// Have some component with an appropriate style name  
Label c = new Label("Here be text");  
c.addStyleName("myresponsive");  
content.addComponent(c);  
  
// Enable Responsive CSS selectors for the component  
Responsive.makeResponsive(c);
```

You can now use `width-range` and `height-range` conditions in CSS selectors as follows:

```
/* Basic settings for all sizes */  
.myresponsive {  
    padding: 5px;  
    line-height: 36pt;  
}  
  
/* Small size */  
.myresponsive[width-range~="0-300px"] {  
    background: orange;  
    font-size: 16pt;  
}  
  
/* Medium size */  
.myresponsive[width-range~="301px-600px"] {  
    background: azure;  
    font-size: 24pt;  
}  
  
/* Anything bigger */  
.myresponsive[width-range~="601px-"] {  
    background: palegreen;  
    font-size: 36pt;  
}
```

You can have overlapping size ranges, in which case all the selectors matching the current size are enabled.

## Flexible Wrapping

You can use the **CssLayout** to have automatic wrap-around when the components in the layout would go off right side of the layout. Components that wrap must, however, have either undefined or fixed width, and thereby can not utilize the full area of the screen. With the **Responsive** extension, you can have more flexible wrap-around that gives the component tiles maximum width.

In the following, we have a text and image box, which are laid out horizontally with 50-50 sizing if the screen is wide enough, but wrap to a vertical layout if the screen is narrow.

```
CssLayout layout = new CssLayout();
layout.setWidth("100%");
layout.addStyleName("flexwrap");
content.addComponent(layout);

// Enable Responsive CSS selectors for the layout
Responsive.makeResponsive(layout);

Label title = new Label("Space is big, really big");
title.addStyleName("title");
layout.addComponent(title);

Label description = new Label("This is a " +
    "long description of the image shown " +
    "on the right or below, depending on the " +
    "screen width. The text here could continue long.");
description.addStyleName("itembox");
description.setSizeUndefined();
layout.addComponent(description);

Image image = new Image(null,
    new ThemeResource("img/planets/Earth.jpg"));
image.addStyleName("itembox");
layout.addComponent(image);
```

The SCSS could be as follows:

```
/* Various general settings */
.flexwrap {
    background: black;
    color: white;

    .title {
        font-weight: bold;
        font-size: 20px;
        line-height: 30px;
        padding: 5px;
    }

    .itembox {
        white-space: normal;
        vertical-align: top;
    }

    .itembox.v-label {padding: 5px}
}
```

```
.flexwrap[width-range~="0-499px"] {
    .itembox {width: 100%}
}

.flexwrap[width-range~="500px-"] {
    .itembox {width: 50%}
}
```

The layout in the wide mode is shown in Figure 7.12, “Flexible Wrapping”.

**Figure 7.12. Flexible Wrapping**



You could also play with the `display: block` vs `display: inline-block` properties.

Notice that, while the **Responsive** extension makes it possible to do various CSS trickery with component sizes, the normal rules for component and layout sizes apply, as described in Section 6.13.1, “Layout Size” and elsewhere, and you should always check the size behaviour of the components. In the above example, we set the label to have `undefined width`, which disables word wrap, so we had to re-enable it.

## Toggling the Display Property

The `display` property allows especially powerful ways to offer radically different UIs for different screen sizes by enabling and disabling UI elements as needed. For example, you could disable some parts of the UI when the space gets too small, but bring forth navigation buttons that, when clicked, add component styles to switch to the hidden parts.

In the following, we simply show alternative components based on screen width:

```
CssLayout layout = new CssLayout();
layout.setWidth("100%");
layout.addStyleName("toggledisplay");
content.addComponent(layout);

// Enable Responsive CSS selectors for the layout
```

```
Responsive.makeResponsive(layout);

Label enoughspace =
    new Label("This space is big, mindbogglingly big");
enoughspace.addStyleName("enoughspace");
layout.addComponent(enoughspace);

Label notEnoughSpace = new Label("Quite small space");
notEnoughSpace.addStyleName("notEnoughSpace");
layout.addComponent(notEnoughSpace);
```

The SCSS could be as follows:

```
/* Common settings */
.toggledisplay {
    .enoughspace, .notEnoughSpace {
        color: white;
        padding: 5px;
    }

    .notEnoughSpace { /* Really small */
        background: red;
        font-weight: normal;
        font-size: 10px;
        line-height: 15px;
    }

    .enoughspace { /* Really big */
        background: darkgreen;
        font-weight: bold;
        font-size: 20px;
        line-height: 30px;
    }
}

/* Quite little space */
.toggledisplay[width-range~="0-499px"] {
    .enoughspace {display: none}
}

/* Plenty of space */
.toggledisplay[width-range~="500px-"] {
    .notEnoughSpace {display: none}
}
```

## Responsive Demos

You can find a simple responsive demo at [demo.vaadin.com/responsive](http://demo.vaadin.com/responsive). It demonstrates the flexible wrapping technique described in the section called “Flexible Wrapping”.

The Book Examples demo provides the examples given in this chapter, as well as some others.

The Parking demo for TouchKit, mentioned in Chapter 20, *Mobile Applications with TouchKit*, uses a responsive theme to adapt to mobile devices with different screen sizes and when the screen orientation changes.

---

# Chapter 8

# Binding Components to Data

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This chapter describes the Vaadin Data Model and shows how you can use it to bind components directly to data sources, such as database queries.

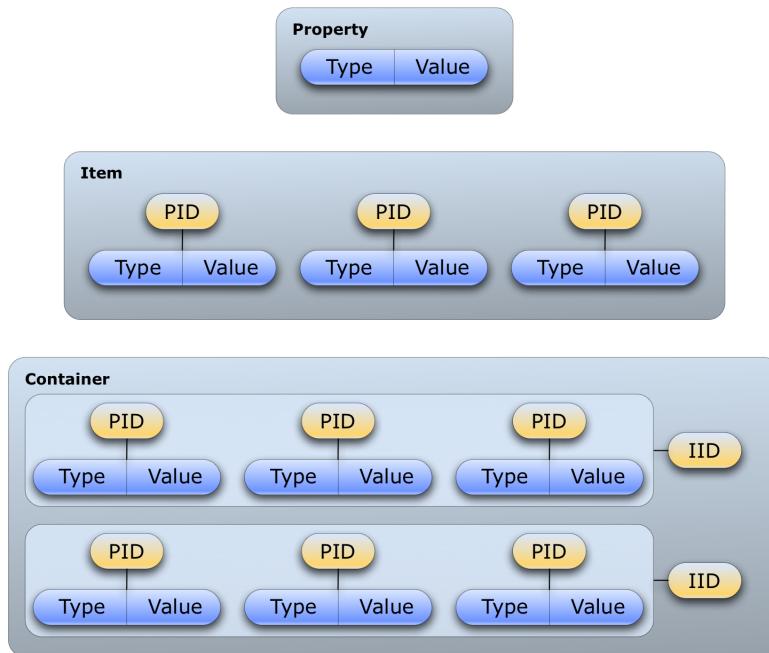
## 8.1. Overview

The Vaadin Data Model is one of the core concepts of the library. To allow the view (user interface components) to access the data model of an application directly, we have introduced a standard data interface.

The model allows binding user interface components directly to the data that they display and possibly allow to edit. There are three nested levels of hierarchy in the data model: *property*,

*item*, and *container*. Using a spreadsheet application as an analogy, these would correspond to a cell, a row, and a table, respectively.

**Figure 8.1. Vaadin Data Model**

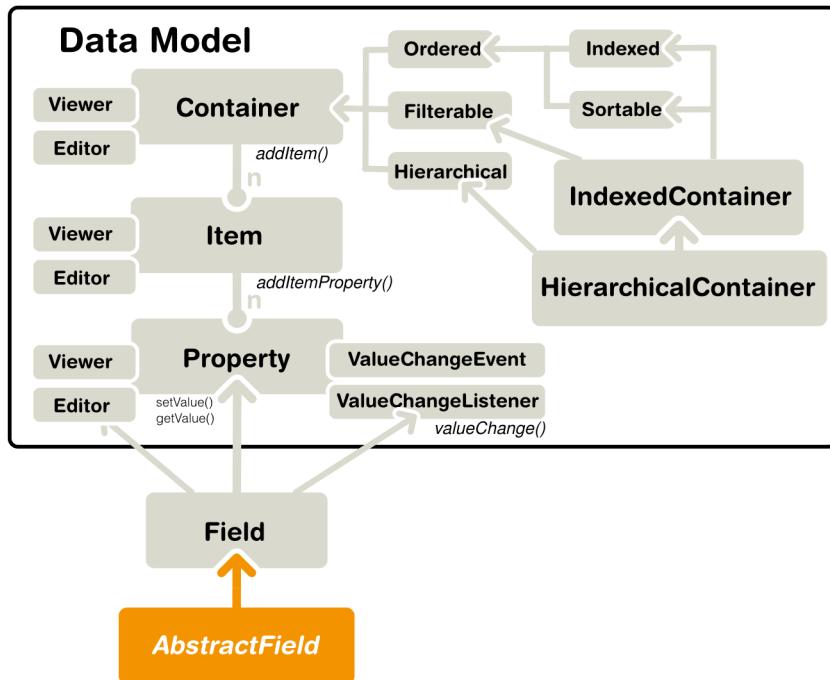


The Data Model is realized as a set of interfaces in the **com.vaadin.data** package. The package contains the **Property**, **Item**, and **Container** interfaces, along with a number of more specialized interfaces and classes.

Notice that the Data Model does not define data representation, but only interfaces. This leaves the representation fully to the implementation of the containers. The representation can be almost anything, such as a plain old Java object (POJO) structure, a filesystem, or a database query.

The Data Model is used heavily in the core user interface components of Vaadin, especially the field components, that is, components that implement the **Field** interface or more typically extend **AbstractField**, which defines many common features. A key feature of all the built-in field components is that they can either maintain their data by themselves or be bound to an external data source. The value of a field is always available through the **Property** interface. As more than one component can be bound to the same data source, it is easy to implement various viewer-editor patterns.

The relationships of the various interfaces are shown in Figure 8.2, “Interface Relationships in Vaadin Data Model”; the value change event and listener interfaces are shown only for the **Property** interface, while the notifier interfaces are omitted altogether.

**Figure 8.2. Interface Relationships in Vaadin Data Model**

The Data Model has many important and useful features, such as support for change notification. Especially containers have many helper interfaces, including ones that allow indexing, ordering, sorting, and filtering the data. Also **Field** components provide a number of features involving the data model, such as buffering, validation, and lazy loading.

Vaadin provides a number of built-in implementations of the data model interfaces. The built-in implementations are used as the default data models in many field components.

In addition to the built-in implementations, many data model implementations, such as containers, are available as add-ons, either from the Vaadin Directory or from independent sources. Both commercial and free implementations exist. The JPACContainer, described in Chapter 19, *Vaadin JPACContainer*, is the most often used commercial container add-on. The installation of add-ons is described in Chapter 17, *Using Vaadin Add-ons*. Notice that unlike with most regular add-on components, you do not need to compile a widget set for add-ons that include just data model implementations.

## 8.2. Properties

The **Property** interface is the base of the Vaadin Data Model. It provides a standardized API for a single data value object that can be read (get) and written (set). A property is always typed, but can optionally support data type conversions. The type of a property can be any Java class. Optionally, properties can provide value change events for following their changes.

You can set the value of a property with `setValue()` and read with `getValue()`.

In the following, we set and read the property value from a **TextField** component, which implements the **Property** interface to allow accessing the field value.

```
final TextField tf = new TextField("Name");
```

```
// Set the value
tf.setValue("The text field value");

// When the field value is edited by the user
tf.addValueChangeListener(
    new Property.ValueChangeListener() {
        public void valueChange(ValueChangeEvent event) {
            // Do something with the new value
            layout.addComponent(new Label(tf.getValue()));
        }
    });
});
```

Changes in the property value usually fire a **ValueChangeEvent**, which can be handled with a **ValueChangeListener**. The event object provides reference to the property with `getProperty()`. Note that its `getValue()` method returns the value with **Object** type, so you need to cast it to the proper type.

Properties are in themselves unnamed. They are collected in *items*, which associate the properties with names: the *Property Identifiers* or *PIDs*. Items can be further contained in containers and are identified with *Item Identifiers* or *IDs*. In the spreadsheet analogy, *Property Identifiers* would correspond to column names and *Item Identifiers* to row names. The identifiers can be arbitrary objects, but must implement the `equals(Object)` and `hashCode()` methods so that they can be used in any standard Java **Collection**.

The **Property** interface can be utilized either by implementing the interface or by using some of the built-in property implementations. Vaadin includes a **Property** interface implementation for arbitrary function pairs and bean properties, with the **MethodProperty** class, and for simple object properties, with the **ObjectProperty** class, as described later.

In addition to the simple components, selection components provide their current selection as the property value. In single selection mode, the property is a single item identifier, while in multiple selection mode it is a set of item identifiers. See the documentation of the selection components for further details.

Components that can be bound to a property have an internal default data source object, typically a **ObjectProperty**, which is described later. As all such components are viewers or editors, also described later, so you can rebind a component to any data source with `setPropertyDataSource()`.

## 8.2.1. Property Viewers and Editors

The most important function of the **Property** as well as of the other data model interfaces is to connect classes implementing the interface directly to editor and viewer classes. This means connecting a data source (model) to a user interface component (views) to allow editing or viewing the data model.

A property can be bound to a component implementing the **Viewer** interface with `setPropertyDataSource()`.

```
// Have a data model
ObjectProperty property =
    new ObjectProperty("Hello", String.class);

// Have a component that implements Viewer
Label viewer = new Label();
```

```
// Bind it to the data
viewer.setPropertyDataSource(property);
```

You can use the same method in the **Editor** interface to bind a component that allows editing a particular property type to a property.

```
// Have a data model
ObjectProperty property =
    new ObjectProperty("Hello", String.class);

// Have a component that implements Viewer
TextField editor = new TextField("Edit Greeting");

// Bind it to the data
editor.setPropertyDataSource(property);
```

As all field components implement the **Property** interface, you can bind any component implementing the **Viewer** interface to any field, assuming that the viewer is able to view the object type of the field. Continuing from the above example, we can bind a **Label** to the **TextField** value:

```
Label viewer = new Label();
viewer.setPropertyDataSource(editor);

// The value shown in the viewer is updated immediately
// after editing the value in the editor (once it
// loses the focus)
editor.setImmediate(true);
```

If a field has validators, as described in Section 5.4.5, “Field Validation”, the validators are executed before writing the value to the property data source, or by calling the `validate()` or `commit()` for the field.

## 8.2.2. ObjectProperty Implementation

The **ObjectProperty** class is a simple implementation of the **Property** interface that allows storing an arbitrary Java object.

```
// Have a component that implements Viewer interface
final TextField tf = new TextField("Name");

// Have a data model with some data
String myObject = "Hello";

// Wrap it in an ObjectProperty
ObjectProperty property =
    new ObjectProperty(myObject, String.class);

// Bind the property to the component
tf.setPropertyDataSource(property);
```

## 8.2.3. Converting Between Property Type and Representation

Fields allow editing a certain type, such as a **String** or **Date**. The bound property, on the other hand, could have some entirely different type. Conversion between a representation edited by the field and the model defined in the property is handled with a converter that implements the **Converter** interface.

Most common type conversions, such as between string and integer, are handled by the default converters. They are created in a converter factory global in the application.

## Basic Use of Converters

The `setConverter(Converter)` method sets the converter for a field. The method is defined in **AbstractField**.

```
// Have an integer property
final ObjectProperty<Integer> property =
    new ObjectProperty<Integer>(42);

// Create a TextField, which edits Strings
final TextField tf = new TextField("Name");

// Use a converter between String and Integer
tf.setConverter(new StringToIntegerConverter());

// And bind the field
tf.setPropertyDataSource(property);
```

The built-in converters are the following:

**Table 8.1. Built-in Converters**

Converter	Representation	Model
<b>StringToIntegerConverter</b>	<b>String</b>	<b>Integer</b>
<b>StringToDoubleConverter</b>	<b>String</b>	<b>Double</b>
<b>StringToNumberConverter</b>	<b>String</b>	<b>Number</b>
<b>StringToBooleanConverter</b>	<b>String</b>	<b>Boolean</b>
<b>StringToDateConverter</b>	<b>String</b>	<b>Date</b>
<b>DateToLongConverter</b>	<b>Date</b>	<b>Long</b>

In addition, there is a **ReverseConverter** that takes a converter as a parameter and reverses the conversion direction.

If a converter already exists for a type, the `setConverter(Class)` retrieves the converter for the given type from the converter factory, and then sets it for the field. This method is used implicitly when binding field to a property data source.

## Implementing a Converter

A conversion always occurs between a *representation type*, edited by the field component, and a *model type*, that is, the type of the property data source. Converters implement the `Converter` interface defined in the `com.vaadin.data.util.converter` package.

For example, let us assume that we have a simple **Complex** type for storing complex values.

```
public class ComplexConverter
    implements Converter<String, Complex> {
    @Override
    public Complex convertToModel(String value, Locale locale)
        throws ConversionException {
        String parts[] =
```

```
        value.replaceAll("\\\\(\\\")", "").split(",");
    if (parts.length != 2)
        throw new ConversionException(
            "Unable to parse String to Complex");
    return new Complex(Double.parseDouble(parts[0]),
                      Double.parseDouble(parts[1]));
}

@Override
public String convertToPresentation(Complex value,
                                    Locale locale)
    throws ConversionException {
    return "("+value.getReal()+" , "+value.getImag()+" )";
}

@Override
public Class<Complex> getModelType() {
    return Complex.class;
}

@Override
public Class<String> getPresentationType() {
    return String.class;
}
}
```

The conversion methods get the locale for the conversion as a parameter.

## Converter Factory

If a field does not directly allow editing a property type, a default converter is attempted to create using an application-global converter factory. If you define your own converters that you wish to include in the converter factory, you need to implement one yourself. While you could implement the `ConverterFactory` interface, it is usually easier to just extend **DefaultConverterFactory**.

```
class MyConverterFactory extends DefaultConverterFactory {
    @Override
    public <PRESENTATION, MODEL> Converter<PRESENTATION, MODEL>
        createConverter(Class<PRESENTATION> presentationType,
                       Class<MODEL> modelType) {
        // Handle one particular type conversion
        if (String.class == presentationType &&
            Complex.class == modelType)
            return (Converter<PRESENTATION, MODEL>)
                new ComplexConverter();

        // Default to the supertype
        return super.createConverter(presentationType,
                                     modelType);
    }
}

// Use the factory globally in the application
Application.getCurrentApplication().setConverterFactory(
    new MyConverterFactory());
```

### 8.2.4. Implementing the Property Interface

Implementation of the **Property** interface requires defining setters and getters for the value and the *read-only* mode. Only a getter is needed for the property type, as the type is often fixed in property implementations.

The following example shows a simple implementation of the **Property** interface:

```
class MyProperty implements Property {
    Integer data      = 0;
    boolean readOnly = false;

    // Return the data type of the model
    public Class<?> getType() {
        return Integer.class;
    }

    public Object getValue() {
        return data;
    }

    // Override the default implementation in Object
    @Override
    public String toString() {
        return Integer.toHexString(data);
    }

    public boolean isReadOnly() {
        return readOnly;
    }

    public void setReadOnly(boolean newStatus) {
        readOnly = newStatus;
    }

    public void setValue(Object newValue)
        throws ReadOnlyException, ConversionException {
        if (readOnly)
            throw new ReadOnlyException();

        // Already the same type as the internal representation
        if (newValue instanceof Integer)
            data = (Integer) newValue;

        // Conversion from a string is required
        else if (newValue instanceof String)
            try {
                data = Integer.parseInt((String) newValue, 16);
            } catch (NumberFormatException e) {
                throw new ConversionException();
            }
        else
            // Don't know how to convert any other types
            throw new ConversionException();

        // Reverse decode the hexadecimal value
    }
}
```

```
// Instantiate the property and set its data
MyProperty property = new MyProperty();
property.setValue(42);

// Bind it to a component
final TextField tf = new TextField("Name", property);
```

The components get the displayed value by the `toString()` method, so it is necessary to override it. To allow editing the value, value returned in the `toString()` must be in a format that is accepted by the `setValue()` method, unless the property is read-only. The `toString()` can perform any type conversion necessary to make the internal type a string, and the `set-Value()` must be able to make a reverse conversion.

The implementation example does not notify about changes in the property value or in the read-only mode. You should normally also implement at least the **Property.ValueChangeNotifier** and **Property.ReadOnlyStatusChangeNotifier**. See the **ObjectProperty** class for an example of the implementation.

## 8.3. Holding properties in Items

The **Item** interface provides access to a set of named properties. Each property is identified by a *property identifier* (PID) and a reference to such a property can be queried from an **Item** with `getItemProperty()` using the identifier.

Examples on the use of items include rows in a **Table**, with the properties corresponding to table columns, nodes in a **Tree**, and the the data bound to a **Form**, with item's properties bound to individual form fields.

Items are generally equivalent to objects in the object-oriented model, but with the exception that they are configurable and provide an event handling mechanism. The simplest way to utilize **Item** interface is to use existing implementations. Provided utility classes include a configurable property set (**PropertysetItem**) and a bean-to-item adapter (**BeanItem**). Also, a **Form** implements the interface and can therefore be used directly as an item.

In addition to being used indirectly by many user interface components, items provide the basic data model underlying the **Form** component. In simple cases, forms can even be generated automatically from items. The properties of the item correspond to the fields of the form.

The **Item** interface defines inner interfaces for maintaining the item property set and listening changes made to it. **PropertySetChangeEvent** events can be emitted by a class implementing the **PropertySetChangeNotifier** interface. They can be received through the **PropertySetChangeListener** interface.

### 8.3.1. The PropertysetItem Implementation

The **PropertysetItem** is a generic implementation of the **Item** interface that allows storing properties. The properties are added with `addItemProperty()`, which takes a name and the property as parameters.

The following example demonstrates a typical case of collecting **ObjectProperty** properties in an item:

```
PropertysetItem item = new PropertysetItem();
item.addItemProperty("name", new ObjectProperty("Zaphod"));
item.addItemProperty("age", new ObjectProperty(42));
```

```
// Bind it to a component
Form form = new Form();
form.setItemDataSource(item);
```

### 8.3.2. Wrapping a Bean in a BeanItem

The **BeanItem** implementation of the **Item** interface is a wrapper for Java Bean objects. In fact, only the setters and getters are required while serialization and other bean features are not, so you can wrap almost any POJOs with minimal requirements.

```
// Here is a bean (or more exactly a POJO)
class Person {
    String name;
    int age;

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    public Integer getAge() {
        return age;
    }

    public void setAge(Integer age) {
        this.age = age.intValue();
    }
}

// Create an instance of the bean
Person bean = new Person();

// Wrap it in a BeanItem
BeanItem<Person> item = new BeanItem<Person>(bean);

// Bind it to a component
Form form = new Form();
form.setItemDataSource(item);
```

You can use the `getBean()` method to get a reference to the underlying bean.

### Nested Beans

You may often have composite classes where one class "has a" another class. For example, consider the following **Planet** class which "has a" discoverer:

```
// Here is a bean with two nested beans
public class Planet implements Serializable {
    String name;
    Person discoverer;

    public Planet(String name, Person discoverer) {
        this.name = name;
        this.discoverer = discoverer;
    }
}
```

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

...
// Create an instance of the bean
Planet planet = new Planet("Uranus",
                           new Person("William Herschel", 1738));
```

When shown in a **Form**, for example, you would want to list the properties of the nested bean along the properties of the composite bean. You can do that by binding the properties of the nested bean individually with a **MethodProperty** or **NestedMethodProperty**. You should usually hide the nested bean from binding as a property by listing only the bound properties in the constructor.

```
// Wrap it in a BeanItem and hide the nested bean property
BeanItem<Planet> item = new BeanItem<Planet>(planet,
                                              new String[]{ "name" });

// Bind the nested properties.
// Use NestedMethodProperty to bind using dot notation.
item.addItemProperty("discoverername",
                      new NestedMethodProperty(planet, "discoverer.name"));

// The other way is to use regular MethodProperty.
item.addItemProperty("discovererborn",
                      new MethodProperty<Person>(planet.getDiscoverer(),
                                                  "born"));
```

The difference is that **NestedMethodProperty** does not access the nested bean immediately but only when accessing the property values, while when using **MethodProperty** the nested bean is accessed when creating the method property. The difference is only significant if the nested bean can be null or be changed later.

You can use such a bean item for example in a **Form** as follows:

```
// Bind it to a component
Form form = new Form();
form.setItemDataSource(item);

// Nicer captions
form.getField("discoverername").setCaption("Discoverer");
form.getField("discovererborn").setCaption("Born");
```

### Figure 8.3. A Form with Nested Bean Properties

Name	Uranus
Discoverer	William Herschel
Born	1738

The **BeanContainer** and **BeanItemContainer** allow easy definition of nested bean properties with `addNestedContainerProperty()`, as described in the section called “Nested Properties”.

## 8.4. Creating Forms by Binding Fields to Items

*Because of pressing release schedules to get this edition to your hands, we were unable to completely update this chapter. Some form handling is still under work, especially form validation.*

Most applications in existence have forms of some sort. Forms contain fields, which you want to bind to a data source, an item in the Vaadin data model. **FieldGroup** provides an easy way to bind fields to the properties of an item. You can use it by first creating a layout with some fields, and then call it to bind the fields to the data source. You can also let the **FieldGroup** create the fields using a field factory. It can also handle commits. Notice that **FieldGroup** is not a user interface component, so you can not add it to a layout.

### 8.4.1. Simple Binding

Let us start with a data model that has an item with a couple of properties. The item could be any item type, as described earlier.

```
// Have an item
PropertysetItem item = new PropertysetItem();
item.addItemProperty("name", new ObjectProperty<String>("Zaphod"));
item.addItemProperty("age", new ObjectProperty<Integer>(42));
```

Next, you would design a form for editing the data. The **FormLayout** (Section 6.5, “**FormLayout**” is ideal for forms, but you could use any other layout as well.

```
// Have some layout and create the fields
FormLayout form = new FormLayout();

TextField nameField = new TextField("Name");
form.addComponent(nameField);

TextField ageField = new TextField("Age");
form.addComponent(ageField);
```

Then, we can bind the fields to the data as follows:

```
// Now create the binder and bind the fields
FieldGroup binder = new FieldGroup(item);
binder.bind(nameField, "name");
binder.bind(ageField, "age");
```

The above way of binding is not different from simply calling `setPropertyDataSource()` for the fields. It does, however, register the fields in the field group, which for example enables buffering or validation of the fields using the field group, as described in Section 8.4.4, “Buffering Forms”.

Next, we consider more practical uses for a **FieldGroup**.

### 8.4.2. Using a FieldFactory to Build and Bind Fields

Using the `buildAndBind()` methods, **FieldGroup** can create fields for you using a **FieldGroupFieldFactory**, but you still have to add them to the correct position in your layout.

```
// Have some layout
FormLayout form = new FormLayout();

// Now create a binder that can also create the fields
```

```
// using the default field factory
FieldGroup binder = new FieldGroup(item);
form.addComponent(binder.buildAndBind("Name", "name"));
form.addComponent(binder.buildAndBind("Age", "age"));
```

### 8.4.3. Binding Member Fields

The `bindMemberFields()` method in **FieldGroup** uses reflection to bind the properties of an item to field components that are member variables of a class. Hence, if you implement a form as a class with the fields stored as member variables, you can use this method to bind them super-easy.

The item properties are mapped to the members by the property ID and the name of the member variable. If you want to map a property with a different ID to a member, you can use the `@PropertyId` annotation for the member, with the property ID as the parameter.

For example:

```
// Have an item
PropertysetItem item = new PropertysetItem();
item.addItemProperty("name", new ObjectProperty<String>("Zaphod"));
item.addItemProperty("age", new ObjectProperty<Integer>(42));

// Define a form as a class that extends some layout
class MyForm extends FormLayout {
    // Member that will bind to the "name" property
    TextField name = new TextField("Name");

    // Member that will bind to the "age" property
    @PropertyId("age")
    TextField ageField = new TextField("Age");

    public MyForm() {
        // Customize the layout a bit
        setSpacing(true);

        // Add the fields
        addComponent(name);
        addComponent(ageField);
    }
}

// Create one
MyForm form = new MyForm();

// Now create a binder that can also creates the fields
// using the default field factory
FieldGroup binder = new FieldGroup(item);
binder.bindMemberFields(form);

// And the form can be used in an higher-level layout
layout.addComponent(form);
```

### Encapsulating in CustomComponent

Using a **CustomComponent** can be better for hiding the implementation details than extending a layout. Also, the use of the **FieldGroup** can be encapsulated in the form class.

Consider the following as an alternative for the form implementation presented earlier:

```
// A form component that allows editing an item
class MyForm extends CustomComponent {
    // Member that will bind to the "name" property
    TextField name = new TextField("Name");

    // Member that will bind to the "age" property
    @PropertyId("age")
    TextField ageField = new TextField("Age");

    public MyForm(Item item) {
        FormLayout layout = new FormLayout();
        layout.addComponent(name);
        layout.addComponent(ageField);

        // Now use a binder to bind the members
        FieldGroup binder = new FieldGroup(item);
        binder.bindMemberFields(this);

        setCompositionRoot(layout);
    }
}

// And the form can be used as a component
layout.addComponent(new MyForm(item));
```

#### 8.4.4. Buffering Forms

Just like for individual fields, as described in Section 5.4.4, “Field Buffering”, a **FieldGroup** can handle buffering the form content so that it is written to the item data source only when `commit()` is called for the group. It runs validation for all fields in the group and writes their values to the item data source only if all fields pass the validation. Edits can be discarded, so that the field values are reloaded from the data source, by calling `discard()`. Buffering is enabled by default, but can be disabled by calling `setBuffered(false)` for the **FieldGroup**.

```
// Have an item of some sort
final PropertysetItem item = new PropertysetItem();
item.addItemProperty("name", new ObjectProperty<String>("Q"));
item.addItemProperty("age", new ObjectProperty<Integer>(42));

// Have some layout and create the fields
Panel form = new Panel("Buffered Form");
form.setContent(new FormLayout());

// Build and bind the fields using the default field factory
final FieldGroup binder = new FieldGroup(item);
form.addComponent(binder.buildAndBind("Name", "name"));
form.addComponent(binder.buildAndBind("Age", "age"));

// Enable buffering (actually enabled by default)
binder.setBuffered(true);

// A button to commit the buffer
form.addComponent(new Button("OK", new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        try {
            binder.commit();
        }
    }
}));
```

```
        Notification.show("Thanks!");
    } catch (CommitException e) {
        Notification.show("You fail!");
    }
}
}));
```

```
// A button to discard the buffer
form.addComponent(new Button("Discard", new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        binder.discard();
        Notification.show("Discarded!");
    }
}));
```

#### 8.4.5. Binding Fields to a Bean

The **BeanFieldGroup** makes it easier to bind fields to a bean. It also handles binding to nested beans properties. To build a field bound to a nested bean property, identify the property with dot notation. For example, if a **Person** bean has a `address` property with an **Address** type, which in turn has a `street` property, you could build a field bound to the property with `buildAndBind("Street", "address.street")`.

The input to fields bound to a bean can be validated using the Java Bean Validation API, as described in Section 8.4.6, “Bean Validation”. The **BeanFieldGroup** automatically adds a **BeanValidator** to every field if a bean validation implementation is included in the classpath.

#### 8.4.6. Bean Validation

Vaadin allows using the Java Bean Validation API 1.0 (JSR-303) for validating input from fields bound to bean properties before the values are committed to the bean. The validation is done based on annotations on the bean properties, which are used for creating the actual validators automatically. See Section 5.4.5, “Field Validation” for general information about validation.

Using bean validation requires an implementation of the Bean Validation API, such as Hibernate Validator (`hibernate-validator-4.2.0.Final.jar` or later) or Apache Bean Validation. The implementation JAR must be included in the project classpath when using the bean validation, or otherwise an internal error is thrown.

Bean validation is especially useful when persisting entity beans with the Vaadin JPAContainer, described in Chapter 19, *Vaadin JPAContainer*.

### Annotations

The validation constraints are defined as annotations. For example, consider the following bean:

```
// Here is a bean
public class Person implements Serializable {
    @NotNull
    @javax.validation.constraints.Size(min=2, max=10)
    String name;

    @Min(1)
    @Max(130)
    int age;
```

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

For a complete list of allowed constraints for different data types, please see the Bean Validation API documentation.

## Validating the Beans

Validating a bean is done with a **BeanValidator**, which you initialize with the name of the bean property it should validate and add it to the editor field.

In the following example, we validate a single unbuffered field:

```
Person bean = new Person("Mung bean", 100);
BeanItem<Person> item = new BeanItem<Person>(bean);

// Create an editor bound to a bean field
TextField firstName = new TextField("First Name",
    item.getItemProperty("name"));

// Add the bean validator
firstName.addValidator(new BeanValidator(Person.class, "name"));

firstName.setImmediate(true);
layout.addComponent(firstName);
```

In this case, the validation is done immediately after focus leaves the field. You could do the same for the other field as well.

Bean validators are automatically created when using a **BeanFieldGroup**.

```
// Have a bean
Person bean = new Person("Mung bean", 100);

// Form for editing the bean
final BeanFieldGroup<Person> binder =
    new BeanFieldGroup<Person>(Person.class);
binder.setItemDataSource(bean);
layout.addComponent(binder.buildAndBind("Name", "name"));
layout.addComponent(binder.buildAndBind("Age", "age"));

// Buffer the form content
binder.setBuffered(true);
layout.addComponent(new Button("OK", new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        try {
            binder.commit();
        } catch (CommitException e) {
        }
    }
}));
```

## Locale Setting for Bean Validation

The validation error messages are defined in the bean validation implementation, in a `ValidationMessages.properties` file. The message is shown in the language specified with the locale setting for the form. The default language is English, but for example Hibernate Validator

contains translations of the messages for a number of languages. If other languages are needed, you need to provide a translation of the properties file.

## 8.5. Collecting Items in Containers

The **Container** interface is the highest containment level of the Vaadin data model, for containing items (rows) which in turn contain properties (columns). Containers can therefore represent tabular data, which can be viewed in a **Table** or some other selection component, as well as hierarchical data.

The items contained in a container are identified by an *item identifier* or *IID*, and the properties by a *property identifier* or *PID*.

### 8.5.1. Basic Use of Containers

The basic use of containers involves creating one, adding items to it, and binding it as a container data source of a component.

#### Default Containers and Delegation

Before saying anything about creation of containers, it should be noted that all components that can be bound to a container data source are by default bound to a default container. For example, **Table** is bound to a **IndexedContainer**, **Tree** to a **HierarchicalContainer**, and so forth.

All of the user interface components using containers also implement the relevant container interfaces themselves, so that the access to the underlying data source is delegated through the component.

```
// Create a table with one column
Table table = new Table("My Table");
table.addContainerProperty("col1", String.class, null);

// Access items and properties through the component
table.addItem("row1"); // Create item by explicit ID
Item item1 = table.getItem("row1");
Property property1 = item1.getItemProperty("col1");
property1.setValue("some given value");

// Equivalent access through the container
Container container = table.getContainerDataSource();
container.addItem("row2");
Item item2 = container.getItem("row2");
Property property2 = item2.getItemProperty("col1");
property2.setValue("another given value");
```

#### Creating and Binding a Container

A container is created and bound to a component as follows:

```
// Create a container of some type
Container container = new IndexedContainer();

// Initialize the container as required by the container type
container.addContainerProperty("name", String.class, "none");
container.addContainerProperty("volume", Double.class, 0.0);

... add items ...
```

```
// Bind it to a component
Table table = new Table("My Table");
table.setContainerDataSource(container);
```

Most components that can be bound to a container allow passing it also in the constructor, in addition to using `setContainerDataSource()`. Creation of the container depends on its type. For some containers, such as the **IndexedContainer**, you need to define the contained properties (columns) as was done above, while some others determine them otherwise. The definition of a property with `addContainerProperty()` requires a unique property ID, type, and a default value. You can also give `null`.

Vaadin has a several built-in in-memory container implementations, such as **IndexedContainer** and **BeanItemContainer**, which are easy to use for setting up nonpersistent data storages. For persistent data, either the built-in **SQLContainer** or the **JPAContainer** add-on container can be used.

## Adding Items and Accessing Properties

Items can be added to a container with the `addItem()` method. The parameterless version of the method automatically generates the item ID.

```
// Create an item
Object itemId = container.addItem();
```

Properties can be requested from container by first requesting an item with `getItem()` and then getting the properties from the item with `getItemProperty()`.

```
// Get the item object
Item item = container.getItem(itemId);

// Access a property in the item
Property<String> nameProperty =
    item.getItemProperty("name");

// Do something with the property
nameProperty.setValue("box");
```

You can also get a property directly by the item and property ids with `getContainerProperty()`.

```
container.getContainerProperty(itemId, "volume").setValue(5.0);
```

## Adding Items by Given ID

Some containers, such as **IndexedContainer** and **HierarchicalContainer**, allow adding items by a given ID, which can be any **Object**.

```
Item item = container.addItem("agivenid");
item.getItemProperty("name").setValue("barrel");
Item.getItemProperty("volume").setValue(119.2);
```

Notice that the actual item *is not* given as a parameter to the method, only its ID, as the interface assumes that the container itself creates all the items it contains. Some container implementations can provide methods to add externally created items, and they can even assume that the item ID object is also the item itself. Lazy containers might not create the item immediately, but lazily when it is accessed by its ID.

## 8.5.2. Container Subinterfaces

The **Container** interface contains inner interfaces that container implementations can implement to fulfill different features required by components that present container data.

### Container.Filterable

Filterable containers allow filtering the contained items by filters, as described in Section 8.5.7, “**Filterable** Containers”.

### Container.Hierarchical

Hierarchical containers allow representing hierarchical relationships between items and are required by the **Tree** and **TreeTable** components. The **HierarchicalContainer** is a built-in in-memory container for hierarchical data, and is used as the default container for the tree components. The **FilesystemContainer** provides access to browsing the content of a file system. Also **JPAContainer** is hierarchical, as described in Section 19.4.4, “Hierarchical Container”.

### Container.Indexed

An indexed container allows accessing items by an index number, not just their item ID. This feature is required by some components, especially **Table**, which needs to provide lazy access to large containers. The **IndexedContainer** is a basic in-memory implementation, as described in Section 8.5.3, “**IndexedContainer**”.

### Container.Ordered

An ordered container allows traversing the items in successive order in either direction. Most built-in containers are ordered.

### Container.SimpleFilterable

This interface enables filtering a container by string matching with `addContainerFilter()`. The filtering is done by either searching the given string anywhere in a property value, or as its prefix.

### Container.Sortable

A sortable container is required by some components that allow sorting the content, such as **Table**, where the user can click a column header to sort the table by the column. Some other components, such as **Calendar**, may require that the content is sorted to be able to display it properly. Depending on the implementation, sorting can be done only when the `sort()` method is called, or the container is automatically kept in order according to the last call of the method.

See the API documentation for a detailed description of the interfaces.

## 8.5.3. IndexedContainer

The **IndexedContainer** is an in-memory container that implements the **Indexed** interface to allow referencing the items by an index. **IndexedContainer** is used as the default container in most selection components in Vaadin.

The properties need to be defined with `addContainerProperty()`, which takes the property ID, type, and a default value. This must be done before any items are added to the container.

```
// Create the container
IndexedContainer container = new IndexedContainer();

// Define the properties (columns)
```

```
container.addContainerProperty("name", String.class, "noname");
container.addContainerProperty("volume", Double.class, -1.0d);

// Add some items
Object content[][] = {{ "jar", 2.0}, {"bottle", 0.75},
                      {"can", 1.5}};
for (Object[] row: content) {
    Item newItem = container.getItem(container.addItem());
    newItem.getItemProperty("name").setValue(row[0]);
    newItem.getItemProperty("volume").setValue(row[1]);
}
```

New items are added with `addItem()`, which returns the item ID of the new item, or by giving the item ID as a parameter as was described earlier. Note that the **Table** component, which has **IndexedContainer** as its default container, has a convenience `addItem()` method that allows adding items as object vectors containing the property values.

The container implements the `Container.Indexed` feature to allow accessing the item IDs by their index number, with `getIdByIndex()`, etc. The feature is required mainly for internal purposes of some components, such as **Table**, which uses it to enable lazy transmission of table data to the client-side.

#### 8.5.4. BeanContainer

The **BeanContainer** is an in-memory container for JavaBean objects. Each contained bean is wrapped inside a **BeanItem** wrapper. The item properties are determined automatically by inspecting the getter and setter methods of the class. This requires that the bean class has public visibility, local classes for example are not allowed. Only beans of the same type can be added to the container.

The generic has two parameters: a bean type and an item identifier type. The item identifiers can be obtained by defining a custom resolver, using a specific item property for the IDs, or by giving item IDs explicitly. As such, it is more general than the **BeanItemContainer**, which uses the bean object itself as the item identifier, making the use usually simpler. Managing the item IDs makes **BeanContainer** more complex to use, but it is necessary in some cases where the `equals()` or `hashCode()` methods have been reimplemented in the bean.

```
// Here is a JavaBean
public class Bean implements Serializable {
    String name;
    double energy; // Energy content in kJ/100g

    public Bean(String name, double energy) {
        this.name = name;
        this.energy = energy;
    }

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    public double getEnergy() {
        return energy;
    }
}
```

```
}

public void setEnergy(double energy) {
    this.energy = energy;
}
}

void basic(VerticalLayout layout) {
    // Create a container for such beans with
    // strings as item IDs.
    BeanContainer<String, Bean> beans =
        new BeanContainer<String, Bean>(Bean.class);

    // Use the name property as the item ID of the bean
    beans.setBeanIdProperty("name");

    // Add some beans to it
    beans.addBean(new Bean("Mung bean", 1452.0));
    beans.addBean(new Bean("Chickpea", 686.0));
    beans.addBean(new Bean("Lentil", 1477.0));
    beans.addBean(new Bean("Common bean", 129.0));
    beans.addBean(new Bean("Soybean", 1866.0));

    // Bind a table to it
    Table table = new Table("Beans of All Sorts", beans);
    layout.addComponent(table);
}
```

To use explicit item IDs, use the methods `addItem(Object, Object)`, `addItemAfter(Object, Object, Object)`, and `addItemAt(int, Object, Object)`.

It is not possible to add additional properties to the container, except properties in a nested bean.

## Nested Properties

If you have a nested bean with an 1:1 relationship inside a bean type contained in a **BeanContainer** or **BeanItemContainer**, you can add its properties to the container by specifying them with `addNestedContainerProperty()`. The feature is defined at the level of **AbstractBeanContainer**.

As with the bean in a bean container, also a nested bean must have public visibility or otherwise an access exception is thrown. An intermediate reference from a bean in the bean container to a nested bean may have a null value.

For example, let us assume that we have the following two beans with the first one nested inside the second one.

```
/** Bean to be nested */
public class EqCoord implements Serializable {
    double rightAscension; /* In angle hours */
    double declination;   /* In degrees */
    ...
    ... setters and getters for the properties ...
}

/** Bean referencing a nested bean */
public class Star implements Serializable {
    String name;
```

```
EqCoord equatorial; /* Nested bean */  
  
    ... setters and getters for the properties ...  
}
```

After creating the container, you can declare the nested properties by specifying their property identifiers with the `addNestedContainerProperty()` in dot notation.

```
// Create a container for beans  
BeanItemContainer<Star> stars =  
    new BeanItemContainer<Star>(Star.class);  
  
// Declare the nested properties to be used in the container  
stars.addNestedContainerProperty("equatorial.rightAscension");  
stars.addNestedContainerProperty("equatorial.declination");  
  
// Add some items  
stars.addBean(new Star("Sirius", new EqCoord(6.75, 16.71611)));  
stars.addBean(new Star("Polaris", new EqCoord(2.52, 89.26417)));  
  
// Here the nested bean reference is null  
stars.addBean(new Star("Vega", null));
```

If you bind such a container to a **Table**, you probably also need to set the column headers. Notice that the entire nested bean itself is still a property in the container and would be displayed in its own column. The `toString()` method is used for obtaining the displayed value, which is by default an object reference. You normally do not want this, so you can hide the column with `setVisibleColumns()`.

```
// Put them in a table  
Table table = new Table("Stars", stars);  
table.setColumnHeader("equatorial.rightAscension", "RA");  
table.setColumnHeader("equatorial.declination", "Decl");  
table.setPageLength(table.size());  
  
// Have to set explicitly to hide the "equatorial" property  
table.setVisibleColumns(new Object[]{ "name",  
    "equatorial.rightAscension", "equatorial.declination" });
```

The resulting table is shown in Figure 8.4, “**Table** Bound to a **BeanContainer** with Nested Properties”.

**Figure 8.4. Table Bound to a BeanContainer with Nested Properties**

name	RA	Decl
Sirius	6,75	16,716
Polaris	2,52	89,264
Vega		

The bean binding in **AbstractBeanContainer** normally uses the **MethodProperty** implementation of the **Property** interface to access the bean properties using the setter and getter methods. For nested properties, the **NestedMethodProperty** implementation is used.

### Defining a Bean ID Resolver

If a bean ID resolver is set using `setBeanIdResolver()` or `setBeanIdProperty()`, the methods `addBean()`, `addBeanAfter()`, `addBeanAt()` and `addAll()` can be used to add items to the container. If one of these methods is called, the resolver is used to generate an identifier for the item (must not return `null`).

Note that explicit item identifiers can also be used when a resolver has been set by calling the `addItem*` methods - the resolver is only used when adding beans using the `addBean*` or `addAll(Collection)` methods.

### 8.5.5. BeanItemContainer

**BeanItemContainer** is a container for JavaBean objects where each bean is wrapped inside a **BeanItem** wrapper. The item properties are determined automatically by inspecting the getter and setter methods of the class. This requires that the bean class has public visibility, local classes for example are not allowed. Only beans of the same type can be added to the container.

**BeanItemContainer** is a specialized version of the **BeanContainer** described in Section 8.5.4, “**BeanContainer**”. It uses the bean itself as the item identifier, which makes it a bit easier to use than **BeanContainer** in many cases. The latter is, however, needed if the bean has reimplemented the `equals()` or `hashCode()` methods.

Let us revisit the example given in Section 8.5.4, “**BeanContainer**” using the **BeanItemContainer**.

```
// Create a container for the beans
BeanItemContainer<Bean> beans =
    new BeanItemContainer<Bean>(Bean.class);

// Add some beans to it
beans.addBean(new Bean("Mung bean", 1452.0));
beans.addBean(new Bean("Chickpea", 686.0));
beans.addBean(new Bean("Lentil", 1477.0));
beans.addBean(new Bean("Common bean", 129.0));
beans.addBean(new Bean("Soybean", 1866.0));

// Bind a table to it
Table table = new Table("Beans of All Sorts", beans);
```

It is not possible to add additional properties to a **BeanItemContainer**, except properties in a nested bean, as described in Section 8.5.4, “**BeanContainer**”.

## 8.5.6. Iterating Over a Container

As the items in a **Container** are not necessarily indexed, iterating over the items has to be done using an **Iterator**. The `getItemIds()` method of **Container** returns a **Collection** of item identifiers over which you can iterate. The following example demonstrates a typical case where you iterate over the values of check boxes in a column of a **Table** component. The context of the example is the example used in Section 5.21, “**Table**”.

```
// Collect the results of the iteration into this string.
String items = "";

// Iterate over the item identifiers of the table.
for (Iterator i = table.getItemIds().iterator(); i.hasNext();) {
    // Get the current item identifier, which is an integer.
    int iid = (Integer) i.next();

    // Now get the actual item from the table.
    Item item = table.getItem(iid);

    // And now we can get to the actual checkbox object.
    Button button = (Button)
        (item.getItemProperty("ismember").getValue());

    // If the checkbox is selected.
    if ((Boolean)button.getValue() == true) {
        // Do something with the selected item; collect the
        // first names in a string.
        items += item.getItemProperty("First Name")
            .getValue() + " ";
    }
}

// Do something with the results; display the selected items.
layout.addComponent (new Label("Selected items: " + items));
```

Notice that the `getItemIds()` returns an *unmodifiable collection*, so the **Container** may not be modified during iteration. You can not, for example, remove items from the **Container** during iteration. The modification includes modification in another thread. If the **Container** is modified during iteration, a **ConcurrentModificationException** is thrown and the iterator may be left in an undefined state.

### 8.5.7. Filterable Containers

Containers that implement the **Container.Filterable** interface can be filtered. For example, the built-in **IndexedContainer** and the bean item containers implement it. Filtering is typically used for filtering the content of a **Table**.

Filters implement the **Filter** interface and you add them to a filterable container with the `addContainerFilter()` method. Container items that pass the filter condition are kept and shown in the filterable component.

```
Filter filter = new SimpleStringFilter("name",
    "Douglas", true, false);
table.addContainerFilter(filter);
```

If multiple filters are added to a container, they are evaluated using the logical AND operator so that only items that are passed by all the filters are kept.

#### Atomic and Composite Filters

Filters can be classified as *atomic* and *composite*. Atomic filters, such as **SimpleStringFilter**, define a single condition, usually for a specific container property. Composite filters make filtering decisions based on the result of one or more other filters. The built-in composite filters implement the logical operators AND, OR, or NOT.

For example, the following composite filter would filter out items where the `name` property contains the name "Douglas" somewhere or where the `age` property has value less than 42. The properties must have **String** and **Integer** types, respectively.

```
filter = new Or(new SimpleStringFilter("name",
    "Douglas", true, false),
    new Compare.Less("age", 42));
```

#### Built-In Filter Types

The built-in filter types are the following:

##### **SimpleStringFilter**

Passes items where the specified property, that must be of **String** type, contains the given `filterString` as a substring. If `ignoreCase` is `true`, the search is case insensitive. If the `onlyMatchPrefix` is `true`, the substring may only be in the beginning of the string, otherwise it may be elsewhere as well.

##### **IsNull**

Passes items where the specified property has null value. For in-memory filtering, a simple `==` check is performed. For other containers, the comparison implementation is container dependent, but should correspond to the in-memory null check.

##### **Equal, Greater, Less, GreaterOrEqual, and LessOrEqual**

The comparison filter implementations compare the specified property value to the given constant and pass items for which the comparison result is true. The comparison operators are included in the abstract **Compare** class.

For the **Equal** filter, the `equals()` method for the property is used in built-in in-memory containers. In other types of containers, the comparison is container dependent and may use, for example, database comparison operations.

For the other filters, the property value type must implement the **Comparable** interface to work with the built-in in-memory containers. Again for the other types of containers, the comparison is container dependent.

### And and Or

These logical operator filters are composite filters that combine multiple other filters.

### Not

The logical unary operator filter negates which items are passed by the filter given as the parameter.

## Implementing Custom Filters

A custom filter needs to implement the **Container.Filter** interface.

A filter can use a single or multiple properties for the filtering logic. The properties used by the filter must be returned with the `appliesToProperty()` method. If the filter applies to a user-defined property or properties, it is customary to give the properties as the first argument for the constructor of the filter.

```
class MyCustomFilter implements Container.Filter {
    protected String propertyId;
    protected String regex;

    public MyCustomFilter(String propertyId, String regex) {
        this.propertyId = propertyId;
        this.regex      = regex;
    }

    /** Tells if this filter works on the given property. */
    @Override
    public boolean appliesToProperty(Object propertyId) {
        return propertyId != null &&
               propertyId.equals(this.propertyId);
    }
}
```

The actual filtering logic is done in the `passesFilter()` method, which simply returns `true` if the item should pass the filter and `false` if it should be filtered out.

```
/** Apply the filter on an item to check if it passes. */
@Override
public boolean passesFilter(Object itemId, Item item)
    throws UnsupportedOperationException {
    // Acquire the relevant property from the item object
    Property p = item.getItemProperty(propertyId);

    // Should always check validity
    if (p == null || !p.getType().equals(String.class))
        return false;
    String value = (String) p.getValue();

    // The actual filter logic
```

```
        return value.matches(regex);
    }
}
```

You can use such a custom filter just like any other:

```
c.addContainerFilter(
    new MyCustomFilter( "Name" , (String) tf.getValue() ));
```



---

# Chapter 9

# Vaadin SQLContainer

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Vaadin SQLContainer is a container implementation that allows easy and customizable access to data stored in various SQL-speaking databases.

SQLContainer supports two types of database access. Using **TableQuery**, the pre-made query generators will enable fetching, updating, and inserting data directly from the container into a database table - automatically, whereas **FreeformQuery** allows the developer to use their own, probably more complex query for fetching data and their own optional implementations for writing, filtering and sorting support - item and property handling as well as lazy loading will still be handled automatically.

In addition to the customizable database connection options, SQLContainer also extends the Vaadin **Container** interface to implement more advanced and more database-oriented filtering

rules. Finally, the add-on also offers connection pool implementations for JDBC connection pooling and JEE connection pooling, as well as integrated transaction support; auto-commit mode is also provided.

The purpose of this section is to briefly explain the architecture and some of the inner workings of SQLContainer. It will also give the readers some examples on how to use SQLContainer in their own applications. The requirements, limitations and further development ideas are also discussed.

SQLContainer is available from the Vaadin Directory under the same unrestrictive Apache License 2.0 as the Vaadin Framework itself.

## 9.1. Architecture

The architecture of SQLContainer is relatively simple. **SQLContainer** is the class implementing the Vaadin **Container** interfaces and providing access to most of the functionality of this add-on. The standard Vaadin **Property** and **Item** interfaces have been implemented as the **ColumnProperty** and **RowItem** classes. Item IDs are represented by **RowId** and **TemporaryRowId** classes. The **RowId** class is built based on the primary key columns of the connected database table or query result.

In the connection package, the **JDBCConnectionPool** interface defines the requirements for a connection pool implementation. Two implementations of this interface are provided: **SimpleJDBCConnectionPool** provides a simple yet very usable implementation to pool and access JDBC connections. **J2EEConnectionPool** provides means to access J2EE DataSources.

The query package contains the **QueryDelegate** interface, which defines everything the SQLContainer needs to enable reading and writing data to and from a database. As discussed earlier, two implementations of this interface are provided: **TableQuery** for automatic read-write support for a database table, and **FreeformQuery** for customizing the query, sorting, filtering and writing; this is done by implementing relevant methods of the **FreeformStatementDelegate** interface.

The query package also contains **Filter** and **OrderBy** classes which have been written to provide an alternative to the standard Vaadin container filtering and make sorting non-String properties a bit more user friendly.

Finally, the generator package contains a **SQLGenerator** interface, which defines the kind of queries that are required by the **TableQuery** class. The provided implementations include support for HSQLDB, MySQL, PostgreSQL (**DefaultSQLGenerator**), Oracle (**OracleGenerator**) and Microsoft SQL Server (**MSSQLGenerator**). A new or modified implementations may be provided to gain compatibility with older versions or other database servers.

For further details, please refer to the SQLContainer API documentation.

## 9.2. Getting Started with SQLContainer

Getting development going with the SQLContainer is easy and quite straight-forward. The purpose of this section is to describe how to create the required resources and how to fetch data from and write data to a database table attached to the container.

### 9.2.1. Creating a connection pool

First, we need to create a connection pool to allow the SQLContainer to connect to a database. Here we will use the **SimpleJDBCConnectionPool**, which is a basic implementation of connection

pooling with JDBC data sources. In the following code, we create a connection pool that uses the HSQLDB driver together with an in-memory database. The initial amount of connections is 2 and the maximum amount is set at 5. Note that the database driver, connection url, username, and password parameters will vary depending on the database you are using.

```
JDBCConnectionPool pool = new SimpleJDBCConnectionPool(  
    "org.hsqldb.jdbc.JDBCDriver",  
    "jdbc:hsqldb:mem:sqlcontainer", "SA", "", 2, 5);
```

## 9.2.2. Creating the TableQuery Query Delegate

After the connection pool is created, we'll need a query delegate for the SQLContainer. The simplest way to create one is by using the built-in **TableQuery** class. The **TableQuery** delegate provides access to a defined database table and supports reading and writing data out-of-the-box. The primary key(s) of the table may be anything that the database engine supports, and are found automatically by querying the database when a new **TableQuery** is instantiated. We create the **TableQuery** with the following statement:

```
TableQuery tq = new TableQuery("tablename", connectionPool);
```

In order to allow writes from several user sessions concurrently, we must set a version column to the **TableQuery** as well. The version column is an integer- or timestamp-typed column which will either be incremented or set to the current time on each modification of the row. **TableQuery** assumes that the database will take care of updating the version column; it just makes sure the column value is correct before updating a row. If another user has changed the row and the version number in the database does not match the version number in memory, an **OptimisticLockException** is thrown and you can recover by refreshing the container and allow the user to merge the data. The following code will set the version column:

```
tq.setVersionColumn("OPTLOCK");
```

## 9.2.3. Creating the Container

Finally, we may create the container itself. This is as simple as stating:

```
SQLContainer container = new SQLContainer(tq);
```

After this statement, the **SQLContainer** is connected to the table tablename and is ready to use for example as a data source for a Vaadin **Table** or a Vaadin **Form**.

# 9.3. Filtering and Sorting

Filtering and sorting the items contained in an SQLContainer is, by design, always performed in the database. In practice this means that whenever the filtering or sorting rules are modified, at least some amount of database communication will take place (the minimum is to fetch the updated row count using the new filtering/sorting rules).

## 9.3.1. Filtering

Filtering is performed using the filtering API in Vaadin, which allows for very complex filtering to be easily applied. More information about the filtering API can be found in Section 8.5.7, “**Filterable Containers**”.

In addition to the filters provided by Vaadin, SQLContainer also implements the **Like** filter as well as the **Between** filter. Both of these map to the equally named WHERE-operators in SQL. The

filters can also be applied on items that reside in memory, for example, new items that have not yet been stored in the database or rows that have been loaded and updated, but not yet stored.

The following is an example of the types of complex filtering that are possible with the new filtering API. We want to find all people named Paul Johnson that are either younger than 18 years or older than 65 years and all Johnsons whose first name starts with the letter "A":

```
mySQLContainer.addContainerFilter(  
    new Or(new And(new Equal("NAME", "Paul"),  
        new Or(new Less("AGE", 18),  
            new Greater("AGE", 65))),  
        new Like("NAME", "A%")));  
mySQLContainer.addContainerFilter(  
    new Equal("LASTNAME", "Johnson"));
```

This will produce the following WHERE clause:

```
WHERE (( "NAME" = "Paul" AND ("AGE" < 18 OR "AGE" > 65) ) OR "NAME" LIKE "A%")  
AND "LASTNAME" = "Johnson"
```

### 9.3.2. Sorting

Sorting can be performed using standard Vaadin, that is, using the sort method from the **Container.Sortable** interface. The *propertyId* parameter refers to column names.

```
public void sort(Object[] propertyId, boolean[] ascending)
```

In addition to the standard method, it is also possible to directly add an **OrderBy** to the container via the `addOrderBy()` method. This enables the developer to insert sorters one by one without providing the whole array of them at once.

All sorting rules can be cleared by calling the sort method with null or an empty array as the first argument.

## 9.4. Editing

Editing the items (**RowItems**) of SQLContainer can be done similarly to editing the items of any Vaadin container. **ColumnProperties** of a **RowItem** will automatically notify SQLContainer to make sure that changes to the items are recorded and will be applied to the database immediately or on commit, depending on the state of the auto-commit mode.

### 9.4.1. Adding items

Adding items to an **SQLContainer** object can only be done via the `addItem()` method. This method will create a new **Item** based on the connected database table column properties. The new item will either be buffered by the container or committed to the database through the query delegate depending on whether the auto commit mode (see the next section) has been enabled.

When an item is added to the container it is impossible to precisely know what the primary keys of the row will be, or will the row insertion succeed at all. This is why the SQLContainer will assign an instance of **TemporaryRowId** as a **RowId** for the new item. We will later describe how to fetch the actual key after the row insertion has succeeded.

If auto-commit mode is enabled in the **SQLContainer**, the `addItem()` method will return the final **RowId** of the new item.

## 9.4.2. Fetching generated row keys

Since it is a common need to fetch the generated key of a row right after insertion, a listener/notifier has been added into the **QueryDelegate** interface. Currently only the **TableQuery** class implements the **RowIdChangeNotifier** interface, and thus can notify interested objects of changed row IDs. The events will be fired after `commit()` in **TableQuery** has finished; this method is called by **SQLContainer** when necessary.

To receive updates on the row IDs, you might use the following code (assuming container is an instance of **SQLContainer**). Note that these events are not fired if auto commit mode is enabled.

```
app.getDbHelp().getCityContainer().addListener(  
    new QueryDelegate.RowIdChangeListener() {  
        public void rowIdChange(RowIdChangeEvent event) {  
            System.out.println("Old ID: " + event.getOldRowId());  
            System.out.println("New ID: " + event.getNewRowId());  
        }  
    });
```

## 9.4.3. Version column requirement

If you are using the **TableQuery** class as the query delegate to the **SQLContainer** and need to enable write support, there is an enforced requirement of specifying a version column name to the **TableQuery** instance. The column name can be set to the **TableQuery** using the following statement:

```
tq.setVersionColumn("OPTLOCK");
```

The version column is preferably an integer or timestamp typed column in the table that is attached to the **TableQuery**. This column will be used for optimistic locking; before a row modification the **TableQuery** will check before that the version column value is the same as it was when the data was read into the container. This should ensure that no one has modified the row inbetween the current user's reads and writes.

Note! **TableQuery** assumes that the database will take care of updating the version column by either using an actual `VERSION` column (if supported by the database in question) or by a trigger or a similar mechanism.

If you are certain that you do not need optimistic locking, but do want to enable write support, you may point the version column to, for example, a primary key column of the table.

## 9.4.4. Auto-commit mode

**SQLContainer** is by default in transaction mode, which means that actions that edit, add or remove items are recorded internally by the container. These actions can be either committed to the database by calling `commit()` or discarded by calling `rollback()`.

The container can also be set to auto-commit mode. When this mode is enabled, all changes will be committed to the database immediately. To enable or disable the auto-commit mode, call the following method:

```
public void setAutoCommit(boolean autoCommitEnabled)
```

It is recommended to leave the auto-commit mode disabled, as it ensures that the changes can be rolled back if any problems are noticed within the container items. Using the auto-commit mode will also lead to failure in item addition if the database table contains non-nullable columns.

### 9.4.5. Modified state

When used in the transaction mode it may be useful to determine whether the contents of the **SQLContainer** have been modified or not. For this purpose the container provides an `isModified()` method, which will tell the state of the container to the developer. This method will return true if any items have been added to or removed from the container, as well as if any value of an existing item has been modified.

Additionally, each **RowItem** and each **ColumnProperty** have `isModified()` methods to allow for a more detailed view over the modification status. Do note that the modification statuses of **RowItem** and **ColumnProperty** objects only depend on whether or not the actual **Property** values have been modified. That is, they do not reflect situations where the whole **RowItem** has been marked for removal or has just been added to the container.

## 9.5. Caching, Paging and Refreshing

To decrease the amount of queries made to the database, **SQLContainer** uses internal caching for database contents. The caching is implemented with a size-limited **LinkedHashMap** containing a mapping from **RowIds** to **RowItems**. Typically developers do not need to modify caching options, although some fine-tuning can be done if required.

### 9.5.1. Container Size

The **SQLContainer** keeps continuously checking the amount of rows in the connected database table in order to detect external addition or removal of rows. By default, the table row count is assumed to remain valid for 10 seconds. This value can be altered from code; with `setSizeValidityMilliseconds()` in **SQLContainer**.

If the size validity time has expired, the row count will be automatically updated on:

- A call to `getItemIds()` method
- A call to `size()` method
- Some calls to `indexOfId(Object itemId)` method
- A call to `firstItemId()` method
- When the container is fetching a set of rows to the item cache (lazy loading)

### 9.5.2. Page Length and Cache Size

The page length of the **SQLContainer** dictates the amount of rows fetched from the database in one query. The default value is 100, and it can be modified with the `setPageLength()` method. To avoid constant queries it is recommended to set the page length value to at least 5 times the amount of rows displayed in a Vaadin **Table**; obviously, this is also dependent on the cache ratio set for the **Table** component.

The size of the internal item cache of the **SQLContainer** is calculated by multiplying the page length with the cache ratio set for the container. The cache ratio can only be set from the code, and the default value for it is 2. Hence with the default page length of 100 the internal cache size becomes 200 items. This should be enough even for larger **Tables** while ensuring that no huge amounts of memory will be used on the cache.

### 9.5.3. Refreshing the Container

Normally, the **SQLContainer** will handle refreshing automatically when required. However, there may be situations where an implicit refresh is needed, for example, to make sure that the version column is up-to-date prior to opening the item for editing in a form. For this purpose a `refresh()` method is provided. This method simply clears all caches, resets the current item fetching offset and sets the container size dirty. Any item-related call after this will inevitably result into row count and item cache update.

*Note that a call to the `refresh` method will not affect or reset the following properties of the container:*

- The **QueryDelegate** of the container
- Auto-commit mode
- Page length
- Filters
- Sorting

### 9.5.4. Cache Flush Notification Mechanism

Cache usage with databases in multiuser applications always results in some kind of a compromise between the amount of queries we want to execute on the database and the amount of memory we want to use on caching the data; and most importantly, risking the cached data becoming stale.

SQLContainer provides an experimental remedy to this problem by implementing a simple cache flush notification mechanism. Due to its nature these notifications are disabled by default but can be easily enabled for a container instance by calling `enableCacheFlushNotifications()` at any time during the lifetime of the container.

The notification mechanism functions by storing a weak reference to all registered containers in a static list structure. To minimize the risk of memory leaks and to avoid unlimited growing of the reference list, dead weak references are collected to a reference queue and removed from the list every time a **SQLContainer** is added to the notification reference list or a container calls the notification method.

When a **SQLContainer** has its cache notifications set enabled, it will call the static `notifyOfCacheFlush()` method giving itself as a parameter. This method will compare the notifier-container to all the others present in the reference list. To fire a cache flush event, the target container must have the same type of **QueryDelegate** (either **TableQuery** or **FreeformQuery**) and the table name or query string must match with the container that fired the notification. If a match is found the `refresh()` method of the matching container is called, resulting in cache flushing in the target container.

*Note: Standard Vaadin issues apply; even if the **SQLContainer** is refreshed on the server side, the changes will not be reflected to the UI until a server round-trip is performed, or unless a push mechanism is used.*

## 9.6. Referencing Another SQLContainer

When developing a database-connected application, there is usually a need to retrieve data related to one table from one or more other tables. In most cases, this relation is achieved with a foreign key reference, where a column of the first table contains a primary key or candidate key of a row in another table.

SQLContainer offers limited support for this kind of referencing relation, although all referencing is currently done on the Java side so no constraints need to be made in the database. A new reference can be created by calling the following method:

```
public void addReference(SQLContainer refdCont,  
                        String refingCol, String refdCol);
```

This method should be called on the source container of the reference. The target container should be given as the first parameter. The *refingCol* is the name of the 'foreign key' column in the source container, and the *refdCol* is the name of the referenced key column in the target container.

*Note: For any **SQLContainer**, all the referenced target containers must be different. You can not reference the same container from the same source twice.*

Handling the referenced item can be done through the three provided set/get methods, and the reference can be completely removed with the `removeReference()` method. Signatures of these methods are listed below:

```
public boolean setReferencedItem(Object itemId,  
                                 Object refdItemId, SQLContainer refdCont)  
public Object getReferencedItemId(Object itemId,  
                                   SQLContainer refdCont)  
public Item getReferencedItem(Object itemId,  
                             SQLContainer refdCont)  
public boolean removeReference(SQLContainer refdCont)
```

The setter method should be given three parameters: *itemId* is the ID of the referencing item (from the source container), *refdItemId* is the referenced *itemId* (from the target container) and *refdCont* is a reference to the target container that identifies the reference. This method returns true if the setting of the referenced item was successful. After setting the referenced item you must normally call `commit()` on the source container to persist the changes to the database.

The `getReferencedItemId()` method will return the item ID of the referenced item. As parameters this method needs the item ID of the referencing item and a reference to the target container as an identifier. **SQLContainer** also provides a convenience method `getReferencedItem()`, which directly returns the referenced item from the target container.

Finally, the referencing can be removed from the source container by calling the `removeReference()` method with the target container as parameter. Note that this does not actually change anything in the database; it merely removes the logical relation that exists only on the Java-side.

## 9.7. Making Freeform Queries

In most cases, the provided **TableQuery** will be enough to allow a developer to gain effortless access to an SQL data source. However there may arise situations when a more complex query with, for example, join expressions is needed. Or perhaps you need to redefine how the writing or filtering should be done. The **FreeformQuery** query delegate is provided for this exact purpose.

Out of the box the **FreeformQuery** supports read-only access to a database, but it can be extended to allow writing also.

## Getting started

Getting started with the **FreeformQuery** may be done as shown in the following. The connection pool initialization is similar to the **TableQuery** example so it is omitted here. Note that the name(s) of the primary key column(s) must be provided to the **FreeformQuery** manually. This is required because depending on the query the result set may or may not contain data about primary key columns. In this example, there is one primary key column with a name 'ID'.

```
FreeformQuery query = new FreeformQuery(  
    "SELECT * FROM SAMPLE", pool, "ID");  
SQLContainer container = new SQLContainer(query);
```

## Limitations

While this looks just as easy as with the **TableQuery**, do note that there are some important caveats here. Using **FreeformQuery** like this (without providing **FreeformQueryDelegate** or **FreeformStatementDelegate** implementation) it can only be used as a read-only window to the resultset of the query. Additionally filtering, sorting and lazy loading features will not be supported, and the row count will be fetched in quite an inefficient manner. Bearing these limitations in mind, it becomes quite obvious that the developer is in reality meant to implement the **FreeformQueryDelegate** or **FreeformStatementDelegate** interface.

The **FreeformStatementDelegate** interface is an extension of the **FreeformQueryDelegate** interface, which returns **StatementHelper** objects instead of pure query **Strings**. This enables the developer to use prepared statements instead of regular statements. It is highly recommended to use the **FreeformStatementDelegate** in all implementations. From this chapter onwards, we will only refer to the **FreeformStatementDelegate** in cases where **FreeformQueryDelegate** could also be applied.

## Creating your own FreeformStatementDelegate

To create your own delegate for **FreeformQuery** you must implement some or all of the methods from the **FreeformStatementDelegate** interface, depending on which ones your use case requires. The interface contains eight methods which are shown below. For more detailed requirements, see the JavaDoc documentation of the interface.

```
// Read-only queries  
public StatementHelper getCountStatement()  
public StatementHelper getQueryStatement(int offset, int limit)  
public StatementHelper getContainsRowQueryStatement(Object... keys)  
  
// Filtering and sorting  
public void setFilters(List<Filter> filters)  
public void setFilters(List<Filter> filters,  
                      FilteringMode filteringMode)  
public void setOrderBy(List<OrderBy> orderBys)  
  
// Write support  
public int storeRow(Connection conn, RowItem row)  
public boolean removeRow(Connection conn, RowItem row)
```

A simple demo implementation of this interface can be found in the SQLContainer package, more specifically in the class **com.vaadin.addon.sqlcontainer.demo.DemoFreeformQueryDelegate**.

## 9.8. Non-Implemented Methods

Due to the database connection inherent to the SQLContainer, some of the methods from the container interfaces of Vaadin can not (or would not make sense to) be implemented. These methods are listed below, and they will throw an **UnsupportedOperationException** on invocation.

```
public boolean addContainerProperty(Object propertyId,
                                    Class<?> type,
                                    Object defaultValue)
public boolean removeContainerProperty(Object propertyId)
public Item addItem(Object itemId)
public Object addItemAt(int index)
public Item addItemAt(int index, Object newItemId)
public Object addItemAfter(Object previousItemId)
public Item addItemAfter(Object previousItemId, Object newItemId)
```

Additionally, the following methods of the **Item** interface are not supported in the **RowItem** class:

```
public boolean addItemProperty(Object id, Property property)
public boolean removeItemProperty(Object id)
```

### About the `getIds()` method

To properly implement the Vaadin **Container** interface, a `getIds()` method has been implemented in the **SQLContainer**. By definition, this method returns a collection of all the item IDs present in the container. What this means in the **SQLContainer** case is that the container has to query the database for the primary key columns of all the rows present in the connected database table.

It is obvious that this could potentially lead to fetching tens or even hundreds of thousands of rows in an effort to satisfy the method caller. This will effectively kill the lazy loading properties of **SQLContainer** and therefore the following warning is expressed here:



#### Warning

It is highly recommended not to call the `getIds()` method, unless it is known that in the use case in question the item ID set will always be of reasonable size.

## 9.9. Known Issues and Limitations

At this point, there are still some known issues and limitations affecting the use of SQLContainer in certain situations. The known issues and brief explanations are listed below:

- Some SQL data types do not have write support when using TableQuery:
  - All binary types
  - All custom types
  - CLOB (if not converted automatically to a **String** by the JDBC driver in use)
  - See **com.vaadin.addon.sqlcontainer.query.generator.StatementHelper** for details.
- When using Oracle or MS SQL database, the column name "`rownum`" can not be used as a column name in a table connected to **SQLContainer**.

This limitation exists because the databases in question do not support limit/offset clauses required for paging. Instead, a generated column named 'rownum' is used to implement paging support.

The permanent limitations are listed below. These can not or most probably will not be fixed in future versions of SQLContainer.

- The `getIds()` method is very inefficient - avoid calling it unless absolutely required!
- When using **FreeformQuery** without providing a **FreeformStatementDelegate**, the row count query is very inefficient - avoid using **FreeformQuery** without implementing at least the count query properly.
- When using **FreeformQuery** without providing a **FreeformStatementDelegate**, writing, sorting and filtering will not be supported.
- When using Oracle database most or all of the numeric types are converted to **java.math.BigDecimal** by the Oracle JDBC Driver.

This is a feature of how Oracle DB and the Oracle JDBC Driver handles data types.



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# Chapter 10

# Visual User Interface Design with Eclipse

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This chapter provides instructions for developing the graphical user interface of Vaadin components with the Vaadin Plugin for the Eclipse IDE.

## 10.1. Overview

The visual editor feature in the Vaadin Plugin for Eclipse allows you to design the user interface of an entire application or of specific composite components. The plugin generates the actual Java code, which is designed to be reusable, so you can design the basic layout of the user interface with the visual editor and build the user interaction logic on top of the generated code. You can use inheritance and composition to modify the components further.

The editor works with classes that extend the **CustomComponent** class, which is the basic technique in Vaadin for creating composite components. Component composition is described

in Section 5.28, “Composition with **CustomComponent**”. Any **CustomComponent** will not do for the visual editor; you need to create a new one as instructed below.

## Using a Composite Component

You can use a composite component just as you would use any Vaadin component. However, the composite as well as its root layout, which is an **AbsoluteLayout**, are full size (100% wide and high) by default. A component with full size (expand-to-fit layout) may not normally be inside a layout with undefined size (shrink-to-fit content). For example, if you put a composite in a **VerticalLayout**, which has undefined height by default, you have to set the layout explicitly to have a defined height, either fixed or full (100%) height.

```
public class MyUI extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        // Create the content root layout for the UI  
        VerticalLayout content = new VerticalLayout();  
        setContent(content);  
  
        // Needed because the composites are full size  
        content.setSizeFull();  
  
        MyComposite myComposite = new MyComposite();  
        content.addComponent(myComposite);  
    }  
}
```

You could also set the size of the root layout of the composite to a fixed height (in component properties in the visual editor). The important thing to notice is that an **AbsoluteLayout** may never have undefined size.

## Installing the Visual Editor

The visual editor is currently included in the Vaadin Plugin for Eclipse. For its installation, see Section 2.4, “Installing Vaadin Plugin for Eclipse”.

The editor runs in an internal browser in Eclipse. The actual browser engine used depends on the operating system. Using the internal browser must be enabled in **Window Preferences General Web Browsers**.

In Ubuntu 12.04 and some other versions, no embedded browser engine is installed in the system by default. You can use at least Firefox XULRunner and WebKit. You can install WebKit as follows:

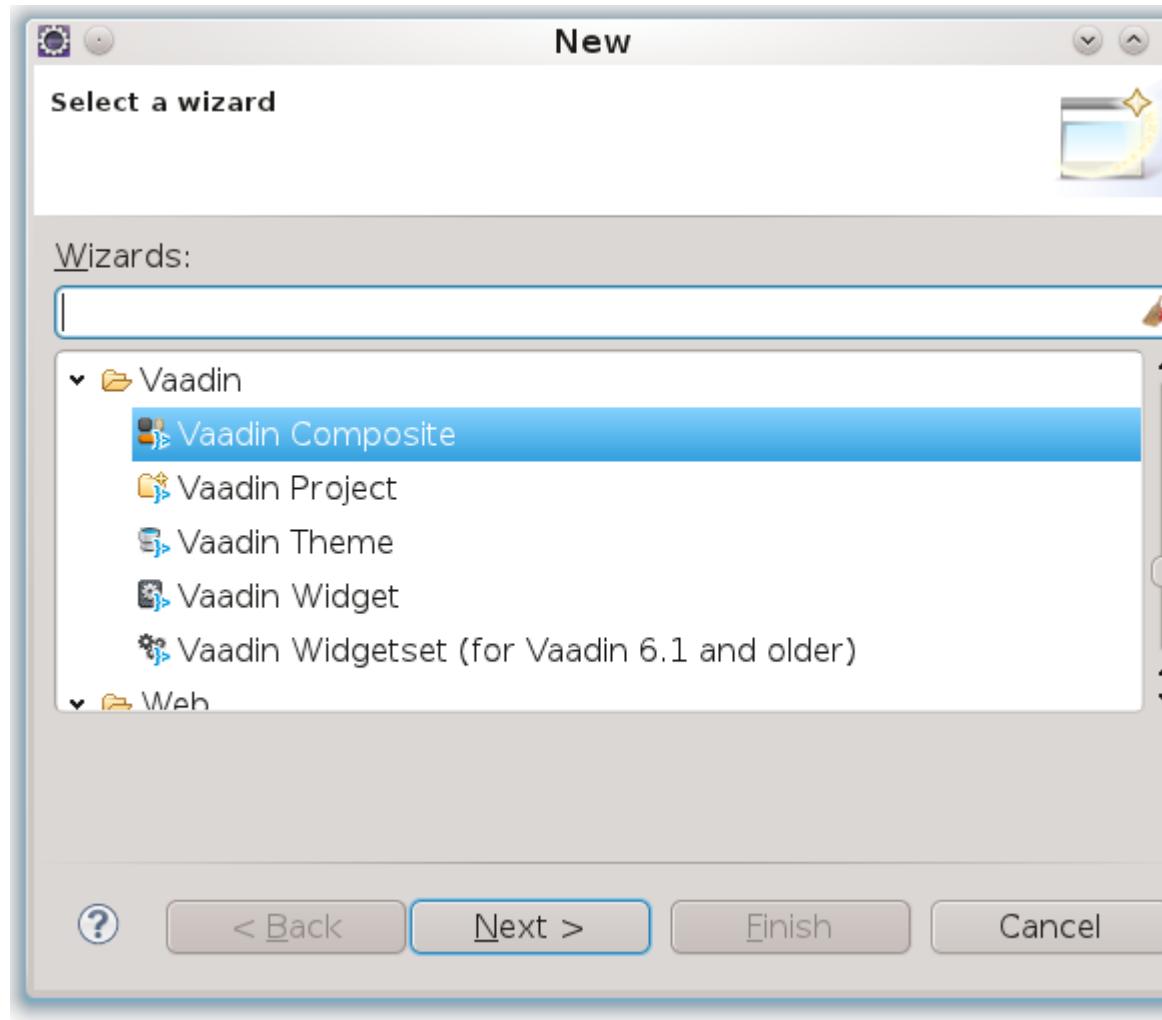
```
$ sudo apt-get install libwebkitgtk-1.0-0
```

Then, restart Eclipse and check that the internal browser is enabled.

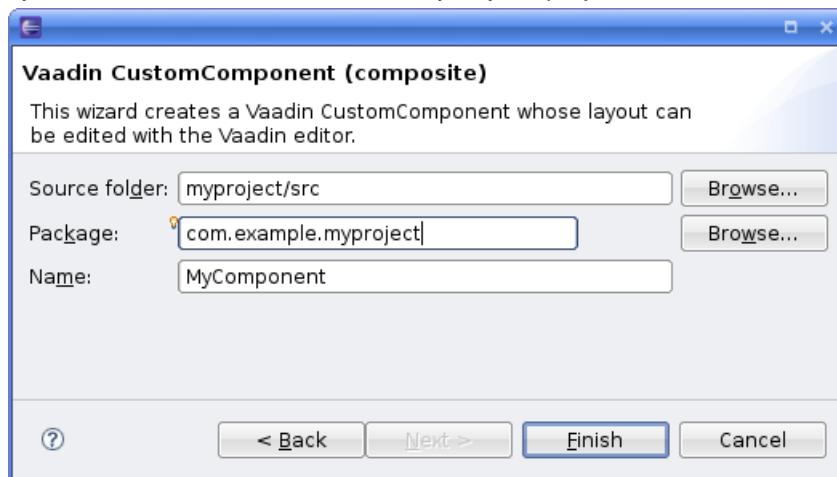
## 10.2. Creating a New Composite

If the Vaadin Plugin is installed in Eclipse, you can create a new composite component as follows.

1. Select **File New Other...** in the main menu or right-click the **Project Explorer** and select **New Other...** to open the **New** window.
2. In the first, **Select a wizard** step, select **Vaadin Vaadin Composite** and click **Next**.



3. The **Source folder** is the root source directory where the new component will be created. This is by default the default source directory of your project.

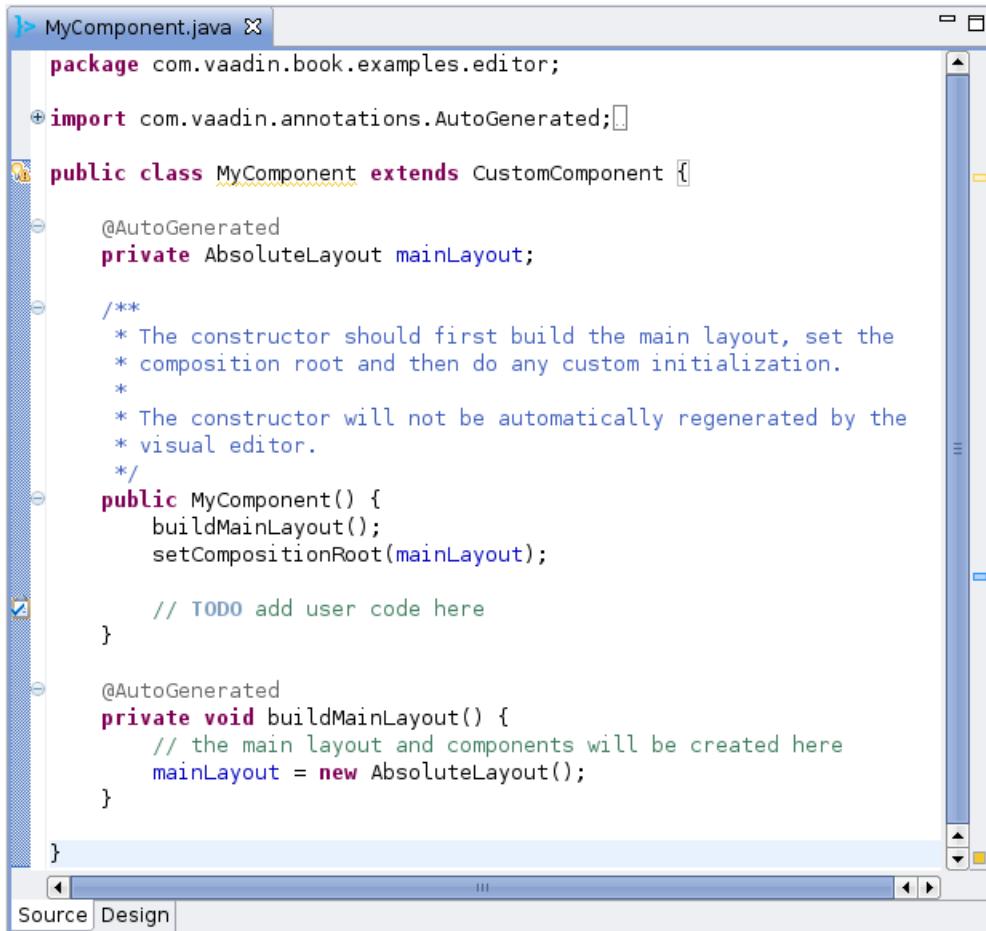


Enter the Java **Package** under which the new component class should be created or select it by clicking the **Browse** button. Also enter the class **Name** of the new component.

Finally, click **Finish** to create the component.

A newly created composite component is opened in the **Design** window, as shown in Figure 10.1, “New Composite Component”.

**Figure 10.1. New Composite Component**



The screenshot shows the Eclipse IDE interface with the following details:

- Title Bar:** Shows the file name "MyComponent.java".
- Source Editor:** Displays the Java code for "MyComponent.java".

```
package com.vaadin.book.examples.editor;

import com.vaadin.annotations.AutoGenerated;

public class MyComponent extends CustomComponent {

    @AutoGenerated
    private AbsoluteLayout mainLayout;

    /**
     * The constructor should first build the main layout, set the
     * composition root and then do any custom initialization.
     *
     * The constructor will not be automatically regenerated by the
     * visual editor.
     */
    public MyComponent() {
        buildMainLayout();
        setCompositionRoot(mainLayout);

        // TODO add user code here
    }

    @AutoGenerated
    private void buildMainLayout() {
        // the main layout and components will be created here
        mainLayout = new AbsoluteLayout();
    }
}
```
- Bottom Tabs:** Shows two tabs: "Source" and "Design".

You can observe that a component that you can edit with the visual editor has two tabs at the bottom of the view: **Source** and **Design**. These tabs allow switching between the source view and the visual design view.

If you later open the source file for editing, the **Source** and **Design** tabs should appear below the source editor. If they do not, right-click the file in the Project Explorer and select **Open With**.

## 10.3. Using The Visual Editor

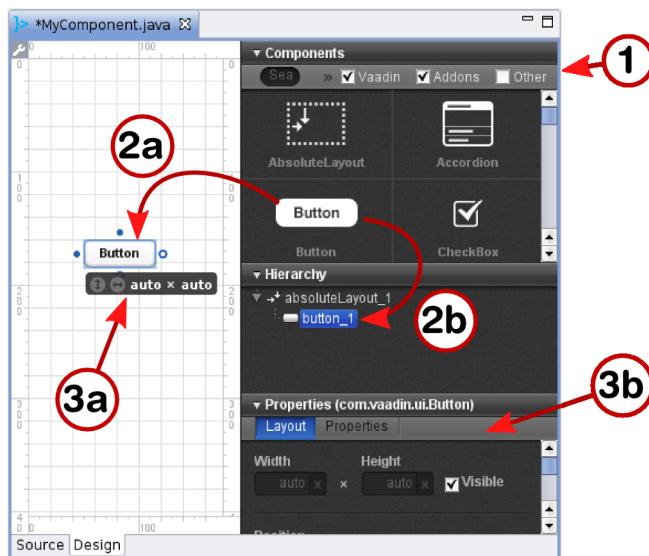
The visual editor view consists of, on the left side, an *editing area* that displays the current layout and, on the right side, a *control panel* that contains a *component list* for selecting new components to add, the current *component tree*, and a *component property panel*.

### 10.3.1. Adding New Components

Adding new components to the user interface is done as follows by dragging them from the component list to either the editing area or to the component tree. If you drag the components to the tree,

1. Select which components are shown in the component list by entering a search string or by expanding the filters and selecting only the desired component categories.
2. Drag a component from the component list to either:
  - a. Editing area, where you can easily move and resize the component. Dragging a component onto a layout component will add it in it and you can also position components within a layout by dragging them.
  - b. Component tree. Remember that you can only add components under a layout component or other component container.
3. Edit the component properties
  - a. In the editing area, you can move and resize the components, and set their alignment in the containing layout.
  - b. In the property panel, you can set the component name, size, position and other properties.

**Figure 10.2. Adding a New Component Node**



You can delete a component by right-clicking it in the component tree and selecting **Remove**. The context menu also allows copying and pasting components.

A composite component created by the plugin must have a **AbsoluteLayout** as its root layout. While it is suitable for the visual editor, absolute layouts are rarely used otherwise in Vaadin applications. If you want to use another root layout, you can add another layout inside the `mainLayout` and set that as the root with `setCompositionRoot()` in the source view. It will be used as the root when the component is actually used in an application.

### 10.3.2. Setting Component Properties

The property setting sub-panel of the control panel allows setting component properties. The panel has two tabs: **Layout** and **Properties**, where the latter defines the various basic properties.

#### Basic Properties

The top section of the property panel, shown in Figure 10.3, “Basic Component Properties”, allows setting basic component properties. The panel also includes properties such as field properties for field components.

**Figure 10.3. Basic Component Properties**



The properties are as follows:

##### Name

The name of the component, which is used for the reference to the component, so it must obey Java notation for variable names.

##### Style Name

A space-separated list of CSS style class names for the component. See Chapter 7, *Themes* for information on component styles in themes.

##### Caption

The caption of a component is usually displayed above the component. Some components, such as **Button**, display the caption inside the component. For **Label** text, you should set the value of the label instead of the caption, which should be left empty.

**Description (tooltip)**

The description is usually displayed as a tooltip when the mouse pointer hovers over the component for a while. Some components, such as **Form** have their own way of displaying the description.

**Icon**

The icon of a component is usually displayed above the component, left of the caption. Some components, such as **Button**, display the icon inside the component.

**Content Type**

Some components allow different content types, such as **Label**, which allow formatting either as **TEXT**, **HTML**, and **PREFORMATTED**.

**Value**

The component value. The value type and how it is displayed by the component varies between different component types and each value type has its own editor. The editor opens by clicking on the ... button.

Most of the basic component properties are defined in the **Component** interface; see Section 5.2.1, “**Component** Interface” for further details.

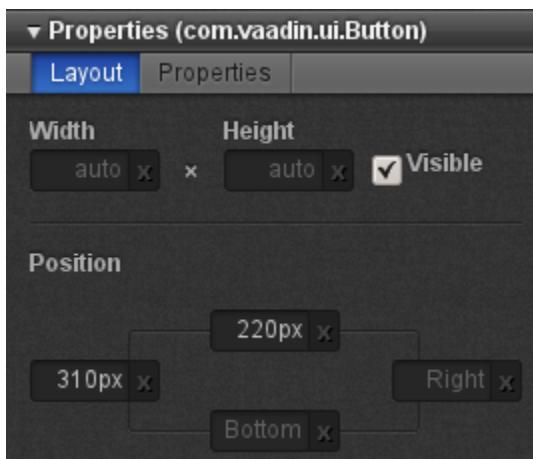
## Layout Properties

The size of a component is determined by its width and height, which you can give in the two edit boxes in the control panel. You can use any unit specifiers for components, as described in Section 5.3.9, “Sizing Components”. Emptying a size box will make the size “automatic”, which means setting the size as *undefined*. In the generated code, the undefined value will be expressed as “-1px”.

Setting width of “100px” and *auto* (undefined or empty) height would result in the following generated settings for a button:

```
// myButton  
myButton = new Button();  
...  
myButton.setHeight( "-1px" );  
myButton.setWidth( "100px" );  
...
```

Figure 10.4, “Layout Properties” shows the control panel area for the size and position.

**Figure 10.4. Layout Properties**

The generated code for the example would be:

```
// myButton  
myButton = new Button();  
myButton.setWidth("-1px");  
myButton.setHeight("-1px");  
myButton.setImmediate(true);  
myButton.setCaption("My Button");  
mainLayout.addComponent(myButton,  
    "top:243.0px;left:152.0px;" );
```

The position is given as a CSS position in the second parameter for `addComponent()`. The values "-1px" for width and height will make the button to be sized automatically to the minimum size required by the caption.

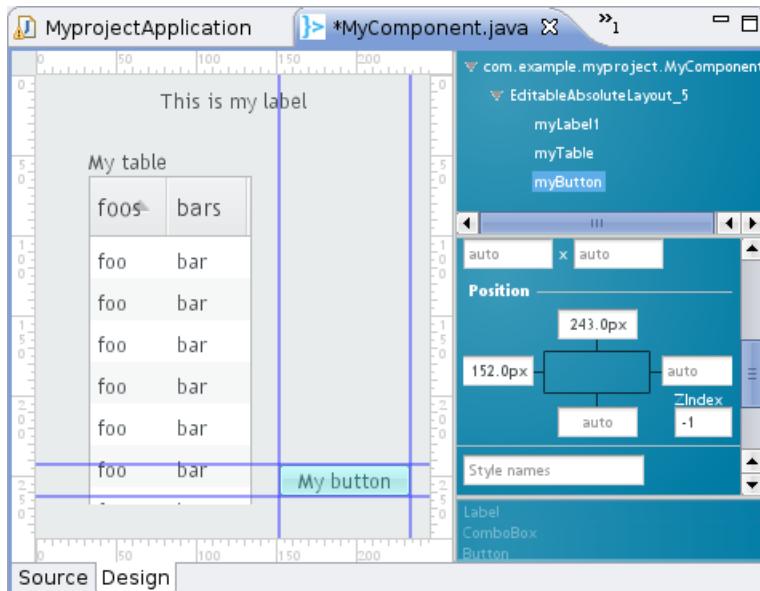
When editing the position of a component inside an **AbsoluteLayout**, the editor will display vertical and horizontal guides, which you can use to set the position of the component. See Section 10.3.3, “Editing an **AbsoluteLayout**” for more information about editing absolute layouts.

The **ZIndex** setting controls the “Z coordinate” of the components, that is, which component will overlay which when they overlap. Value -1 means automatic, in which case the components added to the layout later will be on top.

### 10.3.3. Editing an **AbsoluteLayout**

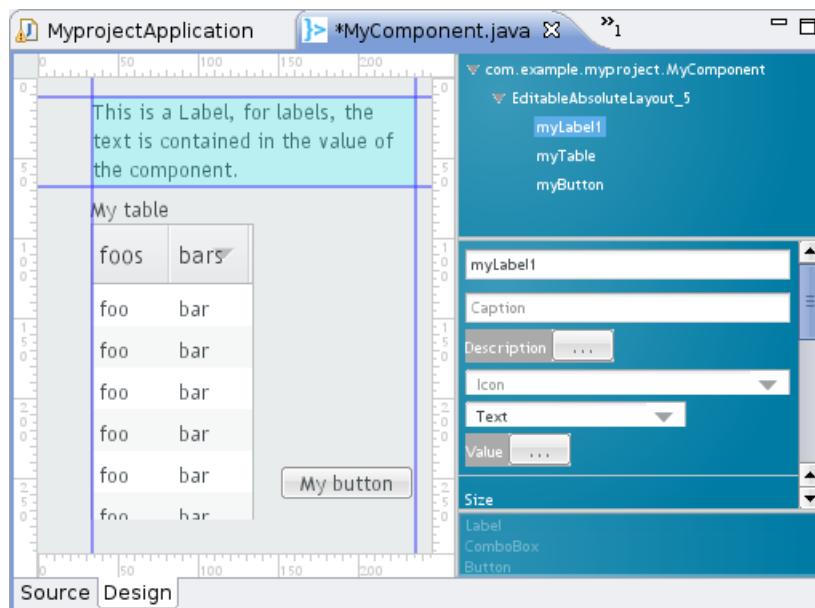
The visual editor has interactive support for the **AbsoluteLayout** component that allows positioning components exactly at specified coordinates. You can position the components using guides that control the position attributes, shown in the control panel on the right. The position values are measured in pixels from the corresponding edge; the vertical and horizontal rulers show the distances from the top and left edge.

Figure 10.5, “Positioning with **AbsoluteLayout**” shows three components, a **Label**, a **Table**, and a **Button**, inside an **AbsoluteLayout**.

**Figure 10.5. Positioning with AbsoluteLayout**

Position attributes that are empty are *automatic* and can be either zero (at the edge) or dynamic to make it shrink to fit the size of the component, depending on the component. Guides are shown also for the automatic position attributes and move automatically; in Figure 10.5, “Positioning with **AbsoluteLayout**” the right and bottom edges of the **Button** are automatic.

Moving an automatic guide manually makes the guide and the corresponding the position attribute non-automatic. To make a manually set attribute automatic, empty it in the control panel. Figure 10.6, “Manually positioned **Label**” shows a **Label** component with all the four edges set manually. Notice that if an automatic position is 0, the guide is at the edge of the ruler.

**Figure 10.6. Manually positioned Label**

## 10.4. Structure of a Visually Editable Component

A component created by the wizard and later managed by the visual editor has a very specific structure that allows you to insert your user interface logic in the component while keeping a minimal amount of code off-limits. You need to know what you can edit yourself and what exactly is managed by the editor. The managed member variables and methods are marked with the **AutoGenerated** annotation, as you can see later.

A visually editable component consists of:

- Member variables containing sub-component references
- Sub-component builder methods
- The constructor

The structure of a composite component is hierarchical, a nested hierarchy of layout components containing other layout components as well as regular components. The root layout of the component tree, or the *composition root* of the **CustomComponent**, is named `mainLayout`. See Section 5.28, “Composition with **CustomComponent**” for a detailed description of the structure of custom (composite) components.

### 10.4.1. Sub-Component References

The **CustomComponent** class will include a reference to each contained component as a member variable. The most important of these is the `mainLayout` reference to the composition root layout. Such automatically generated member variables are marked with the `@AutoGenerated` annotation. They are managed by the editor, so you should not edit them manually, unless you know what you are doing.

A composite component with an **AbsoluteLayout** as the composition root, containing a **Button** and a **Table** would have the references as follows:

```
public class MyComponent extends CustomComponent {  
  
    @AutoGenerated  
    private AbsoluteLayout mainLayout;  
    @AutoGenerated  
    private Button myButton;  
    @AutoGenerated  
    private Table myTable;  
    ...  
}
```

The names of the member variables are defined in the component properties panel of the visual editor, in the **Component name** field, as described in the section called “Basic Properties”. While you can change the name of any other components, the name of the root layout is always `mainLayout`. It is fixed because the editor does not make changes to the constructor, as noted in Section 10.4.3, “The Constructor”. You can, however, change the type of the root layout, which is an **AbsoluteLayout** by default.

Certain typically static components, such as the **Label** label component, will not have a reference as a member variable. See the description of the builder methods below for details.

## 10.4.2. Sub-Component Builders

Every managed layout component will have a builder method that creates the layout and all its contained components. The builder puts references to the created components in their corresponding member variables, and it also returns a reference to the created layout component.

Below is an example of an initial main layout:

```
@AutoGenerated
private AbsoluteLayout buildMainLayout() {
    // common part: create layout
    mainLayout = new AbsoluteLayout();

    // top-level component properties
    setHeight("100.0%");
    setWidth("100.0%");

    return mainLayout;
}
```

Notice that while the builder methods return a reference to the created component, they also write the reference directly to the member variable. The returned reference might not be used by the generated code at all (in the constructor or in the builder methods), but you can use it for your purposes.

The builder of the main layout is called in the constructor, as explained in Section 10.4.3, “The Constructor”. When you have a layout with nested layout components, the builders of each layout will call the appropriate builder methods of their contained layouts to create their contents.

## 10.4.3. The Constructor

When you create a new composite component using the wizard, it will create a constructor for the component and fill its basic content.

```
public MyComponent() {
    buildMainLayout();
    setCompositionRoot(mainLayout);

    // TODO add user code here
}
```

The most important thing to do in the constructor is to set the composition root of the **Custom-Component** with the `setCompositionRoot()` (see Section 5.28, “Composition with **Custom-Component**” for more details on the composition root). The generated constructor first builds the root layout of the composite component with `buildMainLayout()` and then uses the `mainLayout` reference.

The editor will not change the constructor afterwards, so you can safely change it as you want. The editor does not allow changing the member variable holding a reference to the root layout, so it is always named `mainLayout`.



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# Chapter 11

# Advanced Web Application Topics

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This chapter covers various features and topics often needed in applications.

## 11.1. Handling Browser Windows

The UI of a Vaadin application runs in a web page displayed in a browser window or tab. An application can be used from multiple UIs in different windows or tabs, either opened by the user using an URL or by the Vaadin application.

In addition to native browser windows, Vaadin has a **Window** component, which is a floating panel or *sub-window* inside a page, as described in Section 6.7, “Sub-Windows”.

- *Native popup windows*. An application can open popup windows for sub-tasks.
- *Page-based browsing*. The application can allow the user to open certain content to different windows. For example, in a messaging application, it can be useful to open different messages to different windows so that the user can browse through them while writing a new message.
- *Bookmarking*. Bookmarks in the web browser can provide an entry-point to some content provided by an application.
- *Embedding UIs*. UIs can be embedded in web pages, thus making it possible to provide different views to an application from different pages or even from the same page, while keeping the same session. See Section 11.2, “Embedding UIs in Web Pages”.

Use of multiple windows in an application may require defining and providing different UIs for the different windows. The UIs of an application share the same user session, that is, the **VaadinSession** object, as described in Section 4.7.3, “User Session”. Each UI is identified by a URL that is used to access it, which makes it possible to bookmark application UIs. UI instances can even be created dynamically based on the URLs or other request parameters, such as browser information, as described in Section 4.7.4, “Loading a UI”.

Because of the special nature of AJAX applications, use of multiple windows uses require some caveats.

### 11.1.1. Opening Popup Windows

Popup windows are native browser windows or tabs opened by user interaction with an existing window. Due to browser security reasons, it is made inconvenient for a web page to open popup windows using JavaScript commands. At least, the browser will ask for a permission to open the popup, if it is possible at all. This limitation can be circumvented by letting the browser open the new window or tab directly by its URL when the user clicks some target. This is realized in Vaadin with the **BrowserWindowOpener** component extension, which causes the browser to open a window or tab when the component is clicked.

#### The Popup Window UI

A popup Window displays an **UI**. The UI of a popup window is defined just like a main UI in a Vaadin application, and it can have a theme, title, and so forth.

For example:

```
@Theme( "book-examples" )
public static class MyPopupUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        getPage().setTitle("Popup Window");
```

```
// Have some content for it
VBoxLayout content = new VerticalLayout();
Label label =
    new Label("I just popped up to say hi!");
label.setSizeUndefined();
content.addComponent(label);
content.setComponentAlignment(label,
    Alignment.MIDDLE_CENTER);
content.setSizeFull();
setContent(content);
}
}
```

## Popping It Up

A popup window is opened using the **BrowserWindowOpener** extension, which you can attach to any component. The constructor of the extension takes the class object of the UI class to be opened as a parameter.

You can configure the features of the popup window with `setFeatures()`. It takes as its parameter a comma-separated list of window features, as defined in the HTML specification.

```
status=0/1
    Whether the status bar at the bottom of the window should be enabled.

scrollbars
    Enables scrollbars in the window if the document area is bigger than the view area of
    the window.

resizable
    Allows the user to resize the browser window (no effect for tabs).

menubar
    Enables the browser menu bar.

location
    Enables the location bar.

toolbar
    Enables the browser toolbar.

height=value
    Specifies the height of the window in pixels.

width=value
    Specifies the width of the window in pixels.
```

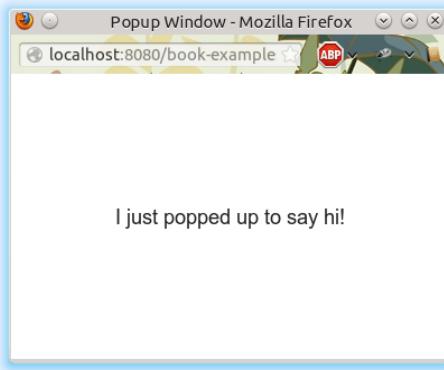
For example:

```
// Create an opener extension
BrowserWindowOpener opener =
    new BrowserWindowOpener(MyPopupUI.class);
opener.setFeatures("height=200,width=300,resizable");

// Attach it to a button
Button button = new Button("Pop It Up");
opener.extend(button);
```

The resulting popup window, which appears when the button is clicked, is shown in Figure 11.1, “A Popup Window”.

**Figure 11.1. A Popup Window**



## Popup Window Name (Target)

The target name is one of the default HTML target names (`_new`, `_blank`, `_top`, etc.) or a custom target name. How the window is exactly opened depends on the browser. Browsers that support tabbed browsing can open the window in another tab, depending on the browser settings.

## URL and Session

The URL path for a popup window UI is by default determined from the UI class name, by prefixing it with "popup/". For example, for the example UI given earlier, the URL would be `/book-examples/book/popup/MyPopupUI`.

### 11.1.2. Closing Popup Windows

Besides closing popup windows from a native window close button, you can close them programmatically by calling the JavaScript `close()` method as follows.

```
public class MyPopup extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        setContent(new Button("Close Window", event -> { // Java 8  
            // Close the popup  
            JavaScript.eval("close()");  
  
            // Detach the UI from the session  
            getUI().close();  
        }));  
    }  
}
```

## 11.2. Embedding UIs in Web Pages

Many web sites are not all Vaadin, but Vaadin UIs are used only for specific functionalities. In practice, many web applications are a mixture of dynamic web pages, such as JSP, and Vaadin UIs embedded in such pages.

Embedding Vaadin UIs in web pages is easy and there are several different ways to embed them. One is to have a `<div>` placeholder for the UI and load the Vaadin Client-Side Engine with some simple JavaScript code. Another method is even easier, which is to simply use the `<iframe>` element. Both of these methods have advantages and disadvantages. One disadvantage of the `<iframe>` method is that the size of the `<iframe>` element is not flexible according to the content while the `<div>` method allows such flexibility. The following sections look closer into these two embedding methods.

### 11.2.1. Embedding Inside a `div` Element

You can embed one or more Vaadin UIs inside a web page with a method that is equivalent to loading the initial page content from the Vaadin servlet in a non-embedded UI. Normally, the **VaadinServlet** generates an initial page that contains the correct parameters for the specific UI. You can easily configure it to load multiple Vaadin UIs in the same page. They can have different widget sets and different themes.

Embedding an UI requires the following basic tasks:

- Set up the page header
- Include a GWT history frame in the page
- Call the `vaadinBootstrap.js` file
- Define the `<div>` element for the UI
- Configure and initialize the UI

Notice that you can view the loader page for the UI easily by opening the UI in a web browser and viewing the HTML source code of the page. You could just copy and paste the embedding code from the page, but some modifications and additional settings are required, mainly related to the URLs that have to be made relative to the page instead of the servlet URL.

*The DIV embedding API is about to change soon after printing this book edition. A tutorial that describes the feature should be made available at the Vaadin website.*

### The Head Matter

The HTML page in which the Vaadin UI is embedded should be a valid HTML 5 document. The content of the head element is largely up to you. The character encoding must be UTF-8. Some meta declarations are necessary for compatibility. You can also set the page favicon in the head element.

```
<!DOCTYPE html>
<html>
  <head>
    <meta http-equiv="Content-Type"
          content="text/html; charset=UTF-8" />
    <meta http-equiv="X-UA-Compatible"
          content="IE=9;chrome=1" />

    <title>This is my Embedding Page</title>

    <!-- Set up the favicon from the Vaadin theme -->
    <link rel="shortcut icon" type="image/vnd.microsoft.icon"
          href="/VAADIN/themes/reindeer/favicon.ico" />
```

```
<link rel="icon" type="image/vnd.microsoft.icon"
      href="/VAADIN/themes/reindeer/favicon.ico" />
</head>
```

## The Body Matter

The page content must include some Vaadin-related definitions before you can embed Vaadin UIs in it.

The `vaadinBootstrap.js` script makes definitions for starting up the UI. It must be called before initializing the UI. The source path must be relative to the path of the embedding page.

```
<body>
  <script type="text/javascript"
    src=".//VAADIN/vaadinBootstrap.js"></script>
```

The bootstrap script is served by the Vaadin servlet from inside the `vaadin-server` JAR.

Vaadin, or more precisely GWT, requires an invisible history frame, which is used for tracking the page or fragment history in the browser.

```
<iframe tabindex="-1" id="__gwt_historyFrame"
  style="position: absolute; width: 0; height: 0;
         border: 0; overflow: hidden"
  src="javascript:false"></iframe>
```

## UI Placeholder Element

A Vaadin UI is embedded in a placeholder `<div>` element. It should have the following features:

- The `<div>` element must have an `id` attribute, which must be a unique ID in the page, normally something that identifies the servlet of the UI uniquely.
- It must have at least the `v-app` style class.
- it should have a nested `<div>` element with `v-app-loading` style class. This is a placeholder for the loading indicator that is displayed while the UI is being loaded.
- It should also contain a `<noscript>` element that is shown if the browser does not support JavaScript or it has been disabled. The content of the element should instruct the user to enable JavaScript in the browser.

The placeholder element can include style settings, typically a width and height. If the sizes are not defined, the UI will have an undefined size in the particular dimension, which must be in accordance with the sizing of the UI components.

For example:

```
<div style="width: 300px; border: 2px solid green;">
  id="helloworldui" class="v-app">
    <div class="v-app-loading"></div>
    <noscript>You have to enable javascript in your browser to
           use an application built with Vaadin.</noscript>
  </div>
```

## Initializing the UI

The UI is loaded by calling the `initApplication()` method for the `vaadin` object defined in the bootstrap script. Before calling it, you should check that the bootstrap script was loaded properly.

```
<script type="text/javascript"> //<![CDATA[  
if (!window.vaadin)  
    alert("Failed to load the bootstrap JavaScript: "+  
        "VAADIN/vaadinBootstrap.js");
```

The `initApplication()` takes two parameters. The first parameter is the UI identifier, exactly as given as the `id` attribute of the placeholder element. The second parameter is an associative map that contains parameters for the UI.

The map must contain the following items:

*browserDetailsUrl*

This should be the URL path (relative to the embedding page) to the Vaadin servlet of the UI. It is used by the bootstrap to communicate browser details. A trailing slash may be needed in some cases.

Notice that this parameter is not included in the loader page generated by the servlet, because in that case, it can default to the current URL.

*serviceUrl*

This is used for server requests after initial loading and should be same as for `browserDetailsUrl`. The two parameters are redundant and either may be removed in future.

*widgetset*

This should be the exact class name of the widget set for the UI, that is, without the `.gwt.xml` file name extension. If the UI has no custom widget set, you can use the **com.vaadin.DefaultWidgetSet**.

*theme*

Name of the theme, such as one of the built-in themes (`reindeer`, `runo`, or `chameleon`) or a custom theme. It must exist under the `VAADIN/themes` folder.

*versionInfo*

This parameter is itself an associative map that can contain two parameters: `vaadin-Version` contains the version number of the Vaadin version used by the application. The `applicationVersion` parameter contains the version of the particular application. The contained parameters are optional, but the `versionInfo` parameter itself is not.

*vaadinDir*

Relative path to the `VAADIN` directory. It is relative to the URL of the embedding page.

*heartbeatInterval*

The `heartbeatInterval` parameter defines the frequency of the keep-alive heartbeat for the UI in seconds, as described in Section 4.7.5, “UI Expiration”.

*debug*

The parameter defines whether the debug window, as described in Section 11.3, “Debug Mode and Window”, is enabled.

**standalone**

This parameter should be *false* when embedding. The parameter defines whether the UI is rendered on its own in the browser window or in some context. A standalone UI may do things that might interfere with other parts of the page, such as change the page title and request focus when it is loaded. When embedding, the UI is not standalone.

**authErrMsg, comErrMsg, and sessExpMsg**

These three parameters define the client-side error messages for authentication error, communication error, and session expiration, respectively. The parameters are associative maps themselves and must contain two key-value pairs: *message*, which should contain the error text in HTML, and *caption*, which should be the error caption.

For example:

```
vaadin.initApplication("helloworldui", {
    "browserDetailsUrl": "helloworld/",
    "serviceUrl": "helloworld/",
    "widgetset": "com.example.MyWidgetSet",
    "theme": "mytheme",
    "versionInfo": { "vaadinVersion": "7.0.0" },
    "vaadinDir": "VAADIN/",
    "heartbeatInterval": 300,
    "debug": true,
    "standalone": false,
    "authErrMsg": {
        "message": "Take note of any unsaved data, "+
                    "and <u>click here</u> to continue.",
        "caption": "Authentication problem"
    },
    "comErrMsg": {
        "message": "Take note of any unsaved data, "+
                    "and <u>click here</u> to continue.",
        "caption": "Communication problem"
    },
    "sessExpMsg": {
        "message": "Take note of any unsaved data, "+
                    "and <u>click here</u> to continue.",
        "caption": "Session Expired"
    }
}); //]]>
</script>
```

Notice that many of the parameters are normally deployment parameters, specified in the deployment descriptor, as described in Section 4.8.6, “Other Servlet Configuration Parameters”.

## Summary of Div Embedding

Below is a complete example of embedding an UI in a `<div>` element.

```
<?xml version="1.0" encoding="UTF-8" ?>
<!DOCTYPE html>
<html>
<head>
    <meta http-equiv="Content-Type"
          content="text/html; charset=UTF-8" />
    <meta http-equiv="X-UA-Compatible"
          content="IE=9;chrome=1" />
```

```
<title>Embedding a Vaadin Application in HTML Page</title>

<!-- Set up the favicon from the Vaadin theme -->
<link rel="shortcut icon" type="image/vnd.microsoft.icon"
      href="/VAADIN/themes/reindeer/favicon.ico" />
<link rel="icon" type="image/vnd.microsoft.icon"
      href="/VAADIN/themes/reindeer/favicon.ico" />
</head>

<body>
<!-- Loads the Vaadin widget set, etc. -->
<script type="text/javascript"
       src="VAADIN/vaadinBootstrap.js"></script>

<!-- GWT requires an invisible history frame. It is    -->
<!-- needed for page/fragment history in the browser. -->
<iframe tabindex="-1" id="__gwt_historyFrame"
        style="position: absolute; width: 0; height: 0;
               border: 0; overflow: hidden"
        src="javascript:false"></iframe>

<h1>Embedding a Vaadin UI</h1>

<p>This is a static web page that contains an embedded Vaadin
   application. It's here:</p>

<!-- So here comes the div element in which the Vaadin -->
<!-- application is embedded.                         -->
<div style="width: 300px; border: 2px solid green;">
  <!-- Optional placeholder for the loading indicator -->
  <div class="v-app-loading"></div>

  <!-- Alternative fallback text -->
  <noscript>You have to enable javascript in your browser to
           use an application built with Vaadin.</noscript>
</div>

<script type="text/javascript">//<![CDATA[
  if (!window.vaadin)
    alert("Failed to load the bootstrap JavaScript: "+
         "VAADIN/vaadinBootstrap.js");

  /* The UI Configuration */
  vaadin.initApplication("helloworld", {
    "browserDetailsUrl": "helloworld/",
    "serviceUrl": "helloworld/",
    "widgetset": "com.example.MyWidgetSet",
    "theme": "mytheme",
    "versionInfo": {"vaadinVersion": "7.0.0"},
    "vaadinDir": "VAADIN/",
    "heartbeatInterval": 300,
    "debug": true,
    "standalone": false,
    "authErrMsg": {
      "message": "Take note of any unsaved data, "+
                 "and <u>click here</u> to continue.",
      "caption": "Authentication problem"
    }
  });
</script>
```

```
        },
        "comErrMsg": {
            "message": "Take note of any unsaved data, "+
                        "and <u>click here</u> to continue.",
            "caption": "Communication problem"
        },
        "sessExpMsg": {
            "message": "Take note of any unsaved data, "+
                        "and <u>click here</u> to continue.",
            "caption": "Session Expired"
        }
    } ) ;//]]>
</script>

<p>Please view the page source to see how embedding works.</p>
</body>
</html>
```

## 11.2.2. Embedding Inside an `iframe` Element

Embedding a Vaadin UI inside an `<iframe>` element is even easier than the method described above, as it does not require definition of any Vaadin specific definitions.

You can embed an UI with an element such as the following:

```
<iframe src="/myapp/myui"></iframe>
```

The `<iframe>` elements have several downsides for embedding. One is that their size of is not flexible depending on the content of the frame, but the content must be flexible to accommodate in the frame. You can set the size of an `<iframe>` element with `height` and `width` attributes. Other issues arise from themeing and communication with the frame content and the rest of the page.

Below is a complete example of using the `<iframe>` to embed two applications in a web page.

```
<!DOCTYPE html>
<html>
    <head>
        <title>Embedding in IFrame</title>
    </head>

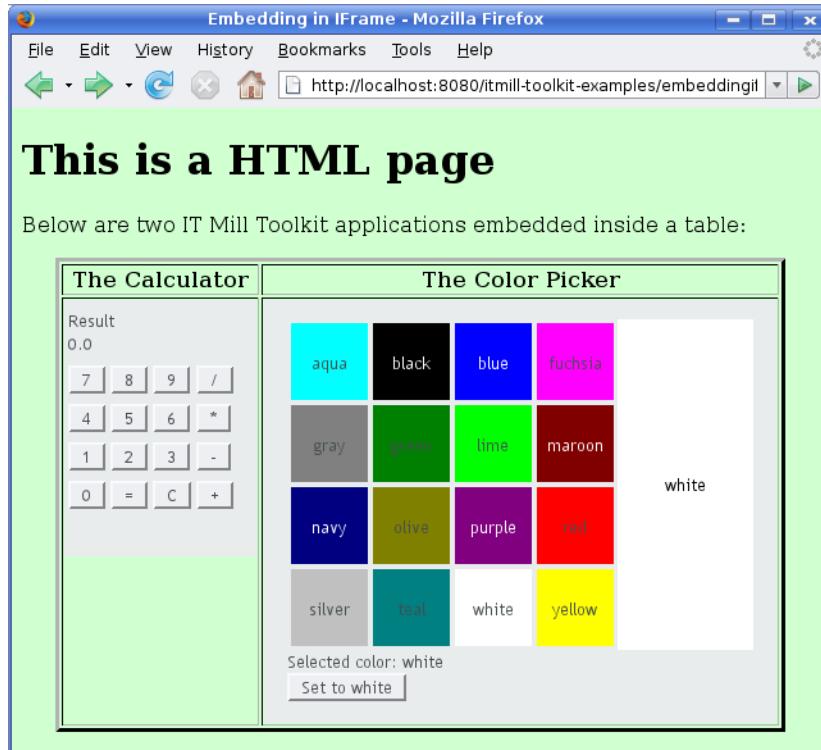
    <body style="background: #d0ffd0;">
        <h1>This is a HTML page</h1>
        <p>Below are two Vaadin applications embedded inside
           a table:</p>

        <table align="center" border="3">
            <tr>
                <th>The Calculator</th>
                <th>The Color Picker</th>
            </tr>
            <tr valign="top">
                <td>
                    <iframe src="/vaadin-examples/Calc" height="200"
                           width="150" frameborder="0"></iframe>
                </td>
                <td>
                    <iframe src="/vaadin-examples/colorpicker"
                           height="330" width="400"></iframe>
                </td>
            </tr>
        </table>
    </body>
</html>
```

```
        frameborder="0">></iframe>
    </td>
</tr>
</table>
</body>
</html>
```

The page will look as shown in Figure 11.2, “Vaadin Applications Embedded Inside IFrames” below.

**Figure 11.2. Vaadin Applications Embedded Inside IFrames**



You can embed almost anything in an iframe, which essentially acts as a browser window. However, this creates various problems. The iframe must have a fixed size, inheritance of CSS from the embedding page is not possible, and neither is interaction with JavaScript, which makes mashups impossible, and so on. Even bookmarking with URI fragments will not work.

Note also that websites can forbid iframe embedding by specifying an `X-Frame-Options: SAMEORIGIN` header in the HTTP response.

### 11.2.3. Cross-Site Embedding with the Vaadin XS Add-on

*The XS add-on is currently not available for Vaadin 7.*

In the previous sections, we described the two basic methods for embedding Vaadin applications: in a `<div>` element and in an `<iframe>`. One problem with div embedding is that it does not work between different Internet domains, which is a problem if you want to have your website running in one server and your Vaadin application in another. The security model in browsers effectively prevents such cross-site embedding of Ajax applications by enforcing the *same origin policy* for XMLHttpRequest calls, even if the server is running in the same domain but different

port. While iframe is more permissive, allowing embedding almost anything in anywhere, it has many disadvantages, as described earlier.

The Vaadin XS (Cross-Site) add-on works around the limitation in div embedding by using JSONP-style communication instead of the standard XMLHttpRequests.

Embedding is done simply with:

```
<script src="http://demo.vaadin.com/xseembed/getEmbedJs"
       type="text/javascript"></script>
```

This includes an automatically generated embedding script in the page, thereby making embedding effortless.

This assumes that the main layout of the application has undefined height. If the height is 100%, you have to wrap it inside an element with a defined height. For example:

```
<div style="height: 500px;">
  <script src="http://demo.vaadin.com/xseembed/getEmbedJs"
         type="text/javascript"></script>
</div>
```

It is possible to restrict where the application can be embedded by using a whitelist. The add-on also encrypts the client-server communication, which is more important for embedded applications than usual.

You can get the Vaadin XS add-on from Vaadin Directory. It is provided as a Zip package. Download and extract the installation package to a local folder. Instructions for installation and further information is given in the `README.html` file in the package.

Some restrictions apply. You can have only one embedded application in one page. Also, some third-party libraries may interfere with the communication. Other notes are given in the `README`.

## 11.3. Debug Mode and Window

Vaadin applications can be run in two modes: *debug mode* and *production mode*. The debug mode, which is on by default, enables a number of built-in debug features for Vaadin developers:

- Debug Window
- Display debug information in the Debug Window and server console
- On-the-fly compilation of Sass themes

### 11.3.1. Enabling the Debug Mode

The debug mode is enabled and production mode disabled by default in the UI templates created with the Eclipse plugin or the Maven archetypes. The debug mode can be enabled by giving a `productionMode=false` parameter to the Vaadin servlet configuration:

```
@VaadinServletConfiguration(
    productionMode = false,
    ui = MyprojectUI.class)
```

Or with a context parameter in the `web.xml` deployment descriptor:

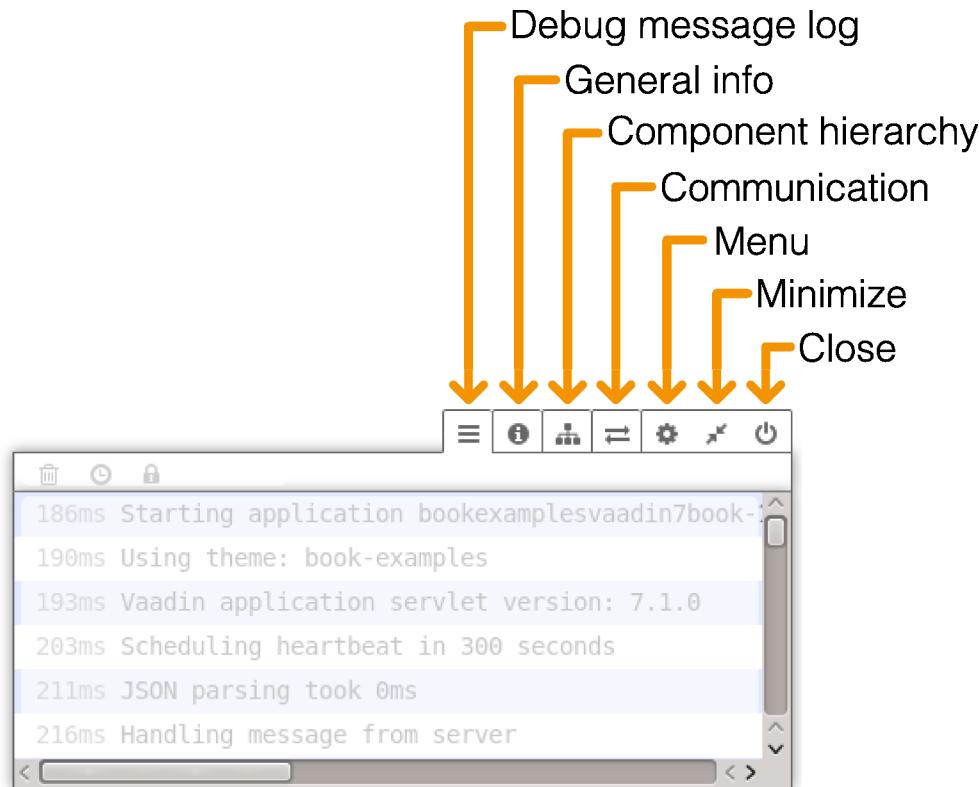
```
<context-param>
  <description>Vaadin production mode</description>
  <param-name>productionMode</param-name>
  <param-value>false</param-value>
</context-param>
```

Enabling the production mode disables the debug features, thereby preventing users from easily inspecting the inner workings of the application from the browser.

### 11.3.2. Opening the Debug Window

Running an application in the debug mode enables the client-side Debug Window in the browser. You can open the Debug Window by adding "?debug" parameter to the URL of the UI, for example, <http://localhost:8080/myapp/?debug>. The Debug Window has buttons for controlling the debugging features and a scrollable log of debug messages.

**Figure 11.3. Debug Window**



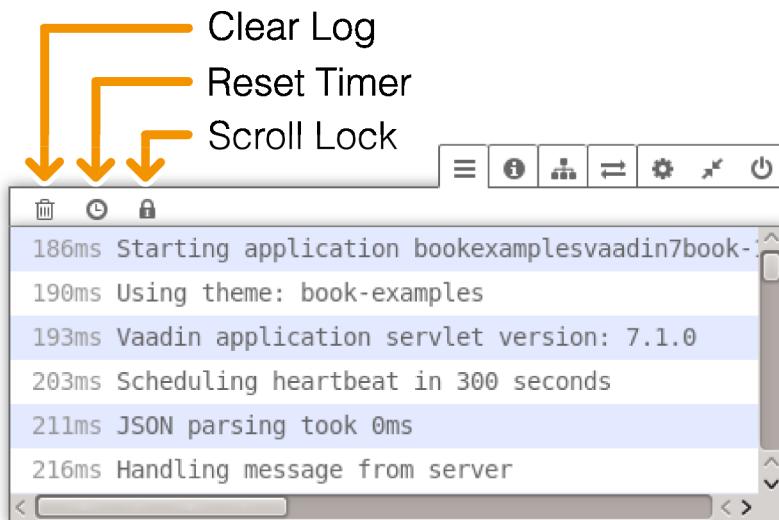
The functionalities are described in detail in the subsequent sections. You can move the window by dragging it from the title bar and resize it from the corners. The **Minimize** button minimizes the debug window in the corner of the browser window, and the **Close** button closes it.

If you use the Firebug plugin for Firefox or the Developer Tools console in Chrome, the log messages will also be printed to the Firebug console. In such a case, you may want to enable client-side debugging without showing the Debug Window with "?debug=quiet" in the URL. In the quiet debug mode, log messages will only be printed to the console of the browser debugger.

### 11.3.3. Debug Message Log

The debug message log displays client-side debug messages, with time counter in milliseconds. The control buttons allow you to clear the log, reset the timer, and lock scrolling.

**Figure 11.4. Debug Message Log**



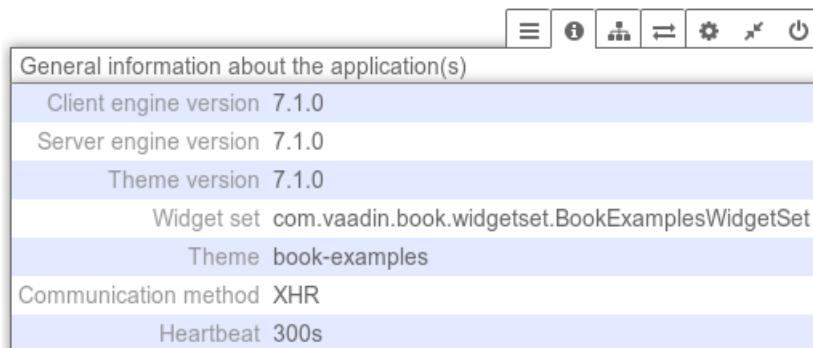
### Logging to Debug Window

You can take advantage of the debug mode when developing client-side components, by using the standard Java **Logger** to write messages to the log. The messages will be written to the debug window and Firebug console. No messages are written if the debug window is not open or if the application is running in production mode.

### 11.3.4. General Information

The **General information about the application(s)** tab displays various information about the UI, such as version numbers of the client and servlet engine, and the theme. If they do not match, you may need to compile the widget set or theme.

**Figure 11.5. General Information**



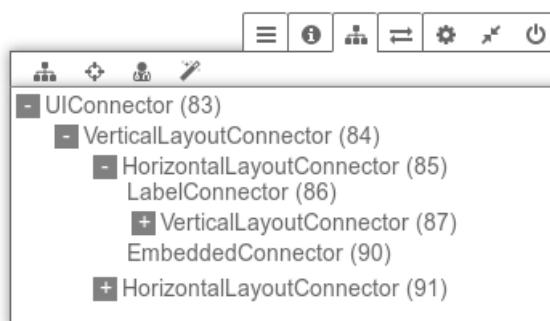
### 11.3.5. Inspecting Component Hierarchy

The **Component Hierarchy** tab has several sub-modes that allow debugging the component tree in various ways.

#### Connector Hierarchy Tree

The **Show the connector hierarchy tree** button displays the client-side connector hierarchy. As explained in Chapter 16, *Integrating with the Server-Side*, client-side widgets are managed by connectors that handle communication with the server-side component counterparts. The connector hierarchy therefore corresponds with the server-side component tree, but the client-side widget tree and HTML DOM tree have more complexity.

**Figure 11.6. Connector Hierarchy Tree**



Clicking on a connector highlights the widget in the UI.

#### Inspecting a Component

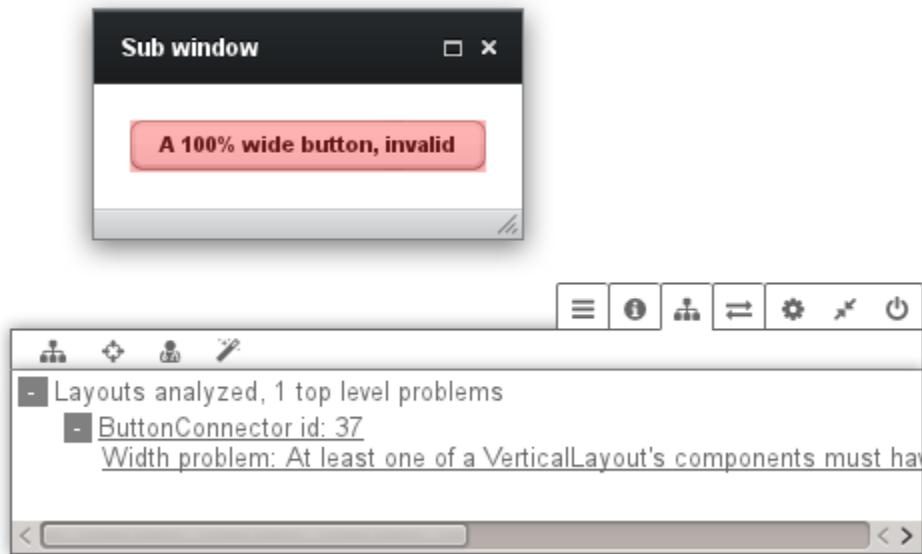
The **Select a component in the page to inspect it** button lets you select a component in the UI by clicking it and display its client-side properties.

To view the HTML structure and CSS styles in more detail, you can use Firebug in Firefox, or the Developer Tools in Chrome, as described in Section 2.2.4, “Firefox and Firebug”. Firefox also has a built-in feature for inspecting HTML and CSS.

#### Analyzing Layout Problems

The **Check layouts for potential problems** button analyzes the currently visible UI and makes a report of possible layout related problems. All detected layout problems are displayed in the log and also printed to the console.

**Figure 11.7. Debug Window Showing the Result of Layout Analysis.**



Clicking on a reported problem highlights the component with the problem in the UI.

The most common layout problem is caused by placing a component that has a relative size inside a container (layout) that has undefined size in the particular direction (height or width). For example, adding a **Button** with 100% width inside a **VerticalLayout** with undefined width. In such a case, the error would look as shown in Figure 11.7, “Debug Window Showing the Result of Layout Analysis.”.

**CustomLayout** components can not be analyzed in the same way as other layouts. For custom layouts, the button analyzes all contained relative-sized components and checks if any relative dimension is calculated to zero so that the component will be invisible. The error log will display a warning for each of these invisible components. It would not be meaningful to emphasize the component itself as it is not visible, so when you select such an error, the parent layout of the component is emphasized if possible.

## Displaying Used Connectors

The last button, **Show used connectors and how to optimize widget set**, displays a list of all currently visible connectors. It also generates a connector bundle loader factory, which you can use to optimize the widget set so that it only contains the widgets actually used in the UI. Note, however, that it only lists the connectors visible in the current UI state, and you usually have more connectors than that.

### 11.3.6. Communication Log

The **Communication** tab displays all server requests. You can unfold the requests to view details, such as the connectors involved. Clicking on a connector highlights the corresponding element in the UI.

You can use Firebug or Developer Tools in Firefox or Chrome, respectively, to get more detailed information about the requests and responses.

### 11.3.7. Debug Modes

The **Menu** tab in the window opens a sub-menu to select various settings. Here you can also launch the GWT SuperDevMode, as described in Section 13.6, “Debugging Client-Side Code”.

## 11.4. Request Handlers

Request handlers are useful for catching request parameters or generating dynamic content, such as HTML, images, PDF, or other content. You can provide HTTP content easily also with stream resources, as described in Section 4.4.5, “Stream Resources”. The stream resources, however, are only usable from within a Vaadin application, such as in an **Image** component. Request handlers allow responding to HTTP requests made with the application URL, including GET or POST parameters. You could also use a separate servlet to generate dynamic content, but a request handler is associated with the Vaadin session and it can easily access all the session data.

To handle requests, you need to implement the `RequestHandler` interface. The `handleRequest()` method gets the session, request, and response objects as parameters.

If the handler writes a response, it must return `true`. This stops running other possible request handlers. Otherwise, it should return `false` so that another handler could return a response. Eventually, if no other handler writes a response, a UI will be created and initialized.

In the following example, we catch requests for a sub-path in the URL for the servlet and write a plain text response. The servlet path consists of the context path and the servlet (sub-)path. Any additional path is passed to the request handler in the `pathInfo` of the request. For example, if the full path is `/myapp/myui/rhexample`, the path info will be `/rhexample`. Also, request parameters are available.

```
VaadinSession.getCurrent().addRequestHandler(  
    new RequestHandler() {  
        @Override  
        public boolean handleRequest(VaadinSession session,  
                                     VaadinRequest request,  
                                     VaadinResponse response)  
            throws IOException {  
            if ("/rhexample".equals(request.getPathInfo())) {  
                response.setContentType("text/plain");  
                response.getWriter().append(  
                    "Here's some dynamically generated content.\n"+  
                    "Time: " + (new Date()).toString());  
                return true; // We wrote a response  
            } else  
                return false; // No response was written  
        }  
    });  
  
    // Find out the base path for the servlet  
    String servletPath = VaadinServlet.getCurrent()  
        .getServletContext().getContextPath() + VaadinServletService  
        .getCurrentServletRequest().getServletPath();  
  
    // Display the page in a popup window  
    Link open = new Link("Click to Show the Page",  
        new ExternalResource(servletPath + "/rhexample"),
```

```
"_blank", 500, 350, BorderStyle.DEFAULT);  
layout.addComponent(open);
```

## 11.5. Shortcut Keys

Vaadin provides simple ways for defining shortcut keys for field components and a default button, and a lower-level generic shortcut key binding API based on actions.

### 11.5.1. Shortcut Keys for Default Buttons

You can add or set a *click shortcut* to a button to set it as "default" button; pressing the defined key, typically **Enter**, in any component in the window causes a click event for the button.

You can define a click shortcut with the `setClickShortcut()` shorthand method:

```
// Have an OK button and set it as the default button  
Button ok = new Button("OK");  
ok.setClickShortcut(KeyCode.ENTER);  
ok.addStyleName(Reindeer.BUTTON_DEFAULT);
```

The `BUTTON_DEFAULT` style name highlights a button to show the default button status; usually with a bolder font than usual, depending on the theme. The result can be seen in Figure 11.8, "Default Button with Click Shortcut".

**Figure 11.8. Default Button with Click Shortcut**



### 11.5.2. Field Focus Shortcuts

You can define a shortcut key that sets the focus to a field component (any component that inherits `AbstractField`) by adding a `FocusShortcut` as a shortcut listener to the field..

The constructor of the `FocusShortcut` takes the field component as its first parameter, followed by the key code, and an optional list of modifier keys, as listed in Section 11.5.4, "Supported Key Codes and Modifier Keys".

```
// A field with Alt+N bound to it  
TextField name = new TextField("Name (Alt+N)");  
name.addShortcutListener(  
    new AbstractField.FocusShortcut(name, KeyCode.N,  
        ModifierKey.ALT));  
layout.addComponent(name);
```

You can also specify the shortcut by a shorthand notation, where the shortcut key is indicated with an ampersand (&).

```
// A field with Alt+A bound to it, using shorthand notation  
TextField address = new TextField("Address (Alt+A)");  
address.addShortcutListener(  
    new AbstractField.FocusShortcut(address, "&Address"));
```

This is especially useful for internationalization, so that you can determine the shortcut key from the localized string.

### 11.5.3. Generic Shortcut Actions

Shortcut keys can be defined as *actions* using the **ShortcutAction** class. It extends the generic **Action** class that is used for example in **Tree** and **Table** for context menus. Currently, the only classes that accept **ShortcutActions** are **Window** and **Panel**.

To handle key presses, you need to define an action handler by implementing the **Handler** interface. The interface has two methods that you need to implement: `getActions()` and `handleAction()`.

The `getActions()` method must return an array of **Action** objects for the component, specified with the second parameter for the method, the *sender* of an action. For a keyboard shortcut, you use a **ShortcutAction**. The implementation of the method could be following:

```
// Have the unmodified Enter key cause an event
Action action_ok = new ShortcutAction("Default key",
    ShortcutAction.KeyCode.ENTER, null);

// Have the C key modified with Alt cause an event
Action action_cancel = new ShortcutAction("Alt+C",
    ShortcutAction.KeyCode.C,
    new int[] { ShortcutAction.ModifierKey.ALT });

Action[] actions = new Action[] {action_cancel, action_ok};

public Action[] getActions(Object target, Object sender) {
    if (sender == myPanel)
        return actions;

    return null;
}
```

The returned **Action** array may be static or you can create it dynamically for different senders according to your needs.

The constructor of **ShortcutAction** takes a symbolic caption for the action; this is largely irrelevant for shortcut actions in their current implementation, but might be used later if implementors use them both in menus and as shortcut actions. The second parameter is the key code and the third a list of modifier keys, which are listed in Section 11.5.4, “Supported Key Codes and Modifier Keys”.

The following example demonstrates the definition of a default button for a user interface, as well as a normal shortcut key, **Alt+C** for clicking the **Cancel** button.

```
public class DefaultButtonExample extends CustomComponent
    implements Handler {
    // Define and create user interface components
    Panel panel = new Panel("Login");
    FormLayout formlayout = new FormLayout();
    TextField username = new TextField("Username");
    TextField password = new TextField("Password");
    HorizontalLayout buttons = new HorizontalLayout();

    // Create buttons and define their listener methods.
    Button ok = new Button("OK", this, "okHandler");
    Button cancel = new Button("Cancel", this, "cancelHandler");

    // Have the unmodified Enter key cause an event
```

```
Action action_ok = new ShortcutAction("Default key",
    ShortcutAction.KeyCode.ENTER, null);

// Have the C key modified with Alt cause an event
Action action_cancel = new ShortcutAction("Alt+C",
    ShortcutAction.KeyCode.C,
    new int[] { ShortcutAction.ModifierKey.ALT });

public DefaultButtonExample() {
    // Set up the user interface
    setCompositionRoot(panel);
    panel.addComponent(formlayout);
    formlayout.addComponent(username);
    formlayout.addComponent(password);
    formlayout.addComponent(buttons);
    buttons.addComponent(ok);
    buttons.addComponent(cancel);

    // Set focus to username
    username.focus();

    // Set this object as the action handler
    panel.addActionHandler(this);
}

/**
 * Retrieve actions for a specific component. This method
 * will be called for each object that has a handler; in
 * this example just for login panel. The returned action
 * list might as well be static list.
 */
public Action[] getActions(Object target, Object sender) {
    System.out.println("getActions()");
    return new Action[] { action_ok, action_cancel };
}

/**
 * Handle actions received from keyboard. This simply directs
 * the actions to the same listener methods that are called
 * with ButtonClick events.
 */
public void handleAction(Action action, Object sender,
    Object target) {
    if (action == action_ok) {
        okHandler();
    }
    if (action == action_cancel) {
        cancelHandler();
    }
}

public void okHandler() {
    // Do something: report the click
    formlayout.addComponent(new Label("OK clicked. "
        + "User=" + username.getValue() + ", password="
        + password.getValue()));
}

public void cancelHandler() {
    // Do something: report the click
```

```
        formlayout.addComponent(new Label("Cancel clicked. User=" + username.getValue() + " , password=" + password.getValue()));
    }
}
```

Notice that the keyboard actions can currently be attached only to **Panels** and **Windows**. This can cause problems if you have components that require a certain key. For example, multi-line **TextField** requires the **Enter** key. There is currently no way to filter the shortcut actions out while the focus is inside some specific component, so you need to avoid such conflicts.

#### 11.5.4. Supported Key Codes and Modifier Keys

The shortcut key definitions require a key code to identify the pressed key and modifier keys, such as Shift, Alt, or Ctrl, to specify a key combination.

The key codes are defined in the **ShortcutAction.KeyCode** interface and are:

*Keys A to Z*  
Normal letter keys

*F1 to F12*  
Function keys

*BACKSPACE, DELETE, ENTER, ESCAPE, INSERT, TAB*  
Control keys

*NUM0 to NUM9*  
Number pad keys

*ARROW\_DOWN, ARROW\_UP, ARROW\_LEFT, ARROW\_RIGHT*  
Arrow keys

*HOME, END, PAGE\_UP, PAGE\_DOWN*  
Other movement keys

Modifier keys are defined in **ShortcutAction.ModifierKey** and are:

*ModifierKey.ALT*  
Alt key

*ModifierKey.CTRL*  
Ctrl key

*ModifierKey.SHIFT*  
Shift key

All constructors and methods accepting modifier keys take them as a variable argument list following the key code, separated with commas. For example, the following defines a **Ctrl+Shift+N** key combination for a shortcut.

```
TextField name = new TextField("Name (Ctrl+Shift+N)");
name.addShortcutListener(
    new AbstractField.FocusShortcut(name, KeyCode.N,
        ModifierKey.CTRL,
        ModifierKey.SHIFT));
```

## Supported Key Combinations

The actual possible key combinations vary greatly between browsers, as most browsers have a number of built-in shortcut keys, which can not be used in web applications. For example, Mozilla Firefox allows binding almost any key combination, while Opera does not even allow binding Alt shortcuts. Other browsers are generally in between these two. Also, the operating system can reserve some key combinations and some computer manufacturers define their own system key combinations.

## 11.6. Printing

Vaadin does not have any special support for printing. There are two basic ways to print - in a printer controlled by the application server or by the user from the web browser. Printing in the application server is largely independent of the UI, you just have to take care that printing commands do not block server requests, possibly by running the print commands in another thread.

For client-side printing, most browsers support printing the web page. You can either print the current or a special print page that you open. The page can be styled for printing with special CSS rules, and you can hide unwanted elements. You can also print other than Vaadin UI content, such as HTML or PDF.

### 11.6.1. Printing the Browser Window

Vaadin does not have special support for launching the printing in browser, but you can easily use the JavaScript `print()` method that opens the print window of the browser.

```
Button print = new Button("Print This Page");
print.addClickListener(new Button.ClickListener() {
    public void buttonClick(ClickEvent event) {
        // Print the current page
        JavaScript.getCurrent().execute("print();");
    }
});
```

The button in the above example would print the current page, including the button itself. You can hide such elements in CSS, as well as otherwise style the page for printing. Style definitions for printing are defined inside a `@media print {}` block in CSS.

### 11.6.2. Opening a Print Window

You can open a browser window with a special UI for print content and automatically launch printing the content.

```
public static class PrintUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        // Have some content to print
        setContent(new Label(
            "<h1>Here's some dynamic content</h1>\n" +
            "<p>This is to be printed.</p>",
            ContentMode.HTML));

        // Print automatically when the window opens
        JavaScript.getCurrent().execute(
            "setTimeout(function() {" +
            "    print(); self.close();}, 0);");
    }
}
```

```
        }
    }
    ...

// Create an opener extension
BrowserWindowOpener opener =
    new BrowserWindowOpener(PrintUI.class);
opener.setFeatures("height=200,width=400,resizable");

// A button to open the printer-friendly page.
Button print = new Button("Click to Print");
opener.extend(print);
```

How the browser opens the window, as an actual (popup) window or just a tab, depends on the browser. After printing, we automatically close the window with JavaScript `close()` call.

### 11.6.3. Printing PDF

To print content as PDF, you need to provide the downloadable content as a static or a dynamic resource, such as a **StreamResource**.

You can let the user open the resource using a **Link** component, or some other component with a **PopupWindowOpener** extension. When such a link or opener is clicked, the browser opens the PDF in the browser, in an external viewer (such as Adobe Reader), or lets the user save the document.

It is crucial to notice that clicking a **Link** or a **PopupWindowOpener** is a client-side operation. If you get the content of the dynamic PDF from the same UI state, you can not have the link or opener enabled, as then clicking it would not get the current UI content. Instead, you have to create the resource object before the link or opener are clicked. This usually requires a two-step operation, or having the print operation available in another view.

```
// A user interface for a (trivial) data model from which
// the PDF is generated.
final TextField name = new TextField("Name");
name.setValue("Slartibartfast");

// This has to be clicked first to create the stream resource
final Button ok = new Button("OK");

// This actually opens the stream resource
final Button print = new Button("Open PDF");
print.setEnabled(false);

ok.addClickListener(new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        // Create the PDF source and pass the data model to it
        StreamSource source =
            new MyPdfSource((String) name.getValue());

        // Create the stream resource and give it a file name
        String filename = "pdf_printing_example.pdf";
        StreamResource resource =
            new StreamResource(source, filename);

        // These settings are not usually necessary. MIME type
        // is detected automatically from the file name, but
```

```
// setting it explicitly may be necessary if the file
// suffix is not ".pdf".
resource.setMIMEType("application/pdf");
resource.getStream().setParameter(
    "Content-Disposition",
    "attachment; filename="+filename);

// Extend the print button with an opener
// for the PDF resource
BrowserWindowOpener opener =
    new BrowserWindowOpener(resource);
opener.extend(print);

name.setEnabled(false);
ok.setEnabled(false);
print.setEnabled(true);
}
});

layout.addComponent(name);
layout.addComponent(ok);
layout.addComponent(print);
```

## 11.7. Google App Engine Integration

*This section is not yet fully updated to Vaadin 7.*

Vaadin includes support to run Vaadin applications in the Google App Engine (GAE). The most essential requirement for GAE is the ability to serialize the application state. Vaadin applications are serializable through the **java.io.Serializable** interface.

To run as a GAE application, an application must use **GAEVaadinServlet** instead of **VaadinServlet**, and of course implement the **java.io.Serializable** interface for all persistent classes. You also need to enable session support in `appengine-web.xml` with:

```
<sessions-enabled>true</sessions-enabled>
```

The Vaadin Project wizard can create the configuration files needed for GAE deployment. See Section 2.5.1, “Creating the Project”. When the Google App Engine deployment configuration is selected, the wizard will create the project structure following the GAE Servlet convention instead of the regular Servlet convention. The main differences are:

- Source directory: `src/main/java`
- Output directory: `war/WEB-INF/classes`
- Content directory: `war`

## Rules and Limitations

Running Vaadin applications in Google App Engine has the following rules and limitations:

- Avoid using the session for storage, usual App Engine limitations apply (no synchronization, that is, it is unreliable).
- Vaadin uses memcache for mutex, the key is of the form `_vmutex<sessionid>`.

- The Vaadin **WebApplicationContext** class is serialized separately into memcache and datastore; the memcache key is `_vac<sessionid>` and the datastore entity kind is `_vac` with identifiers of the type `_vac<sessionid>`.
- *Do not* update the application state when serving an **ConnectorResource** (such as `ClassResource.getStream()`).
- *Avoid* (or be very careful when) updating application state in a **TransactionListener** - it is called even when the application is not locked and won't be serialized (such as with **ConnectorResource**), and changes can therefore be lost (it should be safe to update things that can be safely discarded later, that is, valid only for the current request).
- The application remains locked during uploads - a progress bar is not possible.

## 11.8. Common Security Issues

### 11.8.1. Sanitizing User Input to Prevent Cross-Site Scripting

You can put raw HTML content in many components, such as the **Label** and **CustomLayout**, as well as in tooltips and notifications. In such cases, you should make sure that if the content has any possibility to come from user input, you must make sure that the content is safe before displaying it. Otherwise, a malicious user can easily make a cross-site scripting attack by injecting offensive JavaScript code in such components. See other sources for more information about cross-site scripting.

Offensive code can easily be injected with `<script>` markup or in tag attributes as events, such as `onLoad`. Cross-site scripting vulnerabilities are browser dependent, depending on the situations in which different browsers execute scripting markup.

Therefore, if the content created by one user is shown to other users, the content must be sanitized. There is no generic way to sanitize user input, as different applications can allow different kinds of input. Pruning (X)HTML tags out is somewhat simple, but some applications may need to allow (X)HTML content. It is therefore the responsibility of the application to sanitize the input.

Character encoding can make sanitization more difficult, as offensive tags can be encoded so that they are not recognized by a sanitizer. This can be done, for example, with HTML character entities and with variable-width encodings such as UTF-8 or various CJK encodings, by abusing multiple representations of a character. Most trivially, you could input `<` and `>` with `&lt;` and `&gt;`, respectively. The input could also be malformed and the sanitizer must be able to interpret it exactly as the browser would, and different browsers can interpret malformed HTML and variable-width character encodings differently.

Notice that the problem applies also to user input from a **RichTextArea** is transmitted as HTML from the browser to server-side and is not sanitized. As the entire purpose of the **RichTextArea** component is to allow input of formatted text, you can not just remove all HTML tags. Also many attributes, such as `style`, should pass through the sanitization.

## 11.9. Navigating in an Application

Plain Vaadin applications do not have normal web page navigation as they usually run on a single page, as all Ajax applications do. Quite commonly, however, applications have different views between which the user should be able to navigate. The **Navigator** in Vaadin can be used for most cases of navigation. Views managed by the navigator automatically get a distinct URI

fragment, which can be used to be able to bookmark the views and their states and to go back and forward in the browser history.

### 11.9.1. Setting Up for Navigation

The **Navigator** class manages a collection of *views* that implement the `View` interface. The views can be either registered beforehand or acquired from a *view provider*. When registering, the views must have a name identifier and be added to a navigator with `addView()`. You can register new views at any point. Once registered, you can navigate to them with `navigateTo()`.

**Navigator** manages navigation in a component container, which can be either a `ComponentContainer` (most layouts) or a `SingleComponentContainer` (**UI**, **Panel**, or **Window**). The component container is managed through a `ViewDisplay`. Two view displays are defined: `ComponentContainerViewDisplay` and `SingleComponentContainerViewDisplay`, for the respective component container types. Normally, you can let the navigator create the view display internally, as we do in the example below, but you can also create it yourself to customize it.

Let us consider the following UI with two views: start and main. Here, we define their names with enums to be typesafe. We manage the navigation with the `UI` class itself, which is a `SingleComponentContainer`.

```
public class NavigatorUI extends UI {
    Navigator navigator;
    protected static final String MAINVIEW = "main";

    @Override
    protected void init(VaadinRequest request) {
        getPage().setTitle("Navigation Example");

        // Create a navigator to control the views
        navigator = new Navigator(this, this);

        // Create and register the views
        navigator.addView("", new StartView());
        navigator.addView(MAINVIEW, new MainView());
    }
}
```

The **Navigator** automatically sets the URI fragment of the application URL. It also registers a `URIFragmentChangedListener` in the page (see Section 11.11, “Managing URI Fragments”) to show the view identified by the URI fragment if entered or navigated to in the browser. This also enables browser navigation history in the application.

## View Providers

You can create new views dynamically using a *view provider* that implements the `ViewProvider` interface. A provider is registered in **Navigator** with `addProvider()`.

The `ClassBasedViewProvider` is a view provider that can dynamically create new instances of a specified view class based on the view name.

The `StaticViewProvider` returns an existing view instance based on the view name. The `addView()` in **Navigator** is actually just a shorthand for creating a static view provider for each registered view.

## View Change Listeners

You can handle view changes also by implementing a `ViewChangeListener` and adding it to a **Navigator**. When a view change occurs, a listener receives a `ViewChangeEvent` object, which has references to the old and the activated view, the name of the activated view, as well as the fragment parameters.

### 11.9.2. Implementing a View

Views can be any objects that implement the `View` interface. When the `navigateTo()` is called for the navigator, or the application is opened with the URI fragment associated with the view, the navigator switches to the view and calls its `enter()` method.

To continue with the example, consider the following simple start view that just lets the user to navigate to the main view. It only pops up a notification when the user navigates to it and displays the navigation button.

```
/** A start view for navigating to the main view */
public class StartView extends VerticalLayout implements View {
    public StartView() {
        setSizeFull();

        Button button = new Button("Go to Main View",
            new Button.ClickListener() {
                @Override
                public void buttonClick(ClickEvent event) {
                    navigator.navigateTo(MAINVIEW);
                }
            });
        addComponent(button);
        setComponentAlignment(button, Alignment.MIDDLE_CENTER);
    }

    @Override
    public void enter(ViewChangeEvent event) {
        Notification.show("Welcome to the Animal Farm");
    }
}
```

You can initialize the view content in the constructor, as was done in the example above, or in the `enter()` method. The advantage with the latter method is that the view is attached to the view container as well as to the UI at that time, which is not the case in the constructor.

### 11.9.3. Handling URI Fragment Path

URI fragment part of a URL is the part after a hash # character. Is used for within-UI URLs, because it is the only part of the URL that can be changed with JavaScript from within a page without reloading the page. The URLs with URI fragments can be used for hyperlinking and bookmarking, as well as browser history, just like any other URLs. In addition, an exclamation mark #! after the hash marks that the page is a stateful AJAX page, which can be crawled by search engines. Crawling requires that the application also responds to special URLs to get the searchable content. URI fragments are managed by **Page**, which provides a low-level API.

URI fragments can be used with **Navigator** in two ways: for navigating to a view and to a state within a view. The URI fragment accepted by `navigateTo()` can have the view name at the

root, followed by fragment parameters after a slash ("/"). These parameters are passed to the `enter()` method in the View.

In the following example, we implement within-view navigation.

```
/** Main view with a menu */
public class MainView extends VerticalLayout implements View {
    Panel panel;

    // Menu navigation button listener
    class ButtonListener implements Button.ClickListener {

        String menuitem;
        public ButtonListener(String menuitem) {
            this.menuitem = menuitem;
        }

        @Override
        public void buttonClick(ClickEvent event) {
            // Navigate to a specific state
            navigator.navigateTo(MAINVIEW + " / " + menuitem);
        }
    }

    public MainView() {
        setSizeFull();

        // Layout with menu on left and view area on right
        HorizontalLayout hLayout = new HorizontalLayout();
        hLayout.setSizeFull();

        // Have a menu on the left side of the screen
        Panel menu = new Panel("List of Equals");
        menu.setHeight("100%");
        menu.setWidth(null);
        VerticalLayout menuContent = new VerticalLayout();
        menuContent.addComponent(new Button("Pig",
                new ButtonListener("pig")));
        menuContent.addComponent(new Button("Cat",
                new ButtonListener("cat")));
        menuContent.addComponent(new Button("Dog",
                new ButtonListener("dog")));
        menuContent.addComponent(new Button("Reindeer",
                new ButtonListener("reindeer")));
        menuContent.addComponent(new Button("Penguin",
                new ButtonListener("penguin")));
        menuContent.addComponent(new Button("Sheep",
                new ButtonListener("sheep")));
        menuContent.setWidth(null);
        menuContent.setMargin(true);
        menu.setContent(menuContent);
        hLayout.addComponent(menu);

        // A panel that contains a content area on right
        panel = new Panel("An Equal");
        panel.setSizeFull();
        hLayout.addComponent(panel);
        hLayout.setExpandRatio(panel, 1.0f);
    }
}
```

```
addComponent(hLayout);
setExpandRatio(hLayout, 1.0f);

// Allow going back to the start
Button logout = new Button("Logout",
    new Button.ClickListener() {
        @Override
        public void buttonClick(ClickEvent event) {
            navigator.navigateTo("");
        }
    });
addComponent(logout);
}

@Override
public void enter(ViewChangeEvent event) {
    VerticalLayout panelContent = new VerticalLayout();
    panelContent.setSizeFull();
    panelContent.setMargin(true);
    panel.setContent(panelContent); // Also clears

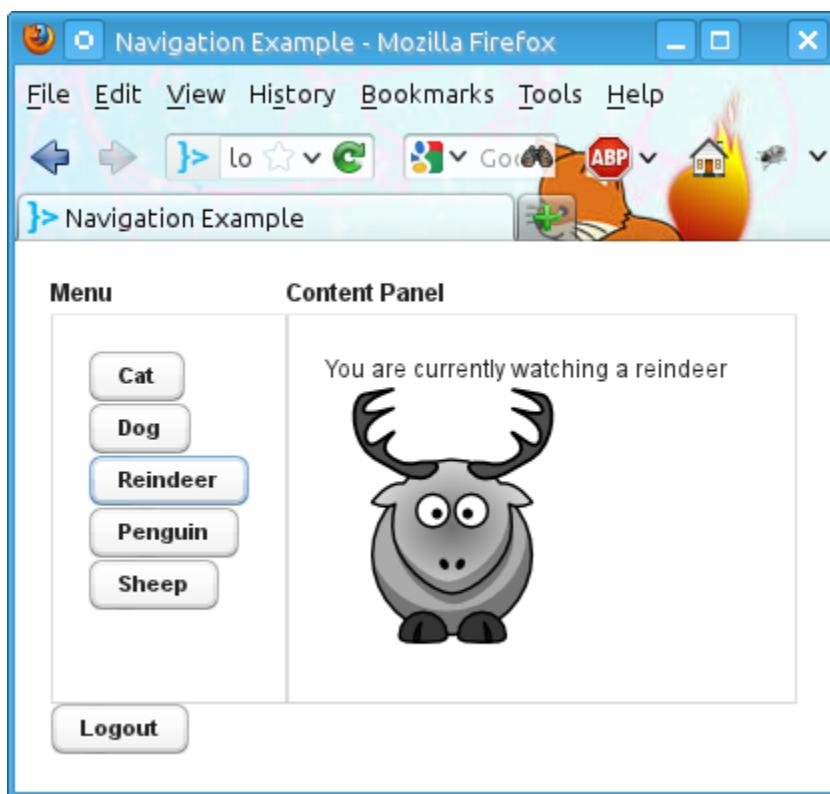
    if (event.getParameters() == null
        || event.getParameters().isEmpty()) {
        panelContent.addComponent(
            new Label("Nothing to see here, " +
                "just pass along."));
        return;
    }

    // Display the fragment parameters
    Label watching = new Label(
        "You are currently watching a " +
        event.getParameters());
    watching.setSizeUndefined();
    panelContent.addComponent(watching);
    panelContent.setComponentAlignment(watching,
        Alignment.MIDDLE_CENTER);

    // Some other content
    Embedded pic = new Embedded(null,
        new ThemeResource("img/" + event.getParameters() +
            "-128px.png"));
    panelContent.addComponent(pic);
    panelContent.setExpandRatio(pic, 1.0f);
    panelContent.setComponentAlignment(pic,
        Alignment.MIDDLE_CENTER);

    Label back = new Label("And the " +
        event.getParameters() + " is watching you");
    back.setSizeUndefined();
    panelContent.addComponent(back);
    panelContent.setComponentAlignment(back,
        Alignment.MIDDLE_CENTER);
}
}
```

The main view is shown in Figure 11.9, “Navigator Main View”. At this point, the URL would be <http://localhost:8080/myapp#!main/reindeer>.

**Figure 11.9. Navigator Main View**

## 11.10. Advanced Application Architectures

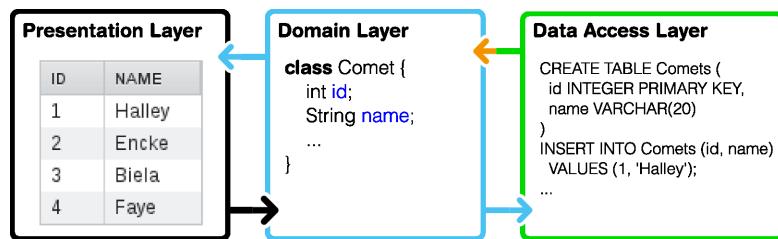
In this section, we continue from the basic application architectures described in Section 4.2, “Building the UI” and discuss some of the more advanced patterns that are often used in Vaadin applications.

### 11.10.1. Layered Architectures

Layered architectures, where each layer has a clearly distinct responsibility, are probably the most common architectures. Typically, applications follow at least a three-layer architecture:

- User interface (or presentation) layer
- Domain layer
- Data store layer

Such an architecture starts from a *domain model*, which defines the data model and the "business logic" of the application, typically as POJOs. A user interface is built on top of the domain model, in our context with the Vaadin Framework. The Vaadin user interface could be bound directly to the data model through the Vaadin Data Model, described in Chapter 8, *Binding Components to Data*. Beneath the domain model lies a data store, such as a relational database. The dependencies between the layers are restricted so that a higher layer may depend on a lower one, but never the other way around.

**Figure 11.10. Three-Layer Architecture**

An *application layer* (or *service layer*) is often distinguished from the domain layer, offering the domain logic as a service, which can be used by the user interface layer, as well as for other uses. In Java EE development, Enterprise JavaBeans (EJBs) are typically used for building this layer.

An *infrastructure layer* (or *data access layer*) is often distinguished from the data store layer, with a purpose to abstract the data store. For example, it could involve a persistence solution such as JPA and an EJB container. This layer becomes relevant with Vaadin when binding Vaadin components to data with the JPAContainer, as described in Chapter 19, *Vaadin JPAContainer*.

### 11.10.2. Model-View-Presenter Pattern

The Model-View-Presenter (MVP) pattern is one of the most common patterns in developing large applications with Vaadin. It is similar to the older Model-View-Controller (MVC) pattern, which is not as meaningful in Vaadin development. Instead of an implementation-aware controller, there is an implementation-agnostic presenter that operates the view through an interface. The view does not interact directly with the model. This isolates the view implementation better than in MVC and allows easier unit testing of the presenter and model.

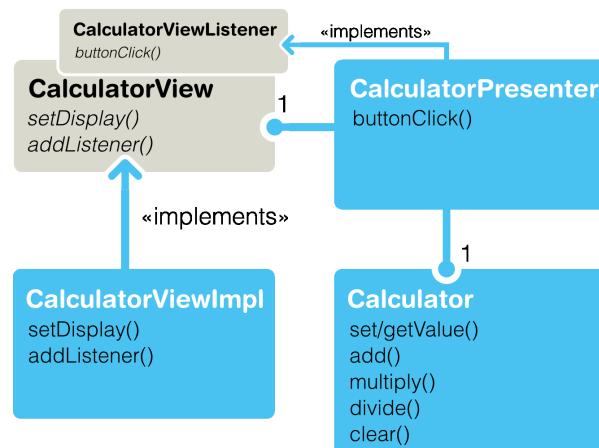
**Figure 11.11. Model-View-Presenter Pattern**

Figure 11.11, “Model-View-Presenter Pattern” illustrates the MVP pattern with a simple calculator. The domain model is realized in the **Calculator** class, which includes a data model and some model logic operations. The **CalculatorViewImpl** is a Vaadin implementation of the view, defined in the **CalculatorView** interface. The **CalculatorPresenter** handles the user interface logic. User interaction events received in the view are translated into implementation-independent events for the presenter to handle (the view implementation could also just call the presenter).

Let us first look how the model and view are bound together by the presenter in the following example:

```
// Create the model and the Vaadin view implementation
CalculatorModel    model = new CalculatorModel();
CalculatorViewImpl view  = new CalculatorViewImpl();

// The presenter binds the model and view together
new CalculatorPresenter(model, view);

// The view implementation is a Vaadin component
layout.addComponent(view);
```

You could add the view anywhere in a Vaadin application, as it is a composite component.

## The Model

Our business model is quite simple, with one value and a number of operations for manipulating it.

```
/** The model */
class CalculatorModel {
    private double value = 0.0;

    public void clear() {
        value = 0.0;
    }

    public void add(double arg) {
        value += arg;
    }

    public void multiply(double arg) {
        value *= arg;
    }

    public void divide(double arg) {
        if (arg != 0.0)
            value /= arg;
    }

    public double getValue() {
        return value;
    }

    public void setValue(double value) {
        this.value = value;
    }
}
```

## The View

The purpose of the view in MVP is to display data and receive user interaction. It relays the user interaction to the presenter in a fashion that is independent of the view implementation, that is, no Vaadin events. It is defined as a UI framework interface that can have multiple implementations.

```
interface CalculatorView {
    public void setDisplay(double value);
```

```
interface CalculatorViewListener {
    void buttonClick(char operation);
}
public void addListener(CalculatorViewListener listener);
}
```

The are design alternatives for the view. It could receive the listener in its constructor, or it could just know the presenter. Here, we forward button clicks as an implementation-independent event.

As we are using Vaadin, we make a Vaadin implementation of the interface as follows:

```
class CalculatorViewImpl extends CustomComponent
    implements CalculatorView, ClickListener {
    private Label display = new Label("0.0");

    public CalculatorViewImpl() {
        GridLayout layout = new GridLayout(4, 5);

        // Create a result label that spans over all
        // the 4 columns in the first row
        layout.addComponent(display, 0, 0, 3, 0);

        // The operations for the calculator in the order
        // they appear on the screen (left to right, top
        // to bottom)
        String[] operations = new String[] {
            "7", "8", "9", "/", "4", "5", "6",
            "*", "1", "2", "3", "-", "0", "=", "C", "+" };

        // Add buttons and have them send click events
        // to this class
        for (String caption: operations)
            layout.addComponent(new Button(caption, this));

        setCompositionRoot(layout);
    }

    public void setDisplay(double value) {
        display.setValue(Double.toString(value));
    }

    /* Only the presenter registers one listener... */
    List<CalculatorViewListener> listeners =
        new ArrayList<CalculatorViewListener>();

    public void addListener(CalculatorViewListener listener) {
        listeners.add(listener);
    }

    /** Relay button clicks to the presenter with an
     * implementation-independent event */
    @Override
    public void buttonClick(ClickEvent event) {
        for (CalculatorViewListener listener: listeners)
            listener.buttonClick(event.getButton()
                .getCaption().charAt(0));
    }
}
```

## The Presenter

The presenter in MVP is a middle-man that handles all user interaction logic, but in an implementation-independent way, so that it doesn't actually know anything about Vaadin. It shows data in the view and receives user interaction back from it.

```
class CalculatorPresenter
    implements CalculatorView.CalculatorViewListener {
    CalculatorModel model;
    CalculatorView view;

    private double current = 0.0;
    private char lastOperationRequested = 'C';

    public CalculatorPresenter(CalculatorModel model,
                               CalculatorView view) {
        this.model = model;
        this.view = view;

        view.setDisplay(current);
        view.addListener(this);
    }

    @Override
    public void buttonClick(char operation) {
        // Handle digit input
        if ('0' <= operation && operation <= '9') {
            current = current * 10
                + Double.parseDouble("" + operation);
            view.setDisplay(current);
            return;
        }

        // Execute the previously input operation
        switch (lastOperationRequested) {
            case '+':
                model.add(current);
                break;
            case '-':
                model.add(-current);
                break;
            case '/':
                model.divide(current);
                break;
            case '*':
                model.multiply(current);
                break;
            case 'C':
                model.setValue(current);
                break;
        } // '=' is implicit

        lastOperationRequested = operation;

        current = 0.0;
        if (operation == 'C')
            model.clear();
        view.setDisplay(model.getValue());
```

```
    }  
}
```

In the above example, we held some state information in the presenter. Alternatively, we could have had an intermediate controller between the presenter and the model to handle the low-level button logic.

## 11.11. Managing URI Fragments

A major issue in AJAX applications is that as they run in a single web page, bookmarking the application URL (or more generally the *URI*) can only bookmark the application, not an application state. This is a problem for many applications, such as product catalogs and discussion forums, in which it would be good to provide links to specific products or messages. Consequently, as browsers remember the browsing history by URI, the history and the **Back** button do not normally work. The solution is to use the *fragment identifier* part of the URI, which is separated from the primary part (address + path + optional query parameters) of the URI with the hash (#) character. For example:

```
http://example.com/path#myfragment
```

The exact syntax of the fragment identifier part is defined in RFC 3986 (Internet standard STD 66) that defines the URI syntax. A fragment may only contain the regular URI *path characters* (see the standard) and additionally the slash and the question mark.

Vaadin offers two ways to enable the use of URI fragments: the high-level **Navigator** utility described in Section 11.9, “Navigating in an Application” and the low-level API described here.

### 11.11.1. Setting the URI Fragment

You can set the current fragment identifier with the `setUriFragment()` method in the **Page** object.

```
Page.getCurrent().setUriFragment("mars");
```

Setting the URI fragment causes an `UriFragmentChangeEvent`, which is processed in the same server request. As with UI rendering, the URI fragment is changed in the browser after the currently processed server request returns the response.

Prefixing the fragment identifier with an exclamation mark enables the web crawler support described in Section 11.11.4, “Supporting Web Crawling”.

### 11.11.2. Reading the URI Fragment

The current URI fragment can be acquired with the `getUriFragment()` method from the current **Page** object. The fragment is known when the `init()` method of the UI is called.

```
// Read initial URI fragment to create UI content  
String fragment = getPage().getUriFragment();  
enter(fragment);
```

To enable reusing the same code when the URI fragment is changed, as described next, it is usually best to build the relevant part of the UI in a separate method. In the above example, we called an `enter()` method, in a way that is similar to handling view changes with **Navigator**.

### 11.11.3. Listening for URI Fragment Changes

After the UI has been initialized, changes in the URI fragment can be handled with a `UriFragmentChangeListener`. The listeners are called when the URI fragment changes, but not when the UI is initialized, where the current fragment is available from the `page` object as described earlier.

For example, we could define the listener as follows in the `init()` method of a UI class:

```
public class MyUI extends UI {  
    @Override  
    protected void init(VaadinRequest request) {  
        getPage().addUriFragmentChangedListener(  
            new UriFragmentChangedListener() {  
                public void uriFragmentChanged(  
                    UriFragmentChangedEventArgs source) {  
                    enter(source.getUriFragment());  
                }  
            } );  
  
        // Read the initial URI fragment  
        enter(getPage().getUriFragment());  
    }  
  
    void enter(String fragment) {  
        ... initialize the UI ...  
    }  
}
```

Figure 11.12, “Application State Management with URI Fragment Utility” shows an application that allows specifying the menu selection with a URI fragment and correspondingly sets the fragment when the user selects a menu item.

**Figure 11.12. Application State Management with URI Fragment Utility**



### 11.11.4. Supporting Web Crawling

Stateful AJAX applications can not normally be crawled by a search engine, as they run in a single page and a crawler can not navigate the states even if URI fragments are enabled. The Google search engine and crawler support a convention where the fragment identifiers are prefixed with exclamation mark, such as `#!myfragment`. The servlet needs to have a separate searchable content page accessible with the same URL, but with a `_escaped_fragment_` parameter. For example, for `/myapp/myui#!myfragment` it would be `/myapp/myui?_escaped_fragment_=myfragment`.

You can provide the crawl content by overriding the `service()` method in a custom servlet class. For regular requests, you should call the super implementation in the **VaadinServlet** class.

```
public class MyCustomServlet extends VaadinServlet
    @Override
    protected void service(HttpServletRequest request,
                          HttpServletResponse response)
        throws ServletException, IOException {
    String fragment = request
        .getParameter("_escaped_fragment_");
    if (fragment != null) {
        response.setContentType("text/html");
        Writer writer = response.getWriter();
        writer.append("<html><body>" +
                     "<p>Here is some crawlable " +
                     "content about " + fragment + "</p>");

        // A list of all crawlable pages
        String items[] = {"mercury", "venus",
                          "earth", "mars"};
        writer.append("<p>Index of all content:</p><ul>");
        for (String item: items) {
            String url = request.getContextPath() +
                request.getServletPath() +
                request.getPathInfo() + "#!" + item;
            writer.append("<li><a href='" + url + "'>" +
                         item + "</a></li>");
        }
        writer.append(" </ul></body> ");
    } else
        super.service(request, response);
}
```

The crawlable content does not need to be human readable. It can provide an index of links to other application states, as we did in the example above. The links should use the "#!" notation, but can not be relative to avoid having the `_escaped_fragment_` parameter.

You need to use the custom servlet class in the `web.xml` deployment descriptor instead of the normal **VaadinServlet** class, as described in Section 4.8.4, “Using a `web.xml` Deployment Descriptor”.

## 11.12. Drag and Drop

Dragging an object from one location to another by grabbing it with mouse, holding the mouse button pressed, and then releasing the button to “drop” it to the other location is a common way to move, copy, or associate objects. For example, most operating systems allow dragging and dropping files between folders or dragging a document on a program to open it. In Vaadin, it is possible to drag and drop components and parts of certain components.

Dragged objects, or *transferables*, are essentially data objects. You can drag and drop rows in **Table** and nodes in **Tree** components, either within or between the components. You can also drag entire components by wrapping them inside **DragAndDropWrapper**.

Dragging starts from a *drag source*, which defines the transferable. Transferables implement the **Transferable** interfaces. For trees and tables, which are bound to **Container** data sources, a node or row transferable is a reference to an **Item** in the Vaadin Data Model. Dragged components

are referenced with a **WrapperTransferable**. Starting dragging does not require any client-server communication, you only need to enable dragging. All drag and drop logic occurs in two operations: determining (*accepting*) where dropping is allowed and actually dropping. Drops can be done on a *drop target*, which implements the **DropTarget** interface. Three components implement the interface: **Tree**, **Table**, and **DragAndDropWrapper**. These accept and drop operations need to be provided in a *drop handler*. Essentially all you need to do to enable drag and drop is to enable dragging in the drag source and implement the `getAcceptCriterion()` and `drop()` methods in the **DropHandler** interface.

The client-server architecture of Vaadin causes special requirements for the drag and drop functionality. The logic for determining where a dragged object can be dropped, that is, *accepting* a drop, should normally be done on the client-side, in the browser. Server communications are too slow to have much of such logic on the server-side. The drag and drop feature therefore offers a number of ways to avoid the server communications to ensure a good user experience.

### 11.12.1. Handling Drops

Most of the user-defined drag and drop logic occurs in a *drop handler*, which is provided by implementing the `drop()` method in the **DropHandler** interface. A closely related definition is the drop accept criterion, which is defined in the `getAcceptCriterion()` method in the same interface. It is described in Section 11.12.4, “Accepting Drops” later.

The `drop()` method gets a **DragAndDropEvent** as its parameters. The event object provides references to two important objects: **Transferable** and **TargetDetails**.

A **Transferable** contains a reference to the object (component or data item) that is being dragged. A tree or table item is represented as a **TreeTransferable** or **TableTransferable** object, which carries the item identifier of the dragged tree or table item. These special transferables, which are bound to some data in a container, are **DataBoundTransferable**. Dragged components are represented as **WrapperTransferable** objects, as the components are wrapped in a **DragAndDropWrapper**.

The **TargetDetails** object provides information about the exact location where the transferable object is being dropped. The exact class of the details object depends on the drop target and you need to cast it to the proper subclass to get more detailed information. If the target is selection component, essentially a tree or a table, the **AbstractSelectTargetDetails** object tells the item on which the drop is being made. For trees, the **TreeTargetDetails** gives some more details. For wrapped components, the information is provided in a **WrapperDropDetails** object. In addition to the target item or component, the details objects provide a *drop location*. For selection components, the location can be obtained with the `getDropLocation()` and for wrapped components with `verticalDropLocation()` and `horizontalDropLocation()`. The locations are specified as either **VerticalDropLocation** or **HorizontalDropLocation** objects. The drop location objects specify whether the transferable is being dropped above, below, or directly on (at the middle of) a component or item.

Dropping on a **Tree**, **Table**, and a wrapped component is explained further in the following sections.

### 11.12.2. Dropping Items On a Tree

You can drag items from, to, or within a **Tree**. Making tree a drag source requires simply setting the drag mode with `setDragMode()`. **Tree** currently supports only one drag mode, **TreeDragMode.NODE**, which allows dragging single tree nodes. While dragging, the dragged node is referenced with a **TreeTransferable** object, which is a **DataBoundTransferable**. The tree node is identified by the item ID of the container item.

When a transferable is dropped on a tree, the drop location is stored in a **TreeTargetDetails** object, which identifies the target location by item ID of the tree node on which the drop is made. You can get the item ID with `getItemIdOver()` method in **AbstractSelectTargetDetails**, which the **TreeTargetDetails** inherits. A drop can occur directly on or above or below a node; the exact location is a **VerticalDropLocation**, which you can get with the `getDropLocation()` method.

In the example below, we have a **Tree** and we allow reordering the tree items by drag and drop.

```
final Tree tree = new Tree("Inventory");
tree.setContainerDataSource(TreeExample.createTreeContent());
layout.addComponent(tree);

// Expand all items
for (Iterator<?> it = tree.rootItemIds().iterator(); it.hasNext();) {
    tree.expandItemsRecursively(it.next());

// Set the tree in drag source mode
tree.setDragMode(TreeDragMode.NODE);

// Allow the tree to receive drag drops and handle them
tree.setDropHandler(new DropHandler() {
    public AcceptCriterion getAcceptCriterion() {
        return AcceptAll.get();
    }

    public void drop(DragAndDropEvent event) {
        // Wrapper for the object that is dragged
        Transferable t = event.getTransferable();

        // Make sure the drag source is the same tree
        if (t.getSourceComponent() != tree)
            return;

        TreeTargetDetails target = (TreeTargetDetails)
            event.getTargetDetails();

        // Get ids of the dragged item and the target item
        Object sourceItemId = t.getData("itemId");
        Object targetItemId = target.getItemIdOver();

        // On which side of the target the item was dropped
        VerticalDropLocation location = target.getDropLocation();

        HierarchicalContainer container = (HierarchicalContainer)
            tree.getContainerDataSource();

        // Drop right on an item -> make it a child
        if (location == VerticalDropLocation.MIDDLE)
            tree.setParent(sourceItemId, targetItemId);

        // Drop at the top of a subtree -> make it previous
        else if (location == VerticalDropLocation.TOP) {
            Object parentId = container.getParent(targetItemId);
            container.setParent(sourceItemId, parentId);
            container.moveAfterSibling(sourceItemId, targetItemId);
            container.moveAfterSibling(targetItemId, sourceItemId);
        }

        // Drop below another item -> make it next
    }
})
```

```
        else if (location == VerticalDropLocation.BOTTOM) {
            Object parentId = container.getParent(targetItemId);
            container.setParent(sourceItemId, parentId);
            container.moveAfterSibling(sourceItemId, targetItemId);
        }
    }
});
```

## Accept Criteria for Trees

**Tree** defines some specialized accept criteria for trees.

### **TargetInSubtree** (client-side)

Accepts if the target item is in the specified sub-tree. The sub-tree is specified by the item ID of the root of the sub-tree in the constructor. The second constructor includes a depth parameter, which specifies how deep from the given root node are drops accepted. Value `-1` means infinite, that is, the entire sub-tree, and is therefore the same as the simpler constructor.

### **TargetItemAllowsChildren** (client-side)

Accepts a drop if the tree has `setChildrenAllowed()` enabled for the target item. The criterion does not require parameters, so the class is a singleton and can be acquired with `Tree.TargetItemAllowsChildren.get()`. For example, the following composite criterion accepts drops only on nodes that allow children, but between all nodes:

```
return new Or (Tree.TargetItemAllowsChildren.get(), new Not(Vertical-
    LocationIs.MIDDLE));
```

### **TreeDropCriterion** (server-side)

Accepts drops on only some items, which as specified by a set of item IDs. You must extend the abstract class and implement the `getAllowedItemIds()` to return the set. While the criterion is server-side, it is lazy-loading, so that the list of accepted target nodes is loaded only once from the server for each drag operation. See Section 11.12.4, “Accepting Drops” for an example.

In addition, the accept criteria defined in **AbstractSelect** are available for a **Tree**, as listed in Section 11.12.4, “Accepting Drops”.

## 11.12.3. Dropping Items On a Table

You can drag items from, to, or within a **Table**. Making table a drag source requires simply setting the drag mode with `setDragMode()`. **Table** supports dragging both single rows, with `TableDragMode.ROW`, and multiple rows, with `TableDragMode.MULTIROW`. While dragging, the dragged node or nodes are referenced with a **TreeTransferable** object, which is a **DataBoundTransferable**. Tree nodes are identified by the item IDs of the container items.

When a transferable is dropped on a table, the drop location is stored in a **AbstractSelectTargetDetails** object, which identifies the target row by its item ID. You can get the item ID with `getItemIdOver()` method. A drop can occur directly on or above or below a row; the exact location is a **VerticalDropLocation**, which you can get with the `getDropLocation()` method from the details object.

## Accept Criteria for Tables

**Table** defines one specialized accept criterion for tables.

**TableDropCriterion** (server-side)

Accepts drops only on (or above or below) items that are specified by a set of item IDs. You must extend the abstract class and implement the `getAllowedItemIds()` to return the set. While the criterion is server-side, it is lazy-loading, so that the list of accepted target items is loaded only once from the server for each drag operation.

### 11.12.4. Accepting Drops

You can not drop the objects you are dragging around just anywhere. Before a drop is possible, the specific drop location on which the mouse hovers must be *accepted*. Hovering a dragged object over an accepted location displays an *accept indicator*, which allows the user to position the drop properly. As such checks have to be done all the time when the mouse pointer moves around the drop targets, it is not feasible to send the accept requests to the server-side, so drops on a target are normally accepted by a client-side *accept criterion*.

A drop handler must define the criterion on the objects which it accepts to be dropped on the target. The criterion needs to be provided in the `getAcceptCriterion()` method of the **DropHandler** interface. A criterion is represented in an **AcceptCriterion** object, which can be a composite of multiple criteria that are evaluated using logical operations. There are two basic types of criteria: *client-side* and *server-side criteria*. The various built-in criteria allow accepting drops based on the identity of the source and target components, and on the *data flavor* of the dragged objects.

To allow dropping any transferable objects, you can return a universal accept criterion, which you can get with `AcceptAll.get()`.

```
tree.setDropHandler(new DropHandler() {
    public AcceptCriterion getAcceptCriterion() {
        return AcceptAll.get();
    }
    ...
});
```

### Client-Side Criteria

The *client-side criteria*, which inherit the **ClientSideCriterion**, are verified on the client-side, so server requests are not needed for verifying whether each component on which the mouse pointer hovers would accept a certain object.

The following client-side criteria are define in `com.vaadin.event.dd.acceptcriterion`:

**AcceptAll**

Accepts all transferables and targets.

**And**

Performs the logical AND operation on two or more client-side criteria; accepts the transferable if all the given sub-criteria accept it.

**ContainsDataFlavour**

The transferable must contain the defined data flavour.

**Not**

Performs the logical NOT operation on a client-side criterion; accepts the transferable if and only if the sub-criterion does not accept it.

**Or**

Performs the logical OR operation on two or more client-side criteria; accepts the transferable if any of the given sub-criteria accepts it.

**Sources**

Accepts all transferables from any of the given source components

**SourcesTarget**

Accepts the transferable only if the source component is the same as the target. This criterion is useful for ensuring that items are dragged only within a tree or a table, and not from outside it.

**TargetDetails**

Accepts any transferable if the target detail, such as the item of a tree node or table row, is of the given data flavor and has the given value.

In addition, target components such as **Tree** and **Table** define some component-specific client-side accept criteria. See Section 11.12.2, “Dropping Items On a **Tree**” for more details.

**AbstractSelect** defines the following criteria for all selection components, including **Tree** and **Table**.

**AcceptItem**

Accepts only specific items from a specific selection component. The selection component, which must inherit **AbstractSelect**, is given as the first parameter for the constructor. It is followed by a list of allowed item identifiers in the drag source.

**AcceptItem.ALL**

Accepts all transferables as long as they are items.

**TargetItems**

Accepts all drops on the specified target items. The constructor requires the target component (**AbstractSelect**) followed by a list of allowed item identifiers.

**VerticalLocationIs.MIDDLE, TOP, and BOTTOM**

The three static criteria accepts drops on, above, or below an item. For example, you could accept drops only in between items with the following:

```
public AcceptCriterion getAcceptCriterion() {
    return new Not(VerticalLocationIs.MIDDLE);
}
```

## Server-Side Criteria

The *server-side criteria* are verified on the server-side with the `accept()` method of the **ServerSideCriterion** class. This allows fully programmable logic for accepting drops, but the negative side is that it causes a very large amount of server requests. A request is made for every target position on which the pointer hovers. This problem is eased in many cases by the component-specific lazy loading criteria **TableDropCriterion** and **TreeDropCriterion**. They do the server visit once for each drag and drop operation and return all accepted rows or nodes for current **Transferable** at once.

The `accept()` method gets the drag event as a parameter so it can perform its logic much like in `drop()`.

```
public AcceptCriterion getAcceptCriterion() {
    // Server-side accept criterion that allows drops on any other
    // location except on nodes that may not have children
    ServerSideCriterion criterion = new ServerSideCriterion() {
        public boolean accept(DragAndDropEvent dragEvent) {
```

```
TreeTargetDetails target = (TreeTargetDetails)
dragEvent.getTargetDetails();

// The tree item on which the load hovers
Object targetItemId = target.getItemIdOver();

// On which side of the target the item is hovered
VerticalDropLocation location = target.getDropLocation();
if (location == VerticalDropLocation.MIDDLE)
    if (!tree.areChildrenAllowed(targetItemId))
        return false; // Not accepted

return true; // Accept everything else
}
};

return criterion;
}
```

The server-side criteria base class **ServerSideCriterion** provides a generic `accept()` method. The more specific **TableDropCriterion** and **TreeDropCriterion** are convenience extensions that allow defining allowed drop targets as a set of items. They also provide some optimization by lazy loading, which reduces server communications significantly.

```
public AcceptCriterion getAcceptCriterion() {
    // Server-side accept criterion that allows drops on any
    // other tree node except on node that may not have children
    TreeDropCriterion criterion = new TreeDropCriterion() {
        @Override
        protected Set<Object> getAllowedItemIds(
            DragAndDropEvent dragEvent, Tree tree) {
            HashSet<Object> allowed = new HashSet<Object>();
            for (Iterator<Object> i =
                tree.getItemIds().iterator(); i.hasNext(); ) {
                Object itemId = i.next();
                if (tree.hasChildren(itemId))
                    allowed.add(itemId);
            }
            return allowed;
        }
    };
    return criterion;
}
```

## Accept Indicators

When a dragged object hovers on a drop target, an *accept indicator* is displayed to show whether or not the location is accepted. For *MIDDLE* location, the indicator is a box around the target (tree node, table row, or component). For vertical drop locations, the accepted locations are shown as horizontal lines, and for horizontal drop locations as vertical lines.

For **DragAndDropWrapper** drop targets, you can disable the accept indicators or *drag hints* with the *no-vertical-drag-hints*, *no-horizontal-drag-hints*, and *no-box-drag-hints* styles. You need to add the styles to the *layout that contains* the wrapper, not to the wrapper itself.

```
// Have a wrapper
DragAndDropWrapper wrapper = new DragAndDropWrapper(c);
layout.addComponent(wrapper);

// Disable the hints
```

```
layout.addStyleName("no-vertical-drag-hints");
layout.addStyleName("no-horizontal-drag-hints");
layout.addStyleName("no-box-drag-hints");
```

## 11.12.5. Dragging Components

Dragging a component requires wrapping the source component within a **DragAndDropWrapper**. You can then allow dragging by putting the wrapper (and the component) in drag mode with `setDragStartMode()`. The method supports two drag modes: `DragStartMode.WRAPPER` and `DragStartMode.COMPONENT`, which defines whether the entire wrapper is shown as the drag image while dragging or just the wrapped component.

```
// Have a component to drag
final Button button = new Button("An Absolute Button");

// Put the component in a D&D wrapper and allow dragging it
final DragAndDropWrapper buttonWrap = new DragAndDropWrapper(button);
buttonWrap.setDragStartMode(DragStartMode.COMPONENT);

// Set the wrapper to wrap tightly around the component
buttonWrap.setSizeUndefined();

// Add the wrapper, not the component, to the layout
layout.addComponent(buttonWrap, "left: 50px; top: 50px;");
```

The default height of **DragAndDropWrapper** is undefined, but the default width is 100%. If you want to ensure that the wrapper fits tightly around the wrapped component, you should call `setSizeUndefined()` for the wrapper. Doing so, you should make sure that the wrapped component does not have a relative size, which would cause a paradox.

Dragged components are referenced in the **WrapperTransferable**. You can get the reference to the dragged component with `getDraggedComponent()`. The method will return `null` if the transferable is not a component. Also HTML 5 drags (see later) are held in wrapper transferables.

## 11.12.6. Dropping on a Component

Drops on a component are enabled by wrapping the component in a **DragAndDropWrapper**. The wrapper is an ordinary component; the constructor takes the wrapped component as a parameter. You just need to define the **DropHandler** for the wrapper with `setDropHandler()`.

In the following example, we allow moving components in an absolute layout. Details on the drop handler are given later.

```
// A layout that allows moving its contained components
// by dragging and dropping them
final AbsoluteLayout absLayout = new AbsoluteLayout();
absLayout.setWidth("100%");
absLayout.setHeight("400px");

... put some (wrapped) components in the layout ...

// Wrap the layout to allow handling drops
DragAndDropWrapper layoutWrapper =
    new DragAndDropWrapper(absLayout);

// Handle moving components within the AbsoluteLayout
layoutWrapper.setDropHandler(new DropHandler() {
```

```
public AcceptCriterion getAcceptCriterion() {
    return AcceptAll.get();
}

public void drop(DragAndDropEvent event) {
    ...
});

});
```

## Target Details for Wrapped Components

The drop handler receives the drop target details in a **WrapperTargetDetails** object, which implements the **TargetDetails** interface.

```
public void drop(DragAndDropEvent event) {
    WrapperTransferable t =
        (WrapperTransferable) event.getTransferable();
    WrapperTargetDetails details =
        (WrapperTargetDetails) event.getTargetDetails();
```

The wrapper target details include a **MouseEventDetails** object, which you can get with `getMouseEvent()`. You can use it to get the mouse coordinates for the position where the mouse button was released and the drag ended. Similarly, you can find out the drag start position from the transferable object (if it is a **WrapperTransferable**) with `getMouseDownEvent()`.

```
// Calculate the drag coordinate difference
int xChange = details.getMouseEvent().getClientX()
    - t.getMouseDownEvent().getClientX();
int yChange = details.getMouseEvent().getClientY()
    - t.getMouseDownEvent().getClientY();

// Move the component in the absolute layout
ComponentPosition pos =
    absLayout.getPosition(t.getSourceComponent());
pos.setLeftValue(pos.getLeftValue() + xChange);
pos.setTopValue(pos.getTopValue() + yChange);
```

You can get the absolute x and y coordinates of the target wrapper with `getAbsoluteLeft()` and `getAbsoluteTop()`, which allows you to translate the absolute mouse coordinates to coordinates relative to the wrapper. Notice that the coordinates are really the position of the wrapper, not the wrapped component; the wrapper reserves some space for the accept indicators.

The `verticalDropLocation()` and `horizontalDropLocation()` return the more detailed drop location in the target.

## 11.12.7. Dragging Files from Outside the Browser

The **DragAndDropWrapper** allows dragging files from outside the browser and dropping them on a component wrapped in the wrapper. Dropped files are automatically uploaded to the application and can be acquired from the wrapper with `getFiles()`. The files are represented as **Html5File** objects as defined in the inner class. You can define an upload **Receiver** to receive the content of a file to an **OutputStream**.

Dragging and dropping files to browser is supported in HTML 5 and requires a compatible browser, such as Mozilla Firefox 3.6 or newer.

## 11.13. Logging

You can do logging in Vaadin application using the standard `java.util.logging` facilities. Configuring logging is as easy as putting a file named `logging.properties` in the default package of your Vaadin application (`src` in an Eclipse project or `src/main/java` or `src/main/resources` in a Maven project). This file is read by the `Logger` class when a new instance of it is initialized.

### Logging in Apache Tomcat

For logging Vaadin applications deployed in Apache Tomcat, you do not need to do anything special to log to the same place as Tomcat itself. If you need to write the Vaadin application related messages elsewhere, just add a custom `logging.properties` file to the default package of your Vaadin application.

If you would like to pipe the log messages through another logging solution, see the section called “Piping to Log4j using SLF4J” below.

### Logging in Liferay

Liferay mutes logging through `java.util.logging` by default. In order to enable logging, you need to add a `logging.properties` file of your own to the default package of your Vaadin application. This file should define at least one destination where to save the log messages.

You can also log through SLF4J, which is used in and bundled with Liferay. Follow the instructions in the section called “Piping to Log4j using SLF4J”.

### Piping to Log4j using SLF4J

Piping output from `java.util.logging` to Log4j is easy with SLF4J (<http://slf4j.org/>). The basic way to go about this is to add the SLF4J JAR file as well as the `jul-to-slf4j.jar` file, which implements the bridge from `java.util.logging`, to SLF4J. You will also need to add a third logging implementation JAR file, that is, `slf4j-log4j12-x.x.x.jar`, to log the actual messages using Log4j. For more info on this, please visit the SLF4J site.

In order to get the `java.util.logging` to SLF4J bridge installed, you need to add the following snippet of code to your `UI` class at the very top:

```
static {
    SLF4JBridgeHandler.install();
}
```

This will make sure that the bridge handler is installed and working before Vaadin starts to process any logging calls.



#### Please note!

This can seriously impact on the cost of disabled logging statements (60-fold increase) and a measurable impact on enabled log statements (20% overall increase). However, Vaadin doesn't log very much, so the effect on performance will be negligible.

## Using Logger

You can do logging with a simple pattern where you register a static logger instance in each class that needs logging, and use this logger wherever logging is needed in the class. For example:

```
public class MyClass {  
    private final static Logger logger =  
        Logger.getLogger(MyClass.class.getName());  
  
    public void myMethod() {  
        try {  
            // do something that might fail  
        } catch (Exception e) {  
            logger.log(Level.SEVERE, "FAILED CATASTROPHICALLY!", e);  
        }  
    }  
}
```

Having a `static` logger instance for each class needing logging saves a bit of memory and time compared to having a logger for every logging class instance. However, it could cause the application to leak PermGen memory with some application servers when redeploying the application. The problem is that the `Logger` may maintain hard references to its instances. As the `Logger` class is loaded with a classloader shared between different web applications, references to classes loaded with a per-application classloader would prevent garbage-collecting the classes after redeploying, hence leaking memory. As the size of the PermGen memory where class objects are stored is fixed, the leakage will lead to a server crash after many redeployments. The issue depends on the way how the server manages classloaders, on the hardness of the back-references, and may also be different between Java 6 and 7. So, if you experience PermGen issues, or want to play it on the safe side, you should consider using non-static `Logger` instances.

## 11.14. JavaScript Interaction

Vaadin supports two-direction JavaScript calls from and to the server-side. This allows interfacing with JavaScript code without writing client-side integration code.

### 11.14.1. Calling JavaScript

You can make JavaScript calls from the server-side with the `execute()` method in the `JavaScript` class. You can get a `JavaScript` instance from the current `Page` object with `getJavaScript()`.

```
// Execute JavaScript in the currently processed page  
Page.getCurrent().getJavaScript().execute("alert('Hello')");
```

The `JavaScript` class itself has a static shorthand method `getCurrent()` to get the instance for the currently processed page.

```
// Shorthand  
JavaScript.getCurrent().execute("alert('Hello')");
```

The JavaScript is executed after the server request that is currently processed returns. If multiple JavaScript calls are made during the processing of the request, they are all executed sequentially after the request is done. Hence, the JavaScript execution does not pause the execution of the server-side application and you can not return values from the JavaScript.

### 11.14.2. Handling JavaScript Function Callbacks

You can make calls with JavaScript from the client-side to the server-side. This requires that you register JavaScript call-back methods from the server-side. You need to implement and register a `JavaScriptFunction` with `addFunction()` in the current `JavaScript` object. A function requires a name, with an optional package path, which are given to the `addFunction()`. You only need to implement the `call()` method to handle calls from the client-side JavaScript.

```
JavaScript.getCurrent().addFunction("com.example.foo.myfunc",
    new JavaScriptFunction() {
        @Override
        public void call(JSONArray arguments) throws JSONException {
            Notification.show("Received call");
        }
    });

Link link = new Link("Send Message", new ExternalResource(
    "javascript:com.example.foo.myfunc()"));
```

Parameters passed to the JavaScript method on the client-side are provided in a **JSONArray** passed to the `call()` method. The parameter values can be acquired with the `get()` method by the index of the parameter, or any of the type-casting getters. The getter must match the type of the passed parameter, or a **JSONException** is thrown.

```
JavaScript.getCurrent().addFunction("com.example.foo.myfunc",
    new JavaScriptFunction() {
        @Override
        public void call(JSONArray arguments) throws JSONException {
            try {
                String message = arguments.getString(0);
                int value = arguments.getInt(1);
                Notification.show("Message: " + message +
                    ", value: " + value);
            } catch (JSONException e) {
                Notification.show("Error: " + e.getMessage());
            }
        }
    });

Link link = new Link("Send Message", new ExternalResource(
    "javascript:com.example.foo.myfunc(prompt('Message'), 42)"));
```

The function callback mechanism is the same as the RPC mechanism used with JavaScript component integration, as described in Section 16.13.4, “RPC from JavaScript to Server-Side”.

## 11.15. Accessing Session-Global Data

*This section is mostly up-to-date with Vaadin 7, but has some information which still needs to be updated.*

Applications typically need to access some objects from practically all user interface code, such as a user object, a business data model, or a database connection. This data is typically initialized and managed in the UI class of the application, or in the session or servlet.

For example, you could hold it in the UI class as follows:

```
class MyUI extends UI {
    UserData userData;

    public void init() {
        userData = new UserData();
    }

    public UserData getUserData() {
        return userData;
    }
}
```

```
    }
}
```

Vaadin offers two ways to access the UI object: with `getUI()` method from any component and the global `UI.getCurrent()` method.

The `getUI()` works as follows:

```
data = ((MyUI)component.getUI()).getUserData();
```

This does not, however work in many cases, because it requires that the components are attached to the UI. That is not the case most of the time when the UI is still being built, such as in constructors.

```
class MyComponent extends CustomComponent {
    public MyComponent() {
        // This fails with NullPointerException
        Label label = new Label("Country: " +
            getApplication().getLocale().getCountry());

        setCompositionRoot(label);
    }
}
```

The global access methods for the currently served servlet, session, and UI allow an easy way to access the data:

```
data = ((MyUI) UI.getCurrent()).getUserData();
```

## The Problem

The basic problem in accessing session-global data is that the `getUI()` method works only after the component has been attached to the application. Before that, it returns `null`. This is the case in constructors of components, such as a **CustomComponent**:

Using a static variable or a singleton implemented with such to give a global access to user session data is not possible, because static variables are global in the entire web application, not just the user session. This can be handy for communicating data between the concurrent sessions, but creates a problem within a session.

The data would be shared by all users and be reinitialized every time a new user opens the application.

## Overview of Solutions

To get the application object or any other global data, you have the following solutions:

- Pass a reference to the global data as a parameter
- Initialize components in `attach()` method
- Initialize components in the `enter()` method of the navigation view (if using navigation)
- Store a reference to global data using the *ThreadLocal Pattern*

Each solution is described in the following sections.

### 11.15.1. Passing References Around

You can pass references to objects as parameters. This is the normal way in object-oriented programming.

```
class MyApplication extends Application {  
    UserData userData;  
  
    public void init() {  
        Window mainWindow = new Window("My Window");  
        setMainWindow(mainWindow);  
  
        userData = new UserData();  
  
        mainWindow.addComponent(new MyComponent(this));  
    }  
  
    public UserData getUserData() {  
        return userData;  
    }  
}  
  
class MyComponent extends CustomComponent {  
    public MyComponent(MyApplication app) {  
        Label label = new Label("Name: " +  
            app.getUserData().getName());  
  
        setCompositionRoot(label);  
    }  
}
```

If you need the reference in other methods, you either have to pass it again as a parameter or store it in a member variable.

The problem with this solution is that practically all constructors in the application need to get a reference to the application object, and passing it further around in the classes is another hard task.

### 11.15.2. Overriding attach()

The `attach()` method is called when the component is attached to the application component through containment hierarchy. The `getApplication()` method always works.

```
class MyComponent extends CustomComponent {  
    public MyComponent() {  
        // Must set a dummy root in constructor  
        setCompositionRoot(new Label "");  
    }  
  
    @Override  
    public void attach() {  
        Label label = new Label("Name: " +  
            ((MyApplication)component.getApplication())  
            .getUserData().getName());  
  
        setCompositionRoot(label);  
    }  
}
```

While this solution works, it is slightly messy. You may need to do some initialization in the constructor, but any construction requiring the global data must be done in the `attach()` method. Especially, **CustomComponent** requires that the `setCompositionRoot()` method is called in the constructor. If you can't create the actual composition root component in the constructor, you need to use a temporary dummy root, as is done in the example above.

Using `getApplication()` also needs casting if you want to use methods defined in your application class.

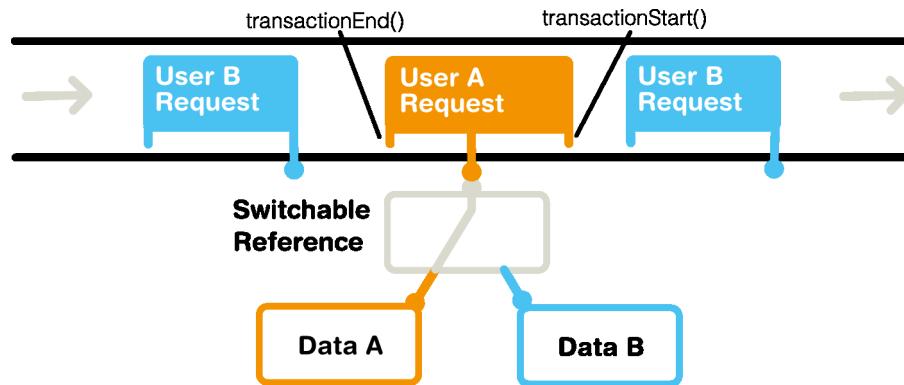
### 11.15.3. ThreadLocal Pattern

Vaadin uses the ThreadLocal pattern for allowing global access to the **UI**, and **Page** objects of the currently processed server request with a static `getCurrent()` method in all the respective classes. This section explains why the pattern is used in Vaadin and how it works. You may also need to reimplement the pattern for some purpose.

The ThreadLocal pattern gives a solution to the global access problem by solving two sub-problems of static variables.

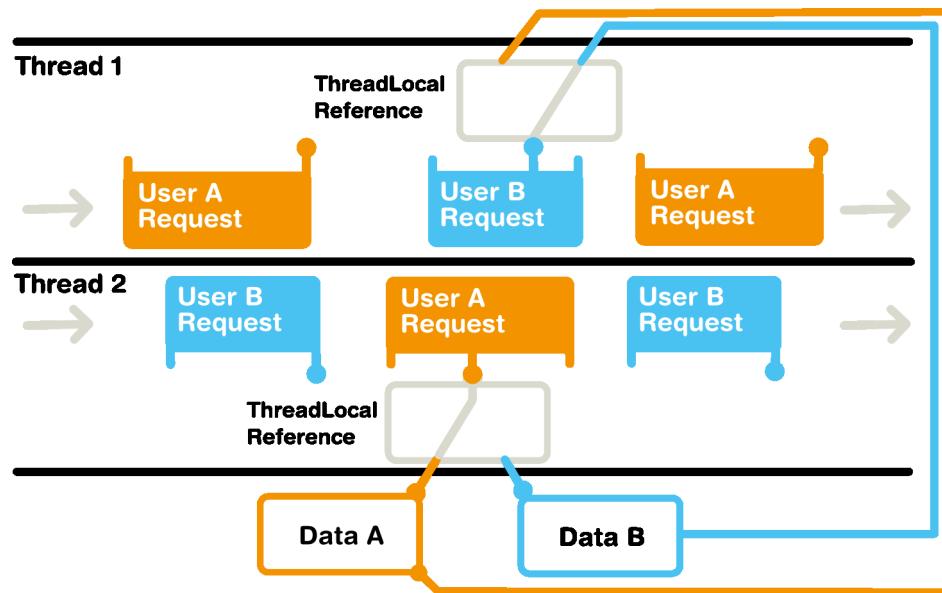
As the first problem, assume that the servlet container processes requests for many users (sessions) sequentially. If a static variable is set in a request belonging one user, it could be read or re-set by the next incoming request belonging to another user. This can be solved by setting the global reference at the beginning of each HTTP request to point to data of the current user, as illustrated in Figure 11.13.

**Figure 11.13. Switching a static (or ThreadLocal) reference during sequential processing of requests**



The second problem is that servlet containers typically do thread pooling with multiple worker threads that process requests. Therefore, setting a static reference would change it in all threads running concurrently, possibly just when another thread is processing a request for another user. The solution is to store the reference in a thread-local variable instead of a static. You can do so by using the **ThreadLocal** class in Java for the switch reference.

**Figure 11.14. Switching ThreadLocal references during concurrent processing of requests**



## 11.16. Server Push

When you need to update a UI from another UI, possibly of another user, or from a background thread running in the server, you usually want to have the update show immediately, not when the browser happens to make the next server request. For this purpose, you can use *server push* that sends the data to the browser immediately. Push is based on a client-server connection, usually a WebSocket connection, that the client establishes and the server can then use to send updates to the client.

The server-client communication is done by default with a WebSocket connection if the browser and the server support it. If not, Vaadin will fall back to a method supported by the browser. Vaadin Push uses a custom build of the Atmosphere framework for client-server communication.

### 11.16.1. Installing the Push Support

The server push support in Vaadin requires the separate Vaadin Push library. It is included in the installation package as `vaadin-push.jar`.

#### Retrieving with Ivy

With Ivy, you can get it with the following declaration in the `ivy.xml`:

```
<dependency org="com.vaadin" name="vaadin-push"
           rev="&vaadin.version;" conf="default->default"/>
```

In some servers, you may need to exclude a `slf4j` dependency as follows:

```
<dependency org="com.vaadin" name="vaadin-push"
           rev="&vaadin.version;" conf="default->default">
    <exclude org="org.slf4j" name="slf4j-api"/>
</dependency>
```

Pay note that the Atmosphere library is a bundle, so if you retrieve the libraries with Ant, for example, you need to retrieve type="jar,bundle".

## Retrieving with Maven

In Maven, you can get the push library with the following dependency in the POM:

```
<dependency>
    <groupId>com.vaadin</groupId>
    <artifactId>vaadin-push</artifactId>
    <version>${vaadin.version}</version>
</dependency>
```

### 11.16.2. Enabling Push for a UI

To enable server push, you need to define the push mode either in the deployment descriptor or with the **@Push** annotation for the UI.

#### Push Modes

You can use server push in two modes: `automatic` and `manual`. The automatic mode pushes changes to the browser automatically after `access()` finishes. With the manual mode, you can do the push explicitly with `push()`, which allows more flexibility.

#### The @Push annotation

You can enable server push for a UI with the **@Push** annotation as follows. It defaults to automatic mode (`PushMode.AUTOMATIC`).

```
@Push
public class PushyUI extends UI {
```

To enable manual mode, you need to give the `PushMode.MANUAL` parameter as follows:

```
@Push(PushMode.MANUAL)
public class PushyUI extends UI {
```

#### Servlet Configuration

You can enable the server push and define the push mode also in the servlet configuration with the `pushmode` parameter for the servlet in the `web.xml` deployment descriptor. If you use a Servlet 3.0 compatible server, you also want to enable asynchronous processing with the `async-supported` parameter. Note the use of Servlet 3.0 schema in the deployment descriptor.

```
<?xml version="1.0" encoding="UTF-8"?>
<web-app
    id="WebApp_ID" version="3.0"
    xmlns="http://java.sun.com/xml/ns/javaee"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://java.sun.com/xml/ns/javaee
        http://java.sun.com/xml/ns/javaee/web-app_3_0.xsd">
    <servlet>
        <servlet-name>Pushy UI</servlet-name>
        <servlet-class>
            com.vaadin.server.VaadinServlet</servlet-class>
        </init-param>
```

```
<param-name>UI</param-name>
<param-value>com.example.my.PushyUI</param-value>
</init-param>

<!-- Enable server push -->
<init-param>
    <param-name>pushmode</param-name>
    <param-value>automatic</param-value>
</init-param>
<async-supported>true</async-supported>
</servlet>
</web-app>
```

### 11.16.3. Accessing UI from Another Thread

Making changes to a **UI** object from another thread and pushing them to the browser requires locking the user session when accessing the UI. Otherwise, the UI update done from another thread could conflict with a regular event-driven update and cause either data corruption or deadlocks. Because of this, you may only access an UI using the `access( )` method, which locks the session to prevent conflicts. It takes a `Runnable` which it executes as its parameter.

For example:

```
ui.access(new Runnable() {
    @Override
    public void run() {
        series.add(new DataSeriesItem(x, y));
    }
});
```

In Java 8, where a parameterless lambda expression creates a runnable, you could simply write:

```
ui.access(() ->
    series.add(new DataSeriesItem(x, y)));
```

If the push mode is `manual`, you need to push the pending UI changes to the browser explicitly with the `push( )` method.

```
ui.access(new Runnable() {
    @Override
    public void run() {
        series.add(new DataSeriesItem(x, y));
        ui.push();
    }
});
```

Below is a complete example of a case where we make UI changes from another thread.

```
public class PushyUI extends UI {
    Chart chart = new Chart(ChartType.AREASPLINE);
    DataSeries series = new DataSeries();

    @Override
    protected void init(VaadinRequest request) {
        chart.setSizeFull();
        setContent(chart);

        // Prepare the data display
        Configuration conf = chart.getConfiguration();
```

```
conf.setTitle("Hot New Data");
conf.setSeries(series);

// Start the data feed thread
new FeederThread().start();
}

class FeederThread extends Thread {
    int count = 0;

    @Override
    public void run() {
        try {
            // Update the data for a while
            while (count < 100) {
                Thread.sleep(1000);

                access(new Runnable() {
                    @Override
                    public void run() {
                        double y = Math.random();
                        series.add(
                            new DataSeriesItem(count++, y),
                            true, count > 10);
                    }
                });
            }
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
    }
}
```

When sharing data between UIs or user sessions, you need to consider the message-passing mechanism more carefully, as explained next.

#### 11.16.4. Broadcasting to Other Users

Broadcasting messages to be pushed to UIs in other user sessions requires having some sort of message-passing mechanism that sends the messages to all UIs that register as recipients. As processing server requests for different UIs is done concurrently in different threads of the application server, locking the threads properly is very important to avoid deadlock situations.

##### The Broadcaster

The standard pattern for sending messages to other users is to use a *broadcaster* singleton that registers the UIs and broadcasts messages to them safely. To avoid deadlocks, it is recommended that the messages should be sent through a message queue in a separate thread. Using a Java **ExecutorService** running in a single thread is usually the easiest and safest way.

```
public class Broadcaster implements Serializable {
    static ExecutorService executorService =
        Executors.newSingleThreadExecutor();

    public interface BroadcastListener {
        void receiveBroadcast(String message);
    }

    private static LinkedList<BroadcastListener> listeners =
        new LinkedList<BroadcastListener>();

    public static synchronized void register(
        BroadcastListener listener) {
        listeners.add(listener);
    }

    public static synchronized void unregister(
        BroadcastListener listener) {
        listeners.remove(listener);
    }

    public static synchronized void broadcast(
        final String message) {
        for (final BroadcastListener listener: listeners)
            executorService.execute(new Runnable() {
                @Override
                public void run() {
                    listener.receiveBroadcast(message);
                }
            });
    }
}
```

In Java 8, you could use lambda expressions for the listeners instead of the interface, and a parameterless expression to create the runnable:

```
for (final Consumer<String> listener: listeners)
    executorService.execute(() ->
        listener.accept(message));
```

## Receiving Broadcasts

The receivers need to implement the receiver interface and register to the broadcaster to receive the broadcasts. A listener should be unregistered when the UI expires. When updating the UI in a receiver, it should be done safely as described earlier, by executing the update through the `access()` method of the UI.

```
@Push
public class PushAroundUI extends UI
    implements Broadcaster.BroadcastListener {

    VerticalLayout messages = new VerticalLayout();

    @Override
    protected void init(VaadinRequest request) {
        ... build the UI ...

        // Register to receive broadcasts
        Broadcaster.register(this);
```

```
    }

    // Must also unregister when the UI expires
    @Override
    public void detach() {
        Broadcaster.unregister(this);
        super.detach();
    }

    @Override
    public void receiveBroadcast(final String message) {
        // Must lock the session to execute logic safely
        access(new Runnable() {
            @Override
            public void run() {
                // Show it somehow
                messages.addComponent(new Label(message));
            }
        });
    }
}
```

## Sending Broadcasts

To send broadcasts with a broadcaster singleton, such as the one described above, you would only need to call the `broadcast()` method as follows.

```
final TextField input = new TextField();
sendBar.addComponent(input);

Button send = new Button("Send");
send.addClickListener(new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        // Broadcast the message
        Broadcaster.broadcast(input.getValue());

        input.setValue(" ");
    }
});
```

## 11.17. Vaadin CDI Add-on

Vaadin CDI add-on makes it easier to use contexts and dependency injection (CDI) in Vaadin applications. CDI is a Java EE feature especially targeted for web applications, which have well-defined contextual scopes, such as sessions, views, requests, and so forth. The lifecycle of objects, such as beans, can be managed by binding their lifecycles to such contexts. Vaadin CDI enables these features with two additional kinds of Vaadin-specific contextual scopes: UIs and navigation views.

To learn more about Vaadin CDI, the [Vaadin CDI Tutorial](#) gives a hands-on introduction. The source code of the CDI Tutorial demo is available for browsing or cloning at <https://github.com/vaadin-samples/cdi-tutorial>.

### 11.17.1. CDI Overview

Contexts and dependency injection, defined in the JSR-299 standard, is a Java EE feature that, through a set of services, helps in improving application architecture by decoupling the management of service object lifecycles from client objects using them. The lifecycle of objects stored in a CDI container is defined by a context. The managed objects or beans are accessed using dependency injection.

CDI builds on the Java concept of beans, but with somewhat different definition and requirements.

Regarding general CDI topics, such as use of qualifiers, interceptors, decorators, event notifications, and other CDI features, we refer you to CDI documentation.

- Introduction to CDI. Pete Muir and Mark Struberg, JAXenter.
- Weld - CDI Reference Implementation
- CDI Specification
- Vaadin CDI Tutorial

### Dependency Injection

*Dependency injection* is a way to pass dependencies (service objects) to dependent objects (clients) by injecting them in member variables or initializer parameters, instead of managing the lifecycle in the clients or passing them explicitly as parameters. In CDI, injection of a service object to a client is specified by the `@Inject` annotation.

For example, if we have a UI view that depends on user data, we could inject the data in the client as follows:

```
public class MainView extends CustomComponent implements View {  
    @Inject  
    User user;  
  
    ...  
    @Override  
    public void enter(ViewChangeEvent event) {  
        greeting.setValue("Hello, " + user.getName());  
    }  
}
```

In addition to injecting managed beans with the annotation, you can query for them from the bean manager.

### Contexts and Scopes

*Contexts* in CDI are services that manage the lifecycle of objects and handle their injection. Generally speaking, a context is a situation in which an instance is used with a unique identity. Such objects are essentially "singletons" in the context. While conventional singletons are application-wide, objects managed by a CDI container can be "singletons" in a more narrow scope: a user session, a particular UI instance associated with the session, a view within the UI, or even just a single request. Such a context defines the lifecycle of the object: its creation, use, and finally its destruction.

As a very typical example in a web application, you would have a user data object associated with a user session.

```
@SessionScoped
public class User {
    private String name;

    public void setName(String name) {this.name = name;}
    public String getName() {return name;}
}
```

Now, when you need to refer to the user, you can use CDI injection to inject the session-scoped "singleton" to a member variable or a constructor parameter.

```
public class MainView extends CustomComponent implements View {
    @Inject
    User user;

    ...

    @Override
    public void enter(ViewChangeEvent event) {
        greeting.setValue("Hello, " + user.getName());
    }
}
```

## 11.17.2. Installing Vaadin CDI Add-on

Vaadin CDI requires a Java EE 7 compatible servlet container, such as Glassfish or Apache TomEE Web Profile, as mentioned for the reference toolchain in Section 2.2, “Setting up the Development Environment”.

To install the Vaadin CDI add-on, either define it as an Ivy or Maven dependency or download it from the Vaadin Directory add-on page at [vaadin.com/directory#addon/vaadin-cdi](http://vaadin.com/directory#addon/vaadin-cdi). See Chapter 17, *Using Vaadin Add-ons* for general instructions for installing and using Vaadin add-ons.

The Ivy dependency is as follows:

```
<dependency org="com.vaadin" name="vaadin-cdi"
            rev="latest.release"/>
```

The Maven dependency is as follows:

```
<dependency>
    <groupId>com.vaadin</groupId>
    <artifactId>vaadin-cdi</artifactId>
    <version>LATEST</version>
</dependency>
```

## 11.17.3. Preparing Application for CDI

A Vaadin application that uses CDI must have a file named `beans.xml` in the `WEB-INF` directory. The file can be completely empty (it has content only in certain limited situations), but it must be present.

The application should not have a servlet extending **VaadinServlet**, as Vaadin servlet has its own **VaadinCDIServlet** that is deployed automatically. If you need multiple servlets or need to customize the Vaadin CDI servlet, see Section 11.17.6, “Deploying CDI UIs and Servlets”.

### 11.17.4. Injecting a UI with `@CDIUI`

Vaadin CDI offers an easier way to instantiate UIs and to define the URL mapping for them than the usual ways described in Section 4.8, “Deploying an Application”. To define a UI class that should be instantiated for a given URL, you simply need to annotate the class with `@CDIUI`. It takes an optional URL path as parameter.

```
@CDIUI( "myniceui" )
@Theme( "valo" )
public class MyNiceUI extends UI {
    ...
}
```

Giving empty UI path maps the UI to the root of the application context.

```
@CDIUI( "" )
```

If the optional UI path is not given, the path is determined automatically from the class name by removing a possible “-UI” suffix in the class name, making it lower-case, and for capitalized letters, a hyphen is added. For example, a UI with class name **MyNiceUI** would have path `my-nice`. The URL consists of the server address, application context, and the UI path. For example, when running a Vaadin application in a development workstation, you would have URL such as `http://localhost:8080/myproject/my-nice`.

UI path mappings are reported in the server log during deployment.

See Section 11.17.6, “Deploying CDI UIs and Servlets” for how to handle servlet URL mapping of CDI UIs when working with multiple servlets in the same web application.

### 11.17.5. Scopes

As in programming languages, where a variable name refers to a unique object within the scope of the variable, a CDI scope is a context in which an object has unique identity. In CDI, objects to be injected are identified by their type and any qualifiers they may have. The scope can be defined as an annotation to the service class as follows:

```
@SessionScoped
public class User {
    ...
}
```

CDI defines a number of scopes. Note that the standard CDI scopes are defined under the `javax.enterprise.context` package and Vaadin CDI scopes under `com.vaadin.cdi`, while JSF scopes are defined in `javax.faces.bean`.

#### UI Scope

UI-scoped beans are uniquely identified within a UI instance, that is, a browser window or tab.

Vaadin CDI provides two annotations for the UI scope, differing in how they enable proxies, as explained later.

##### `@UIScoped` (`com.vaadin.cdi`)

Injection with this annotation will create a direct reference to the bean rather than a proxy. There are some limitations when not using proxies. Circular references (injecting A to B and B to A) will not work, and neither do CDI interceptors and decorators.

**@NormalUIScoped** (com.vaadin.cdi)

As **@UIScoped**, but injecting with this annotation creates a proxy for the contextual instance rather than provides the contextual instance itself.

Defining a CDI view (annotated with **@CDIView** as described later) as **@UIScoped** makes the view retain the same instance when the user navigates away and back to the view.

## View Scopes

The lifecycle of a view-scoped bean starts when the user navigates to a view referring to the object and ends when the user navigates out of the view (or when the UI is closed or expires).

Vaadin CDI provides two annotations for the view scope, differing in how they enable proxies, as explained later.

**@ViewScoped** (com.vaadin.cdi)

Injection with this annotation will create a direct reference to the bean rather than a proxy. There are some limitations when not using proxies. Circular references (injecting A to B and B to A) will not work, and neither do CDI interceptors and decorators.

**@NormalViewScoped** (com.vaadin.cdi)

As **@NormalScoped**, except that injecting with this annotation will create a proxy for the contextual instance rather than provide the contextual instance itself. See the explanation of proxies below.

## Standard CDI Scopes

**@ApplicationScoped**

Application-scoped beans are shared by all servlets in the web application, and are essentially equal to singletons. Note that referencing application-scoped beans is not thread-safe and access must be synchronized.

**@SessionScoped**

The lifecycle and visibility of session-scoped beans is bound to a HTTP or user session, which in Vaadin applications is associated with the **VaadinSession** (see Section 4.7.3, “User Session”). This is a very typical scope to store user data, as is done in many examples in this section, or database connections. The lifecycle of session-scoped beans starts when a user opens the page for a UI in the browser, and ends when the session expires after the last UI in the session is closed.

## Proxies vs Direct References

CDI uses proxy objects to enable many of the CDI features, by hooking into message-passing from client to service beans. Under the hood, a proxy is an instance of an automatically generated class that extends the proxied bean type, so communicating through a proxy occurs transparently, as it has the same polymorphic type as the actual bean. Whether proxying is enabled or not is defined in the scope: CDI scopes are either *normal scopes*, which can be proxied, or *pseudo-scopes*, which use direct references to injected beans.

The proxying mechanism creates some requirements for injecting objects in normal scope:

- The objects may not be primitive types or arrays
- The bean class must not be final

- The bean class must not have final methods

Beans annotated with **@UIScoped** or **@ViewScoped** use a pseudoscope, and are therefore injected with direct references to the bean instances, while **@NormalUIScoped** and **@NormalViewScoped** beans will use a proxy for communicating with the beans.

When using proxies, be aware that it is not guaranteed that the `hashCode()` or `equals()` will match when comparing a proxy to its underlying instance. It is imperative to be aware of this when, for example, adding proxies to a `Collection`.

You should avoid using normal scopes with Vaadin components, as proxies may not work correctly within the Vaadin framework. If Vaadin CDI plugin detects such use, it displays a warning such as the following:

```
INFO: The following Vaadin components are injected
into normal scoped contexts:
    @NormalUIScoped      org.example.User
This approach uses proxy objects and has not been
extensively tested with the framework. Please report
any unexpected behavior. Switching to a pseudo-scoped
context may also resolve potential issues.
```

Both proxied and direct scopes have the same underlying scope, so it is possible to get both a proxy and a direct reference to the same object by using the two annotations.

## 11.17.6. Deploying CDI UIs and Servlets

Vaadin CDI hooks into Vaadin framework by using a special **VaadinCDIServlet**. As described earlier, you do not need to map an URL path to a UI, as it is handled by Vaadin CDI. However, in the following, we go through some cases where you need to customize the servlet or use CDI with non-CDI servlets and UIs in a web application.

### Defining Servlet Root with **@URLMapping**

CDI UIs are managed by a CDI servlet (**VaadinCDIServlet**), which is by default mapped to the root of the application context. For example, if the name of a CDI UI is "my-cdi" and application context is `/myproject`, the UI would by default have URL `"/myproject/my-cdi"`. If you do not want to have the servlet mapped to context root, you can use the **@URLMapping** annotation to map all CDI UIs to a sub-path. The annotation must be given to only one CDI UI, usually the one with the default ("") path.

For example, if we have a root UI and another:

```
@CDIUI("") // At CDI servlet root
@URLMapping("mycdiuis") // Define CDI Servlet root
public class MyCDIRootUI extends UI {...}

@CDIUI("another")
public class AnotherUI extends UI {...}
```

These two UIs would have URLs `/myproject/mycdiuis` and `/myproject/mycdiuis/another`, respectively.

You can also map the CDI servlet to another URL in servlet definition in `web.xml`, as described the following.

## Mixing With Other Servlets

The **VaadinCDIServlet** is normally used as the default servlet, but if you have other servlets in the application, such as for non-CDI UIs, you need to define the CDI servlet explicitly in the `web.xml`. You can map the servlet to any URL path, but perhaps typically, you define it as the default servlet as follows, and map the other servlets to other URL paths:

```
<web-app>
  ...
  <servlet>
    <servlet-name>Default</servlet-name>
    <servlet-class>
      com.vaadin.cdi.internal.VaadinCDIServlet
    </servlet-class>
  </servlet>

  <servlet-mapping>
    <servlet-name>Default</servlet-name>
    <url-pattern>/*</url-pattern>
  </servlet-mapping>

  <servlet-mapping>
    <servlet-name>Default</servlet-name>
    <url-pattern>/VAADIN/*</url-pattern>
  </servlet-mapping>
</web-app>
```

## Custom Servlets

When customizing the Vaadin servlet, as outlined in Section 4.7.2, “Vaadin Servlet, Portlet, and Service”, you simply need to extend **com.vaadin.cdi.internal.VaadinCDIServlet** instead of **com.vaadin.servlet.VaadinServlet**.

The custom servlet must not have **@WebServlet** annotation or **@VaadinServletConfiguration**, as you would normally with a Vaadin servlet, as described in Section 4.8, “Deploying an Application”.

### 11.17.7. View Navigation

Vaadin CDI extends the navigation framework in Vaadin, described in Section 11.9, “Navigating in an Application”. It manages CDI views with a special view provider and enables view scoping.

#### Preparing the UI

You can define navigation for any single-component container, as described in Section 11.9.1, “Setting Up for Navigation”, but typically you set up navigation for the entire UI content. To use Vaadin CDI views, you need to inject a **CDIViewProvider** in the UI and add it as a provider for the navigator.

```
@CDIUI("mycdiui")
public class MyCDIUI extends UI {
  @Inject
  CDIViewProvider viewProvider;

  @Override
  protected void init(VaadinRequest request) {
```

```
    Navigator navigator = new Navigator(this, this);
    navigator.addProvider(viewProvider);

    // Navigate to start view
    navigator.navigateTo("");
}
}
```

## The View

A view managed by Vaadin CDI only needs to have the **@CDIView** annotation.

```
@CDIView("main")
public class MainView extends CustomComponent implements View {
    ...
}
```

The annotation can have the following optional parameters:

### value (optional)

Specifies the view name by which it can be accessed programmatically and by the URI fragment.

```
@CDIView("main")
```

If other optional parameters are given, the value must be given by the named *value* parameter.

If the view name is not given, it is derived from the class name by removing a possible "View" suffix, making it lower case, and using a dash ("") to separate words originally denoted by capital letters. Thereby, a view class such as **MyFunnyView** would have name "my-funny".

### supportsParameters

Specifies whether view parameters can be passed to the view as a suffix to the name in the navigation state, that is, in the form of `viewname+viewparameters`. The view name is merely a prefix and there is no separator nor format for the parameters, but those are left for the view to handle. The parameter support mode is disabled by default.

```
@CDIView(value="myview", supportsParameters=true)
```

You could then navigate to the state with a URI fragment such as `#!myview/someparameter` or programmatically with:

```
getUI().getNavigator().navigateTo("myview/someparameter");
```

The `enter()` method of the view gets the URI fragment as parameter as is and can interpret it in any application-defined way.

Note that in this mode, matching a navigation state to a view is done by the prefix of the fragment! Thereby, no other views may start with the name of the view as prefix. For example, if the view name is "main", you must not have a view named "maintenance".

### uis

If the application has multiple UIs that use **CDIViewProvider**, you can use this parameter to specify which UIs can show the view.

```
@CDIView(value="myview", uis={MyCDIUI.class})
```

If the list contains `UI.class`, the view is available to all UIs.

```
@CDIView(value="myview", uis={UI.class})
```

In the following, we have a login view that accesses a session-scoped user object. Here, we use a constant to define the view name, so that we can use the constant when navigating to it.

```
@CDIView(LoginView.VIEWNAME)
public class LoginView extends CustomComponent
    implements View {
    public final static String VIEWNAME = "";

    // Here we inject to the constructor and actually do
    // not store the injected object to use it later
    @Inject
    public LoginView(User user) {
        VerticalLayout layout = new VerticalLayout();

        // An input field for editing injected data
        BeanItem<User> item = new BeanItem<User>(user);
        TextField username = new TextField("User name",
            item.getItemProperty("name"));
        username.setNullRepresentation("");
        layout.addComponent(username);

        // Login button (authentication omitted) / Java 8
        layout.addComponent(new Button("Login", e ->
            getUI().getNavigator().
                navigateTo(MainView.VIEWNAME)));
    }

    setCompositionRoot(layout);
}

@Override
public void enter(ViewChangeEvent event) {}
```

You could now navigate to the view from any other view in the UI with:

```
getUI().getNavigator().navigateTo(LoginView.VIEWNAME);
```

## 11.17.8. CDI Events

CDI events can be used for many purposes in Vaadin applications, such as passing messages between different parts of a view, between views, between UIs, or between users. Some cases require special consideration, such as when communicating between UIs and how injected components should be scoped.

### Observing Events

Let us consider a case where changes in one part of the UI (or view) require updating other parts of the UI. This is typical in master-detail views, for updating the master view after editing details, or when handling input from a sub-window. While you can handle such a situation with a custom call-back listener, CDI event mechanism simplifies the task.

Let us consider the following simple UI containing two panels. The input panel will send events, which are received by other parts of the UI, in this case a display panel. The panels need to be injected to enable CDI event passing in them.

```
@CDIUI("cdievents")
@Theme("valo")
public class CDIEventUI extends UI {
    @Inject
    InputPanel inputPanel;

    @Inject
    DisplayPanel displayPanel;

    @Override
    protected void init(VaadinRequest request) {
        Layout content =
            new HorizontalLayout(inputPanel, displayPanel);
        setContent(content);
    }
}
```

Now, let us look closer at the sending panel. To send messages, it needs to inject a **javax.enterprise.event.Event** object. As we are injecting the event to a component class, we need to specify the full package name to avoid confusion with Vaadin **Component.Event**.

```
class InputPanel extends Panel {
    @Inject
    private javax.enterprise.event.Event<MyEvent> event;

    public InputPanel() {
        super("Input");

        TextField editor = new TextField();
        Button save = new Button("Save", e -> // Java 8
            event.fire(new MyEvent(editor.getValue())));

        setContent(new VerticalLayout(editor, save));
    }
}
```

Firing an event is done with the `fire()` method on the injected event object. In our example, the event is as follows:

```
public class MyEvent implements Serializable {
    private String text;

    public MyEvent(String text) {
        this.text = text;
    }

    public String getName() {
        return text;
    }
}
```

The event is received by any method (in an injected object) marked by **@Observes** annotation for the event parameter to observe the event type.

```
@UIScoped
class DisplayPanel extends Panel {
    Label display = new Label("-nothing to display-");

    public DisplayPanel() {
```

```

        super("Display");
        setContent(display);
    }

    void myEventObserver(@Observes MyEvent event) {
        display.setValue("Observed: " + event.getName());
    }
}

```

Such a component that observes events from other components must be scoped to the UI or view, as otherwise it will be request-scoped and a new instance is created for receiving each event.

The UI with interaction is shown in Figure 11.15, “Observing CDI Events”.

**Figure 11.15. Observing CDI Events**



Any injection qualifiers defined for the event object in the sender are matched in the observers, which feature we will use later to avoid receiving unwanted events.

## Communicating Between UIs

CDI events are not propagated to inactive contexts, and only the context of the currently processed UI is active. Further, as explained in Section 11.16.3, “Accessing UI from Another Thread”, other Vaadin UIs may not be accessed without proper synchronization, as their requests are processed concurrently in different server threads. Therefore, you need to pass the events through an application-scoped messaging service and synchronize the access to other UIs by using the `access()` method.

In Section 11.16.4, “Broadcasting to Other Users” we looked into how to pass messages to all other UIs using a broadcasting service. In that example, we used static variables and methods to store references and to access the service. With CDI, we can let the context manage its lifecycle, access it by injection, and pass messages by CDI events. By scoping the messaging service to application, we essentially make it a singleton.

```
@ApplicationScoped
public class CDIBroadcaster implements Serializable {
```

As we can not let CDI deliver the messages, the messaging service needs to keep book of the messaging clients (UIs) waiting to receive messages.

```
private Collection<UI> uis = new HashSet<UI>();

public synchronized void register(UI listener) {
    uis.add(listener);
```

```
}

public synchronized void unregister(UI listener) {
    uis.remove(listener);
}
```

The main logic of the messaging service is to observe messages and fire them in the recipient UIs. As we are broadcasting to all UIs here, we again use an executor service to execute the code. To lock on the session when accessing the UIs, we use the `access()` method.

```
// Inject event to be fired
@Inject
private javax.enterprise.event.Event<BroadcastMessage>
    messageEvent;

ExecutorService executorService =
    Executors.newSingleThreadExecutor();

// Observe messages (only from clients)
@SuppressWarnings("unused")
private synchronized void observeMessage(
    @Observes @OriginalSender
    final BroadcastMessage message) {
    for (final UI listener: uis)
        executorService.execute(() ->
            listener.access(() ->
                messageEvent.fire(message)));
}
```

Here we use a `@OriginalSender` qualifier to receive events only from a client (original sender), not from the messaging service itself, which would cause an infinite event loop. The qualifier is defined as follows:

```
@Qualifier
@Retention(RUNTIME)
@Target({PARAMETER, FIELD})
public @interface OriginalSender {}
```

The message type is a simple POJO as follows:

```
public class BroadcastMessage {
    private String text;
    private Object sender; // For checking if sent by self

    ... constructor, getters, and setters ...
}
```

Let us take a look at the UI class, which manages both the messaging service and the client components. The UI just needs to register itself in the messaging service and build the UI, including the UI components doing messaging. We could, of course, do that also at view level.

```
@CDIUI("cdichat")
@Push
public class CDIChatUI extends UI {
    @Inject
    CDIBroadcaster broadcaster;

    @Inject
```

```
ChatBox chatbox;

@Override
protected void init(VaadinRequest request) {
    setContent(chatbox);

    // Register to receive broadcasts
    broadcaster.register(this);
}

// Must also unregister when the UI expires or is closed
@Override
public void detach() {
    broadcaster.unregister(this);
    super.detach();
}
}
```

Now for an actual messaging client, we look at the chat box component. Most of the UI code is omitted from the example. As noted earlier, the component receiving events must be scoped to the UI, to avoid creation of invalid instances.

```
@UIScoped
class ChatBox extends CustomComponent {
    VerticalLayout messages = new VerticalLayout();

    public ChatBox(CDIChatUI cdiChatUI) {
        ... build the composite ...

        TextField input = new TextField();

        Button send = new Button("Send", e -> { // Java 8
            // Broadcast the input
            broadcast(input.getValue());
            addMessage(input.getValue()); // Add to self
        });
        ...
    }

    @Inject
    @OriginalSender
    private javax.enterprise.event.Event<BroadcastMessage>
        messageEvent;

    // Sends a message
    private void broadcast(String msg) {
        messageEvent.fire(new BroadcastMessage(msg, this));
    }

    // Receives messages
    @SuppressWarnings("unused")
    private void observeMessage(
        @Observes BroadcastMessage event) {
        if (event.getSender() != this)
            addMessage(event.getText());
    }

    private void addMessage(String msg) {
        messages.addComponent(new Label(msg));
    }
}
```

```
    }  
}
```

Note that the client object is completely unaware of the fact that the messages are delivered through a messaging service; we have successfully decoupled the messaging logic required by Vaadin UIs from the component. Only the requirement for using the event qualifier remains (notice that its use is not checked at compile time).

---

# Chapter 12

# Portal Integration

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## 12.1. Overview

Vaadin supports running UIs as portlets in a portal, as defined in the JSR-286 (Java Portlet API 2.0) standard. A portlet UI is defined just as a regular UI, but deploying to a portal is somewhat different from deployment of regular web applications, requiring special portlet descriptors, etc. Creating the portlet project with the Vaadin Plugin for Eclipse or a Maven archetype automatically generates the necessary descriptors.

In addition to providing user interface through the Vaadin UI, portlets can integrate with the portal to switch between portlet modes and process special portal requests, such as actions and events.

While providing generic support for all portals implementing the standard, Vaadin especially supports the Liferay portal and the needed portal-specific configuration in this chapter is given for Liferay. Vaadin also has a special Liferay IPC add-on to enable communication between portlets.

## 12.2. Creating a Generic Portlet in Eclipse

Here we describe the creation of a generic portlet project in Eclipse. You can use the Maven archetypes also in other IDEs or without an IDE.

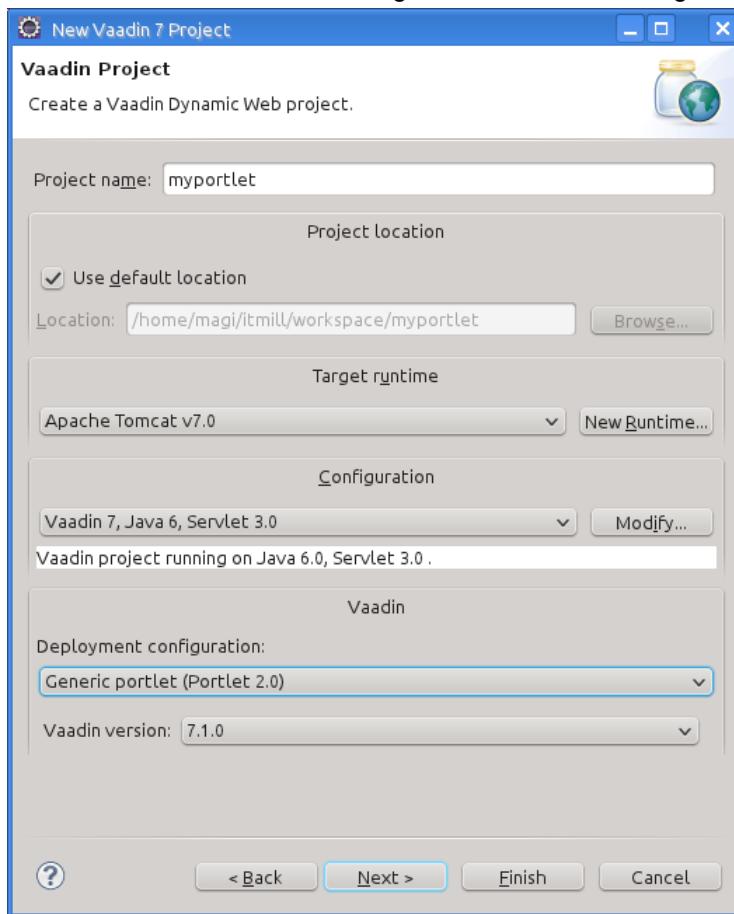
For Liferay portlet development, you may instead want to use the Maven archetype or Liferay IDE to create the project, as described in Section 12.3, “Developing Vaadin Portlets for Liferay”.

### 12.2.1. Creating a Project with Vaadin Plugin

The Vaadin Plugin for Eclipse has a wizard for easy creation of generic portlet projects. It creates a UI class and all the necessary descriptor files.

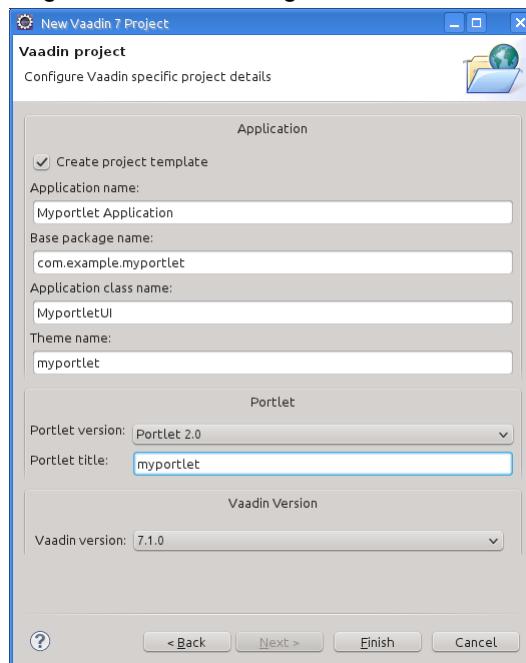
Creating a portlet project is almost identical to the creation of a regular Vaadin servlet application project. For a full treatment of the New Project Wizard and the possible options, please see Section 2.5.1, “Creating the Project”.

1. Start creating a new project by selecting from the menu **File New Project...**
2. In the **New Project** window that opens, select **Web Vaadin 7 Project** and click **Next**.
3. In the **Vaadin Project** step, you need to set the basic web project settings. You need to give at least the project name, the runtime, select **Generic Portlet** for the **Deployment configuration**; the default values should be good for the other settings.



You can click **Finish** here to use the defaults for the rest of the settings, or click **Next**.

4. The settings in the **Web Module** step define the basic servlet-related settings and the structure of the web application project. All the settings are pre-filled, and you should normally accept them as they are and click **Next**.
5. The **Vaadin project** step page has various Vaadin-specific application settings. These are largely the same as for regular applications. Setting them here is easiest - later some of the changes require changes in several different files. The **Create portlet template** option should be automatically selected. You can give another portlet title if you want. You can change most of the settings afterward.



#### **Create project template**

Creates a UI class and all the needed portlet deployment descriptors.

#### **Application name**

The application name is used in the title of the browser window, which is usually invisible in portlets, and as an identifier, either as is or with a suffix, in various deployment descriptors.

#### **Base package name**

Java package for the UI class.

#### **Application class name**

Name of the UI class. The default is derived from the project name.

#### **Theme name**

Name of the custom portlet theme to use.

#### **Portlet version**

Same as in the project settings.

**Portlet title**

The portlet title, defined in `portlet.xml`, can be used as the display name of the portlet (at least in Liferay). The default value is the project name. The title is also used as a short description in `liferay-plugin-package.properties`.

**Vaadin version**

Same as in the project settings.

Finally, click **Finish** to create the project.

6. Eclipse may ask you to switch to J2EE perspective. A Dynamic Web Project uses an external web server and the J2EE perspective provides tools to control the server and manage application deployment. Click **Yes**.

## 12.3. Developing Vaadin Portlets for Liferay

A Vaadin portlet requires resources such as the server-side Vaadin libraries, a theme, and a widget set. You have two basic ways to deploy these: either globally in Liferay, so that the resources are shared between all Vaadin portlets, or as self-contained WARs, where each portlet carries their own resources.

The self-contained way is easier and more flexible to start with, as the different portlets may have different versions of the resources. Currently, the latest Maven archetypes support the self-contained portlets, while with portlets created with the Vaadin Plugin for Eclipse only support globally deployed resources.

Using shared resources is more efficient when you have multiple Vaadin portlets on the same page, as they can share the common resources. However, they must use exactly same Vaadin version. This is recommended for production environments, where you can even serve the theme and widget set from a front-end server. You can install the shared resources as described in Section 12.3.5, “Installing Vaadin Resources”.

At the time of writing, the latest Liferay release 6.2 is bundled with a version of Vaadin release 6. If you want to use Vaadin 7 portlets with shared resources, you first need to remove the old ones as described in Section 12.3.4, “Removing the Bundled Installation”.

### 12.3.1. Defining Liferay Profile for Maven

When creating a Liferay portlet project with a Maven archetype or the Liferay IDE, you need to define a Liferay profile. With the Liferay IDE, you can create it when you create the project, as described in Section 12.3.3, “Creating a Portlet Project in Liferay IDE”, but for creating a project from the Maven archetype, you need to define it manually.

#### Defining Profile in `settings.xml`

Liferay profile can be defined either in the user or in the global `settings.xml` file for Maven. The global settings file is located in `~/.m2/settings.xml` and the user settings file in `~/.m2/settings.xml`. To create a user settings file, copy at least the relevant headers and root element from the global settings file.

```
...
<profile>
  <id>liferay</id>
  <properties>
    <liferayinstall>/opt/liferay-portal-6.2-ce-ga2
```

```
</liferayinstall>
<plugin.type>portlet</plugin.type>
<liferay.version>6.2.1</liferay.version>
<liferay.maven.plugin.version>6.2.1
</liferay.maven.plugin.version>
<liferay.auto.deploy.dir>${liferayinstall}/deploy
</liferay.auto.deploy.dir>

<!-- Application server version - here for Tomcat -->
<liferay.tomcat.version>7.0.42</liferay.tomcat.version>
<liferay.tomcat.dir>
    ${liferayinstall}/tomcat-${liferay.tomcat.version}
</liferay.tomcat.dir>

<liferay.app.server.deploy.dir>${liferay.tomcat.dir}/webapps
</liferay.app.server.deploy.dir>
<liferay.app.server.lib.global.dir>${liferay.tomcat.dir}/lib/ext
</liferay.app.server.lib.global.dir>
<liferay.app.server.portal.dir>${liferay.tomcat.dir}/webapps/ROOT
</liferay.app.server.portal.dir>
</properties>
</profile>
```

The parameters are as follows:

`liferayinstall`

Full (absolute) path to the Liferay installation directory.

`liferay.version`

Liferay version by the Maven version numbering scheme. The first two (major and minor) numbers are same as in the installation package. The third (maintenance) number starts from 0 with first GA (general availability) release.

`liferay.maven.plugin.version`

This is usually the same as the Liferay version.

`liferay.auto.deploy.dir`

The Liferay auto-deployment directory. It is by default `deploy` under the Liferay installation path.

`liferay.tomcat.version (optional)`

If using Tomcat, its version number.

`liferay.tomcat.dir`

Full (absolute) path to Tomcat installation directory. For Tomcat bundled with Liferay, this is under the Liferay installation directory.

`liferay.app.server.deploy.dir`

Directory where portlets are deployed in the application server used for Liferay. This depends on the server - for Tomcat it is the `webapps` directory under the Tomcat installation directory.

`liferay.app.server.lib.global.dir`

Library path where libraries globally accessible in the application server should be installed.

`liferay.app.server.portal.dir`

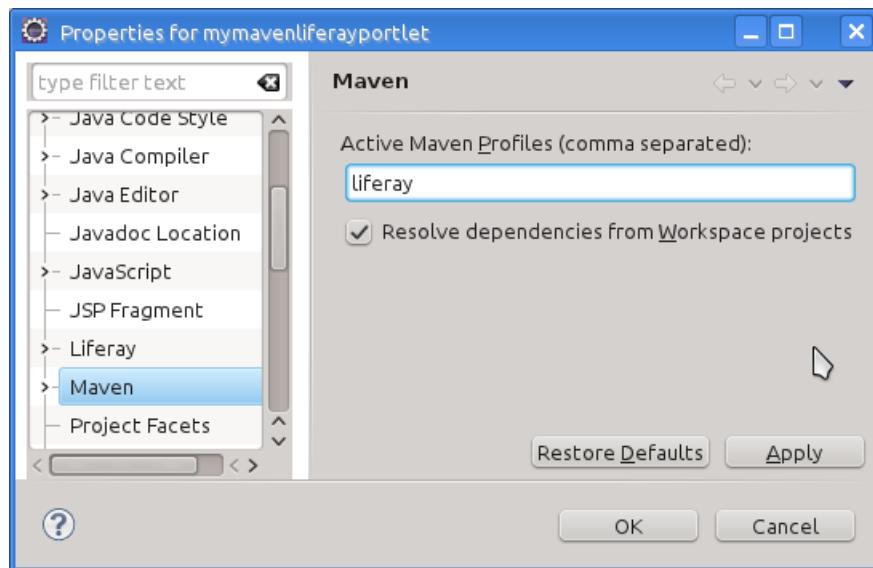
Deployment directory for static resources served by the application server, under the root path of the server.

If you modify the settings after the project is created, you need to touch the POM file in the project to have the settings reloaded.

## Activating the Maven Profile

The Maven 2 Plugin for Eclipse (m2e) must know which Maven profiles you use in a project. This is configured in the **Maven** section of the project properties. In the **Active Maven Profiles** field, enter the profile ID defined in the `settings.xml` file, as illustrated in Figure 12.1, “Activating Maven Liferay Profile”.

**Figure 12.1. Activating Maven Liferay Profile**



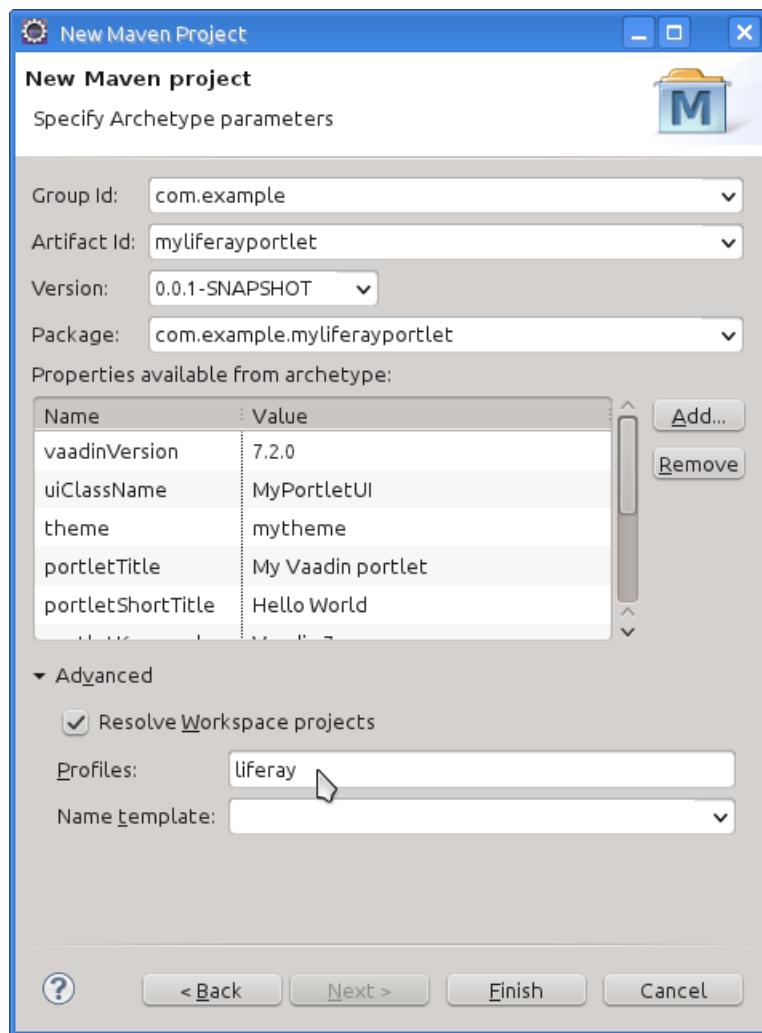
### 12.3.2. Creating a Portlet Project with Maven

Creation of Vaadin a Maven project is described in Section 2.6, “Using Vaadin with Maven”. For a Liferay project, you should use the `vaadin-archetype-liferay-portlet`.

#### Archetype Parameters

The archetype has a number of parameters. If you use Maven Plugin for Eclipse (m2e) to create the project, you get to enter the parameters after selecting the archetype, as shown in Figure 12.2, “Liferay Project Archetype Parameters”.

Minimally, you just need to enter the artifact ID. To activate the Maven profile created as described earlier in Section 12.3.1, “Defining Liferay Profile for Maven”, you need to specify the profile in the **Profiles** field under the **Advanced** section.

**Figure 12.2. Liferay Project Archetype Parameters**

The other parameters are the following:

`vaadinVersion`

Vaadin release version for the Maven dependency.

`uiClassName`

Class name of the UI class stub to be created.

`theme`

Theme to use. You can use either a project theme, which must be compiled before deployment, or use the liferay theme.

`portletTitle`

Title shown in the portlet title bar.

`portletShortTitle`

Title shown in contexts where a shorter title is preferred.

**portletKeywords**

Keywords for finding the portlet in Liferay.

**portletDescription**

A description of the portlet.

**portletName**

Identifier for the portlet, used for identifying it in the configuration files.

**portletDisplayName**

Name of the portlet for contexts where it is displayed.

### 12.3.3. Creating a Portlet Project in Liferay IDE

Liferay IDE, which you install in Eclipse as plugins just like the Vaadin plugin, enables a development environment for Liferay portlets. Liferay IDE allows integrated deployment of portlets to Liferay, just like you would deploy servlets to a server in Eclipse. The project creation wizard supports creation of Vaadin portlets.

Loading widget sets, themes, and the Vaadin JAR from a portlet is possible as long as you have a single portlet, but causes a problem if you have multiple portlets. To solve this, Vaadin portlets need to use a globally installed widget set, theme, and Vaadin libraries.

*Liferay 6.2, which is the latest Liferay version at the time of publication of this book, comes bundled with an older Vaadin 6 version. If you want to use Vaadin 7, you need to remove the bundled version and install the newer one manually as described in this chapter.*

In these instructions, we assume that you use Liferay bundled with Apache Tomcat, although you can use almost any other application server with Liferay just as well. The Tomcat installation is included in the Liferay installation package, under the `tomcat-x.x.x` directory.

### 12.3.4. Removing the Bundled Installation

Before installing a new Vaadin version, you need to remove the version bundled with Liferay. You need to remove the Vaadin library JAR from the library directory of the portal and the `VAADIN` directory from under the root context. For example, with Liferay bundled with Tomcat, they are usually located as follows:

- `tomcat-x.x.x/webapps/ROOT/html/VAADIN`
- `tomcat-x.x.x/webapps/ROOT/WEB-INF/lib/vaadin.jar`

### 12.3.5. Installing Vaadin Resources

To use common resources needed by multiple Vaadin portlets, you can install them globally as shared resources as described in the following.

If you are installing Vaadin in a Liferay version that comes bundled with an older version of Vaadin, you first need to remove the resources as described in Section 12.3.4, “Removing the Bundled Installation”.

In the following, we assume that you use only the built-in “liferay” theme in Vaadin and the default widget set.

1. Get the Vaadin installation package from the Vaadin download page

2. Extract the following Vaadin JARs from the installation package: `vaadin-server.jar` and `vaadin-shared.jar`, as well as the `vaadin-shared-deps.jar` and `jsoup.jar` dependencies from the `lib` folder

3. Rename the JAR files as they were listed above, without the version number

4. Put the libraries in `tomcat-x.x.x/webapps/ROOT/WEB-INF/lib/`

5. Extract the VAADIN folders from `vaadin-server.jar`, `vaadin-themes.jar`, and `vaadin-client-compiled.jar` and copy their contents to `tomcat-x.x.x/webapps/ROOT/html/VAADIN`.

```
$ cd tomcat-x.x.x/webapps/ROOT/html  
$ unzip path-to/vaadin-server-7.1.0.jar 'VAADIN/*'  
$ unzip path-to/vaadin-themes-7.1.0.jar 'VAADIN/*'  
$ unzip path-to/vaadin-client-compiled-7.1.0.jar 'VAADIN/*'
```

You need to define the widget set, the theme, and the JAR in the `portal-ext.properties` configuration file for Liferay, as described earlier. The file should normally be placed in the Liferay installation directory. See Liferay documentation for details on the configuration file.

Below is an example of a `portal-ext.properties` file:

```
# Path under which the VAADIN directory is located.  
# (/html is the default so it is not needed.)  
# vaadin.resources.path=/html  
  
# Portal-wide widget set  
vaadin.widgetset=com.vaadin.server.DefaultWidgetSet  
  
# Theme to use  
vaadin.theme=liferay
```

The allowed parameters are:

`vaadin.resources.path`

Specifies the resource root path under the portal context. This is `/html` by default. Its actual location depends on the portal and the application server; in Liferay with Tomcat it would be located at `webapps/ROOT/html` under the Tomcat installation directory.

`vaadin.widgetset`

The widget set class to use. Give the full path to the class name in the dot notation. If the parameter is not given, the default widget set is used.

`vaadin.theme`

Name of the theme to use. If the parameter is not given, the default theme is used, which is `reindeer` in Vaadin 6.

You will need to restart Liferay after creating or modifying the `portal-ext.properties` file.

## 12.4. Portlet UI

A portlet UI is just like in a regular Vaadin application, a class that extends `com.vaadin.ui.UI`.

```
@Theme( "myportlet" )
public class MyportletUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        final VerticalLayout layout = new VerticalLayout();
        layout.setMargin(true);
        setContent(layout);

        Button button = new Button("Click Me");
        button.addClickListener(new Button.ClickListener() {
            public void buttonClick(ClickEvent event) {
                layout.addComponent(
                    new Label("Thank you for clicking"));
            }
        });
        layout.addComponent(button);
    }
}
```

If you created the project as a Servlet 3.0 project, the generated UI stub includes a static servlet class annotated with **@WebServlet**, as described in Section 2.5.2, “Exploring the Project”.

```
@WebServlet(value = "/*", asyncSupported = true)
@VaadinServletConfiguration(productionMode = false,
                           ui = MyportletUI.class)
public static class Servlet extends VaadinServlet {
```

This enables running the portlet UI in a servlet container while developing it, which may be easier than deploying to a portal. For Servlet 2.4 projects, a `web.xml` is created.

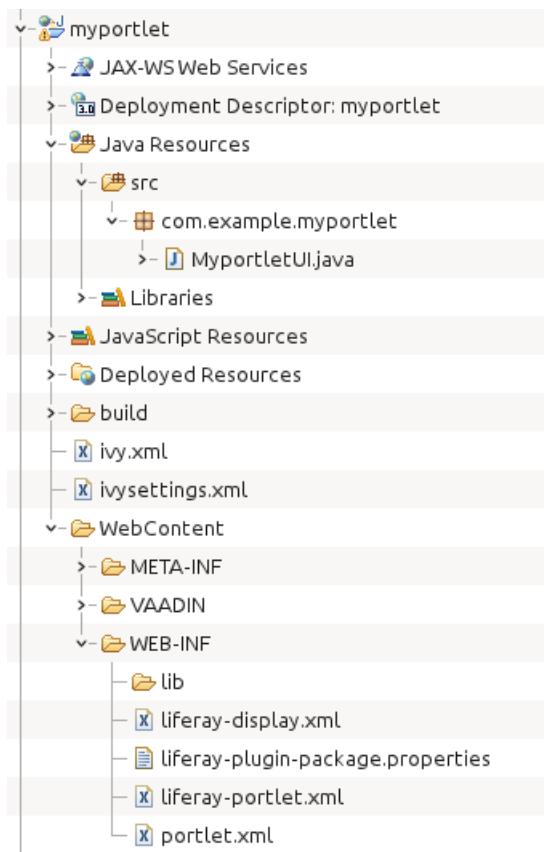
The portlet theme is defined with the **@Theme** annotation as usual. The theme for the UI must match a theme installed in the portal. You can use any of the built-in themes in Vaadin. For Liferay theme compatibility, there is a special `liferay` theme. If you use a custom theme, you need to compile it to CSS with the theme compiler and install it in the portal under the `VAADIN/themes` context to be served statically.

In addition to the UI class, you need the portlet descriptor files, Vaadin libraries, and other files as described later. Figure 12.3, “Portlet Project Structure in Eclipse” shows the complete project structure under Eclipse.

Installed as a portlet in Liferay from the **Add Application** menu, the application will show as illustrated in Figure 12.4, “Hello World Portlet”.

**Figure 12.4. Hello World Portlet**



**Figure 12.3. Portlet Project Structure in Eclipse**

## 12.5. Deploying to a Portal

To deploy a portlet WAR in a portal, you need to provide a `portlet.xml` descriptor specified in the Java Portlet API 2.0 standard (JSR-286). In addition, you may need to include possible portal vendor specific deployment descriptors. The ones required by Liferay are described below.

Deploying a Vaadin UI as a portlet is essentially just as easy as deploying a regular application to an application server. You do not need to make any changes to the UI itself, but only the following:

- Application packaged as a WAR
  - WEB-INF/portlet.xml descriptor
  - WEB-INF/liferay-portlet.xml descriptor for Liferay
  - WEB-INF/liferay-display.xml descriptor for Liferay
  - WEB-INF/liferay-plugin-package.properties for Liferay
- Widget set installed to portal (optional)
- Themes installed to portal (optional)
- Vaadin libraries installed to portal (optional)
- Portal configuration settings (optional)

The Vaadin Plugin for Eclipse creates these files for you, when you create a portlet project as described in Section 12.2, “Creating a Generic Portlet in Eclipse”.

Installing the widget set and themes to the portal is required for running two or more Vaadin portlets simultaneously in a single portal page. As this situation occurs quite easily, we recommend installing them in any case. Instructions for Liferay are given in Section 12.3, “Developing Vaadin Portlets for Liferay” and the procedure is similar for other portals.

In addition to the Vaadin libraries, you will need to have the `portlet.jar` in your project classpath. However, notice that you must *not* put the `portlet.jar` in the same `WEB-INF/lib` directory as the Vaadin JAR or otherwise include it in the WAR to be deployed, because it would create a conflict with the internal portlet library of the portal. The conflict would cause errors such as `"ClassCastException: ...VaadinPortlet cannot be cast to javax.portlet.Portlet"`.

## 12.5.1. Portlet Deployment Descriptor

The portlet WAR must include a portlet descriptor located at `WEB-INF/portlet.xml`. A portlet definition includes the portlet name, mapping to a servlet, modes supported by the portlet, and other configuration. Below is an example of a simple portlet definition in `portlet.xml` descriptor.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<portlet-app
    xmlns="http://java.sun.com/xml/ns/portlet/portlet-app_2_0.xsd"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    version="2.0"
    xsi:schemaLocation=
        "http://java.sun.com/xml/ns/portlet/portlet-app_2_0.xsd
         http://java.sun.com/xml/ns/portlet/portlet-app_2_0.xsd">

    <portlet>
        <portlet-name>Portlet Example portlet</portlet-name>
        <display-name>Vaadin Portlet Example</display-name>

        <!-- Map portlet to a servlet. -->
        <portlet-class>
            com.vaadin.server.VaadinPortlet
        </portlet-class>
        <init-param>
            <name>UI</name>

            <!-- The application class with package name. -->
            <value>com.example.myportlet.MyportletUI</value>
        </init-param>

        <!-- Supported portlet modes and content types. -->
        <supports>
            <mime-type>text/html</mime-type>
            <portlet-mode>view</portlet-mode>
            <portlet-mode>edit</portlet-mode>
            <portlet-mode>help</portlet-mode>
        </supports>

        <!-- Not always required but Liferay requires these. -->
        <portlet-info>
            <title>Vaadin Portlet Example</title>
            <short-title>Portlet Example</short-title>
        </portlet-info>
    </portlet>
</portlet-app>
```

Listing supported portlet modes in `portlet.xml` enables the corresponding portlet controls in the portal user interface that allow changing the mode, as described later.

### 12.5.2. Liferay Portlet Descriptor

Liferay requires a special `liferay-portlet.xml` descriptor file that defines Liferay-specific parameters. Especially, Vaadin portlets must be defined as "*instanceable*", but not "*ajaxable*".

Below is an example descriptor for the earlier portlet example:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE liferay-portlet-app PUBLIC
  "-//Liferay//DTD Portlet Application 4.3.0//EN"
  "http://www.liferay.com/dtd/liferay-portlet-app_4_3_0.dtd">

<liferay-portlet-app>
  <portlet>
    <!-- Matches definition in portlet.xml.          -->
    <!-- Note: Must not be the same as servlet name. -->
    <portlet-name>Portlet Example portlet</portlet-name>

    <instanceable>true</instanceable>
    <ajaxable>false</ajaxable>
  </portlet>
</liferay-portlet-app>
```

See Liferay documentation for further details on the `liferay-portlet.xml` deployment descriptor.

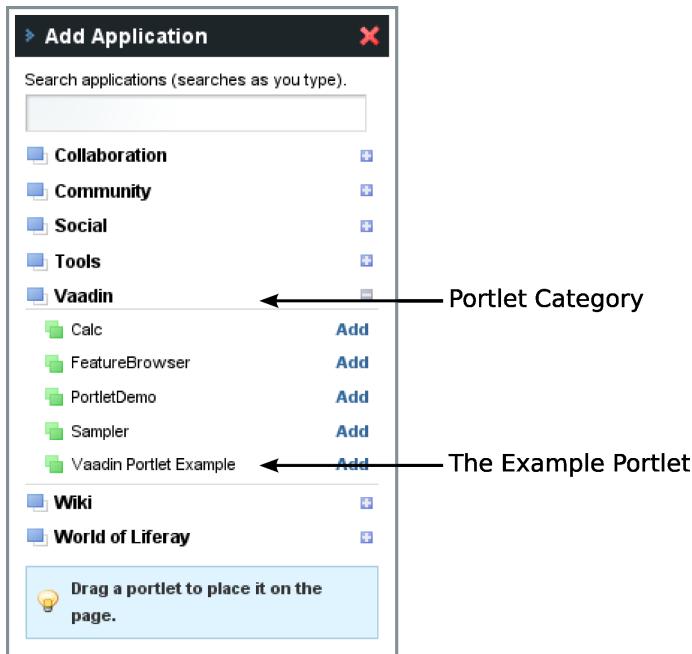
### 12.5.3. Liferay Display Descriptor

The `WEB-INF/liferay-display.xml` file defines the portlet category under which portlets are located in the **Add Application** window in Liferay. Without this definition, portlets will be organized under the "Undefined" category.

The following display configuration, which is included in the demo WAR, puts the Vaadin portlets under the "Vaadin" category, as shown in Figure 12.5, "Portlet Categories in Add Application Window".

```
<?xml version="1.0"?>
<!DOCTYPE display PUBLIC
  "-//Liferay//DTD Display 4.0.0//EN"
  "http://www.liferay.com/dtd/liferay-display_4_0_0.dtd">

<display>
  <category name="Vaadin">
    <portlet id="Portlet Example portlet" />
  </category>
</display>
```

**Figure 12.5. Portlet Categories in Add Application Window**

See Liferay documentation for further details on how to configure the categories in the `liferay-display.xml` deployment descriptor.

#### 12.5.4. Liferay Plugin Package Properties

The `liferay-plugin-package.properties` file defines a number of settings for the portlet, most importantly the Vaadin JAR to be used.

```
name=Portlet Example portlet
short-description=myportlet
module-group-id=Vaadin
module-incremental-version=1
#change-log=
#page-uri=
#author=
license=Proprietary
portal-dependency-jars=\
    vaadin.jar
```

*name*

The plugin name must match the portlet name.

*short-description*

A short description of the plugin. This is by default the project name.

*module-group-id*

The application group, same as the category id defined in `liferay-display.xml`.

*license*

The plugin license type; "proprietary" by default.

*portal-dependency-jars*

The JAR libraries on which this portlet depends. This should have value `vaadin.jar`, unless you need to use a specific version. The JAR must be installed in the portal, for example, in Liferay bundled with Tomcat to `tomcat-x.x.x/webapps/ROOT/WEB-INF/lib/vaadin.jar`.

## 12.5.5. Using a Single Widget Set

If you have just one Vaadin application that you ever need to run in your portal, you can just deploy the WAR as described above and that's it. However, if you have multiple applications, especially ones that use different custom widget sets, you run into problems, because a portal window can load only a single Vaadin widget set at a time. You can solve this problem by combining all the different widget sets in your different applications into a single widget set using inheritance or composition.

For example, if using the default widget set for portlets, you should have the following for all portlets so that they will all use the same widget set:

```
<portlet>
...
<!-- Use the portal default widget set for all portal demos. -->
<init-param>
    <name>widgetset</name>
    <value>com.vaadin.portal.PortalDefaultWidgetSet</value>
</init-param>
...

```

The `PortalDefaultWidgetSet` extends `SamplerWidgetSet`, which extends the `DefaultWidgetSet`. The `DefaultWidgetSet` is therefore essentially a subset of `PortalDefaultWidgetSet`, which contains also the widgets required by the Sampler demo. Other applications that would otherwise require only the regular `DefaultWidgetSet`, and do not define their own widgets, can just as well use the larger set, making them compatible with the demos. The `PortalDefaultWidgetSet` will also be the default Vaadin widgetset bundled in Liferay 5.3 and later.

If your portlets are contained in multiple WARs, which can happen quite typically, you need to install the widget set and theme portal-wide so that all the portlets can use them. See Section 12.3, “Developing Vaadin Portlets for Liferay” on configuring the widget sets in the portal itself.

## 12.5.6. Building the WAR Package

To deploy the portlet, you need to build a WAR package. For production deployment, you probably want to either use Maven or an Ant script to build the package. In Eclipse, you can right-click on the project and select **Export WAR**. Choose a name for the package and a target. If you have installed Vaadin in the portal as described in Section 12.3, “Developing Vaadin Portlets for Liferay”, you should exclude all the Vaadin libraries, as well as widget set and themes from the WAR.

## 12.5.7. Deploying the WAR Package

How you actually deploy a WAR package depends on the portal. In Liferay, you simply drop it to the `deploy` subdirectory under the Liferay installation directory. The deployment depends on the application server under which Liferay runs; for example, if you use Liferay bundled with Tomcat, you will find the extracted package in the `webapps` directory under the Tomcat installation directory included in Liferay.

## 12.6. Portlet Context

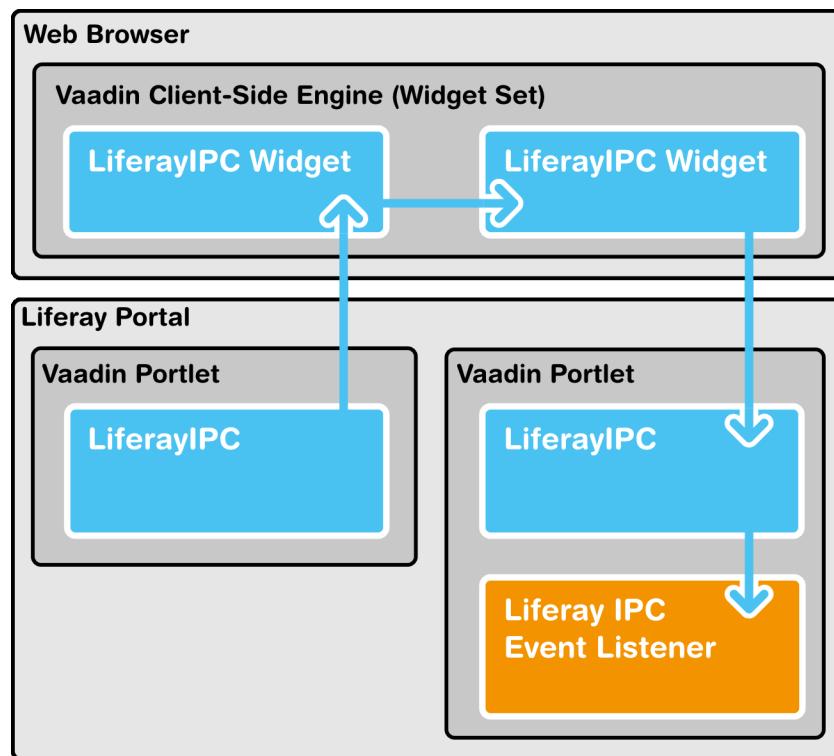
To Be Done.

## 12.7. Vaadin IPC for Liferay

Portlets rarely live alone. A page can contain multiple portlets and when the user interacts with one portlet, you may need to have the other portlets react to the change immediately. This is not normally possible with Vaadin portlets, as Vaadin applications need to get an Ajax request from the client-side to change their user interface. On the other hand, the regular inter-portlet communication (IPC) mechanism in Portlet 2.0 Specification requires a complete page reload, but that is not appropriate with Vaadin or in general Ajax applications, which do not require a page reload. One solution is to communicate between the portlets on the server-side and then use a server-push mechanism to update the client-side.

The Vaadin IPC for Liferay Add-on takes another approach by communicating between the portlets through the client-side. Events (messages) are sent through the **LiferayIPC** component and the client-side widget relays them to the other portlets, as illustrated in Figure 12.6, “Vaadin IPC for Liferay Architecture”.

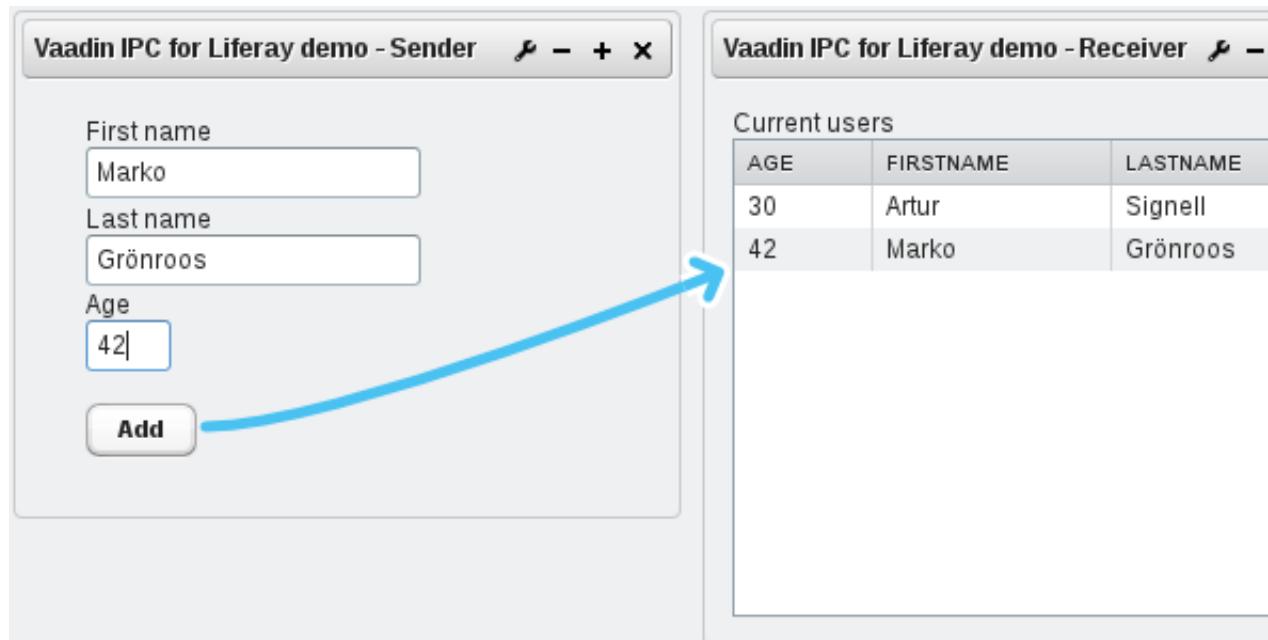
**Figure 12.6. Vaadin IPC for Liferay Architecture**



Vaadin IPC for Liferay uses the Liferay JavaScript event API for client-side inter-portlet communication, so you can communicate just as easily with other Liferay portlets.

Notice that you can use this communication only between portlets on the same page.

Figure 12.7, “Vaadin IPC Add-on Demo with Two Portlets” shows Vaadin IPC for Liferay in action. Entering a new item in one portlet is updated interactively in the other.

**Figure 12.7. Vaadin IPC Add-on Demo with Two Portlets**

### 12.7.1. Installing the Add-on

The Vaadin IPC for Liferay add-on is available from the Vaadin Directory as well as from a Maven repository. To download the installation package or find out the Maven or Ivy dependency, see the add-on page at Vaadin Directory, and install the add-on as described in Chapter 17, *Using Vaadin Add-ons*.

The contents of the installation package are as follows:

`vaadin-ipc-for-liferay-x.x.x.jar`

The add-on JAR in the installation package must be installed in the `WEB-INF/lib` directory under the root context. The location depends on the server - for example in Liferay running in Tomcat it is located under the `webapps/ROOT` folder of the server.

`doc`

The documentation folder includes a `README.TXT` file that describes the contents of the installation package briefly, and `licensing.txt` and `license-asl-2.0.txt`, which describe the licensing under the Apache License 2.0. Under the `doc/api` folder is included the complete JavaDoc API documentation for the add-on.

`vaadin-ipc-for-liferay-x.x.x-demo.war`

A WAR containing demo portlets. After installing the add-on library and compiling the widget set, as described below, you can deploy the WAR to Liferay and add the two demo portlets to a page, as shown in Figure 12.7, "Vaadin IPC Add-on Demo with Two Portlets". The source of the demo is available at [dev.vaadin.com/svn/addons/IPCforLiferay/trunk/](http://dev.vaadin.com/svn/addons/IPCforLiferay/trunk/).

The add-on contains a widget set, which you must compile into the Vaadin widget set installed in the portal.

## 12.7.2. Basic Communication

**LiferayIPC** is an invisible user interface component that can be used to send messages between two or more Vaadin portlets. You add it to an application layout as you would any regular user interface component.

```
LiferayIPC liferayipc = new LiferayIPC();
layout.addComponent(liferayipc);
```

You should be careful not to remove the invisible component from the portlet later if you modify the layout of the portlet.

The component can be used both for sending and receiving messages, as described next.

### Sending Events

You can send an event (a message) with the `sendEvent()` method, which takes an event ID and the message data as parameters. The event is broadcast to all listening portlets. The event ID is a string that can be used to identify the recipient of an event or the event type.

```
liferayipc.sendEvent("hello", "This is Data");
```

If you need to send more complex data, you need to format or serialize it to a string representation as described in Section 12.7.5, “Serializing and Encoding Data”.

### Receiving Events

A portlet wishing to receive events (messages) from other portlets needs to register a listener in the component with `addListener()`. The listener receives the messages in a **LiferayIPCEvent** object. Filtering events by the ID is built in into the listener handler, you give the listened event ID as the first parameter for the `addListener()`. The actual message data is held in the `data` property, which you can read with `getData()`.

```
liferayipc.addListener("hello", new LiferayIPCEventListener() {
    public void eventReceived(LiferayIPCEvent event) {
        // Do something with the message data
        String data = event.getData();
        Notification.show("Received hello: " + data);
    }
});
```

A listener added to a **LiferayIPC** can be removed with `removeListener()`.

## 12.7.3. Considerations

Both security and efficiency should be considered with inter-portlet communications when using the Vaadin IPC for Liferay.

### Browser Security

As the message data is passed through the client-side (browser), any code running in the browser has access to the data. You should be careful not to expose any security-critical data in client-side messaging. Also, malicious code running in the browser could alter or fake messages. Sanitization can help with the latter problem and encryption to solve the both issues. You can also share the sensitive data through session attributes or a database and use the client-side IPC only to notify that the data is available.

## Efficiency

Sending data through the browser requires loading and sending it in HTTP requests. The data is held in the memory space of the browser, and handling large data in the client-side JavaScript code can take time. Noticeably large message data can therefore reduce the responsiveness of the application and could, in extreme cases, go over browser limits for memory consumption or JavaScript execution time.

### 12.7.4. Communication Through Session Attributes

In many cases, such as when considering security or efficiency, it is better to pass the bulk data on the server-side and use the client-side IPC only for notifying the other portlet(s) that the data is available. Session attributes are a convenient way of sharing data on the server-side. You can also share objects through them, not just strings.

The session variables have a *scope*, which should be *APPLICATION\_SCOPE*. The "application" refers to the scope of the Java web application (WAR) that contains the portlets.

If the communicating portlets are in the same Java web application (WAR), no special configuration is needed. You can also communicate between portlets in different WARs, in which case you need to disable the *private-session-attributes* parameter in *liferay-portlet.xml* by setting it to *false*. Please see Liferay documentation for more information regarding the configuration.

You can also share Java objects between the portlets in the same WAR, not just strings. If the portlets are in different WARs, they normally have different class loaders, which could cause incompatibilities, so you can only communicate with strings and any object data needs to be serialized.

Session attributes are accessible through the **PortletSession** object, which you can access through the portlet context from the Vaadin **Application** class.

```
Person person = new Person(firstname, lastname, age);
...
PortletSession session =
    ((PortletApplicationContext2)getContext()).
        getPortletSession();

// Share the object
String key = "IPCDEMO_person";
session.setAttribute(key, person,
                    PortletSession.APPLICATION_SCOPE);

// Notify that it's available
liferayipc.sendEvent("ipc_demodata_available", key);
```

You can then receive the attribute in a **LiferayIPCEventListener** as follows:

```
public void eventReceived(LiferayIPCEvent event) {
    String key = event.getData();

    PortletSession session =
        ((PortletApplicationContext2)getContext()).
            getPortletSession();

    // Get the object reference
```

```
Person person = (Person) session.getAttribute(key);

// We can now use the object in our application
BeanItem<Person> item = new BeanItem<Person> (person);
form.setItemDataSource(item);
}
```

Notice that changes to a shared object bound to a user interface component are not updated automatically if it is changed in another portlet. The issue is the same as with double-binding in general.

## 12.7.5. Serializing and Encoding Data

The IPC events support transmitting only plain strings, so if you have object or other non-string data, you need to format or serialize it to a string representation. For example, the demo application formats the trivial data model as a semicolon-separated list as follows:

```
private void sendPersonViaClient(String firstName,
                                String lastName, int age) {
    liferayIPC_1.sendEvent("newPerson", firstName + ";" +
                          lastName + ";" + age);
}
```

You can use standard Java serialization for any classes that implement the `Serializable` interface. The transmitted data may not include any control characters, so you also need to encode the string, for example by using Base64 encoding.

```
// Some serializable object
MyBean mybean = new MyBean();
...

// Serialize
ByteArrayOutputStream baostr = new ByteArrayOutputStream();
ObjectOutputStream oostr;
try {
    oostr = new ObjectOutputStream(baostr);
    oostr.writeObject(mybean); // Serialize the object
    oostr.close();
} catch (IOException e) {
    Notification.show("IO PAN!"); // Complain
}

// Encode
BASE64Encoder encoder = new BASE64Encoder();
String encoded = encoder.encode(baostr.toByteArray());

// Send the IPC event to other portlet(s)
liferayipc.sendEvent("mybeanforyou", encoded);
```

You can then deserialize such a message at the receiving end as follows:

```
public void eventReceived(LiferayIPCEvent event) {
    String encoded = event.getData();

    // Decode and deserialize it
    BASE64Decoder decoder = new BASE64Decoder();
    try {
        byte[] data = decoder.decodeBuffer(encoded);
        ObjectInputStream ois =
```

```
        new ObjectInputStream(
            new ByteArrayInputStream(data));

        // The deserialized bean
        MyBean serialized = (MyBean) ois.readObject();
        ois.close();

        ... do something with the bean ...

    } catch (IOException e) {
        e.printStackTrace(); // Handle somehow
    } catch (ClassNotFoundException e) {
        e.printStackTrace(); // Handle somehow
    }
}
```

## 12.7.6. Communicating with Non-Vaadin Portlets

You can use the Vaadin IPC for Liferay to communicate also between a Vaadin application and other portlets, such as JSP portlets. The add-on passes the events as regular Liferay JavaScript events. The demo WAR includes two JSP portlets that demonstrate the communication.

When sending events from non-Vaadin portlet, fire the event using the JavaScript `Liferay.fire()` method with an event ID and message. For example, in JSP you could have:

```
<%@ taglib uri="http://java.sun.com/portlet_2_0"
           prefix="portlet" %>
<portlet:defineObjects />

<script>
function send_message() {
    Liferay.fire('hello', "Hello, I'm here!");
}
</script>

<input type="button" value="Send message"
       onclick="send_message()" />
```

You can receive events using a Liferay JavaScript event handler. You define the handler with the `on()` method in the `Liferay` object. It takes the event ID and a callback function as its parameters. Again in JSP you could have:

```
<%@ taglib uri="http://java.sun.com/portlet_2_0"
           prefix="portlet" %>
<portlet:defineObjects />

<script>
Liferay.on('hello', function(event, data) {
    alert("Hello: " + data);
});
</script>
```



---

# Chapter 13

# Client-Side Vaadin Development

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This chapter gives an overview of the Vaadin client-side framework, its architecture, and development tools.

## 13.1. Overview

As noted in the introduction, Vaadin supports two development models: server-side and client-side. Client-side Vaadin code is executed in the web browser as JavaScript code. The code is written in Java, like all Vaadin code, and then compiled to JavaScript with the *Vaadin Client Compiler*. You can develop client-side widgets and integrate them with server-side counterpart components to allow using them in server-side Vaadin applications. That is how the components in the server-side framework and in most add-ons are done. Alternatively, you can create pure client-side GWT applications, which you can simply load in the browser from an HTML page and use even without server-side connectivity.

The client-side framework is based on the Google Web Toolkit (GWT), with added features and bug fixes. Vaadin is compatible with GWT to the extent of the basic GWT feature set. Vaadin Ltd

is a member of the GWT Steering Committee, working on the future direction of GWT together with Google and other supporters of GWT.



### Widgets and Components

Google Web Toolkit uses the term *widget* for user interface components. In this book, we use the term *widget* to refer to client-side components, while using the term *component* in a general sense and also in the special sense for server-side components.

The main idea in server-side Vaadin development is to render the server-side components in the browser with the Client-Side Engine. The engine is essentially a set of widgets paired with *connectors* that serialize their state and events with the server-side counterpart components. The client-side engine is technically called a *widget set*, to describe the fact that it mostly consists of widgets and that widget sets can be combined, as described later.

## 13.2. Installing the Client-Side Development Environment

The installation of the client-side development libraries is described in Chapter 2, *Getting Started with Vaadin*. You especially need the `vaadin-client` library, which contains the client-side Java API, and `vaadin-client-compiler`, which contains the Vaadin Client Compiler for compiling Java to JavaScript.

## 13.3. Client-Side Module Descriptor

Client-side Vaadin modules, such as the Vaadin Client-Side Engine (widget set) or pure client-side applications, that are to be compiled to JavaScript, are defined in a *module descriptor* (`.gwt.xml`) file.

When defining a widget set to build the Vaadin client-side engine, the only necessary task is to inherit a base widget set. If you are developing a regular widget set, you should normally inherit the **DefaultWidgetSet**.

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE module PUBLIC
  "-//Google Inc.//DTD Google Web Toolkit 1.7.0//EN"
  "http://google-web-toolkit.googlecode.com/svn/tags/1.7.0/distro-
source/core/src/gwt-module.dtd">

<module>
  <!-- Inherit the default widget set -->
  <inherits name="com.vaadin.DefaultWidgetSet" />
</module>
```

If you are developing a pure client-side application, you should instead inherit **com.vaadin.Vaadin**, as described in Chapter 14, *Client-Side Applications*. In that case, the module descriptor also needs an entry-point.

If you are using the Eclipse IDE, the New Vaadin Widget wizard will automatically create the GWT module descriptor. See Section 16.2.1, “Creating a Widget” for detailed instructions.

### 13.3.1. Specifying a Stylesheet

A client-side module can include CSS stylesheets. When the module is compiled, these stylesheets are copied to the output target. In the module descriptor, define a `stylesheet` element.

For example, if you are developing a custom widget and want to have a default stylesheet for it, you could define it as follows:

```
<stylesheet src="mywidget/styles.css" />
```

The specified path is relative to the *public* folder under the folder of the module descriptor.

### 13.3.2. Limiting Compilation Targets

Compiling widget sets takes considerable time. You can reduce the compilation time significantly by compiling the widget sets only for your browser, which is useful during development. You can do this by setting the `user.agent` property in the module descriptor.

```
<set-property name="user.agent" value="gecko1_8" />
```

The `value` attribute should match your browser. The browsers supported by GWT depend on the GWT version, below is a list of browser identifiers supported by GWT.

**Table 13.1. GWT User Agents**

Identifier	Name
ie6	Internet Explorer 6
ie8	Internet Explorer 8
gecko1_8	Mozilla Firefox 1.5 and later
safari	Apple Safari and other Webkit-based browsers including Google Chrome
opera	Opera
ie9	Internet Explorer 9

For more information about the GWT Module XML Format, please see Google Web Toolkit Developer Guide.

## 13.4. Compiling a Client-Side Module

A client-side module, either a widget set or a pure client-side module, needs to be compiled to JavaScript using the Vaadin Client Compiler. During development, the Development Mode makes the compilation automatically when you reload the page, provided that the module has been initially compiled once with the compiler.

As most Vaadin add-ons include widgets, widget set compilation is usually needed when using add-ons. In that case, the widget sets from different add-ons are compiled into a *project widget set*, as described in Chapter 17, *Using Vaadin Add-ons*.

### 13.4.1. Vaadin Compiler Overview

The Vaadin Client Compiler compiles Java to JavaScript. It is provided as the `vaadin-client-compiler` JAR, which you can execute with the `-jar` parameter for the Java runtime. It requires the `vaadin-client` JAR, which contains the Vaadin client-side framework.

The compiler compiles a *client module*, which can be either a pure client-side module or a Vaadin widget set, that is, the Vaadin Client-Side Engine that includes the widgets used in the application. The client module is defined with a module descriptor, which was described in Section 13.3, “Client-Side Module Descriptor”.

The compiler writes the compilation result to a target folder that will include the compiled JavaScript with any static resources included in the module.

### 13.4.2. Compiling in Eclipse

When the Vaadin Plugin is installed in Eclipse, you can simply click the **Compile Vaadin widgets** button in the toolbar. It will compile the widget set it finds from the project. If the project has multiple widget sets, such as one for custom widgets and another one for the project, you need to select the module descriptor of the widget set to compile before clicking the button.

The compilation with Vaadin Plugin for Eclipse currently requires that the module descriptor has suffix `Widgetset.gwt.xml`, although you can use it to compile also other client-side modules than widget sets. The result is written under `WebContent/VAADIN/widgetsets` folder.

### 13.4.3. Compiling with Ant

You can find a script template for compiling widget sets with Ant and Ivy at the Vaadin download page. You can copy the build script to your project and, once configured, run it with Ant.

### 13.4.4. Compiling with Maven

You can compile the widget set with the `vaadin:compile` goal as follows:

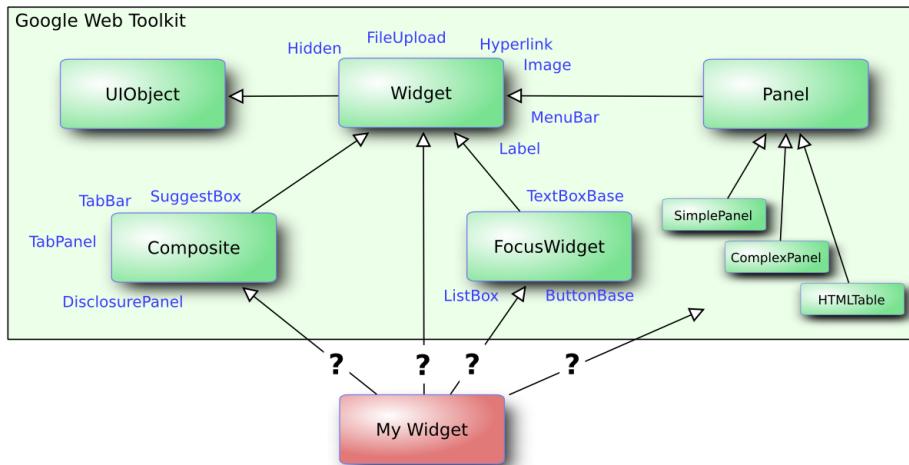
```
$ mvn vaadin:compile
```

## 13.5. Creating a Custom Widget

Creating a new Vaadin component usually begins from making a client-side widget, which is later integrated with a server-side counterpart to enable server-side development. In addition, you can also choose to make pure client-side widgets, a possibility which we also describe later in this section.

### 13.5.1. A Basic Widget

All widgets extend the **Widget** class or some of its subclasses. You can extend any core GWT or supplementary Vaadin widgets. Perhaps typically, an abstraction such as **Composite**. The basic GWT widget component hierarchy is illustrated in Figure 13.1, “GWT Widget Base Class Hierarchy”. Please see the GWT API documentation for a complete description of the widget classes.

**Figure 13.1. GWT Widget Base Class Hierarchy**

For example, we could extend the **Label** widget to display some custom text.

```

package com.example.myapp.client;

import com.google.gwt.user.client.ui.Label;

public class MyWidget extends Label {
    public static final String CLASSNAME = "mywidget";

    public MyWidget() {
        setStyleName(CLASSNAME);
        setText("This is MyWidget");
    }
}
  
```

The above example is largely what the Eclipse plugin generates as a widget stub. It is a good practice to set a distinctive style class for the widget, to allow styling it with CSS.

The client-side source code *must* be contained in a `client` package under the package of the descriptor file, which is covered later.

### 13.5.2. Using the Widget

You can use a custom widget just like you would use any widget, possibly integrating it with a server-side component, or in pure client-side modules such as the following:

```

public class MyEntryPoint implements EntryPoint {
    @Override
    public void onModuleLoad() {
        // Use the custom widget
        final MyWidget mywidget = new MyWidget();
        RootPanel.get().add(mywidget);
    }
}
  
```

## 13.6. Debugging Client-Side Code

Vaadin currently includes SuperDevMode for debugging client-side code right in the browser.

The predecessor of SuperDevMode, the GWT Development Mode, no longer works in recent versions of Firefox and Chrome, because of certain API changes in the browsers. There exists workarounds on some platforms, but for the sake of simplicity, we recommend using the SuperDevMode.

### 13.6.1. Launching Development Mode

The Development Mode launches the application in the browser, compiles the client-side module (or widget set) when the page is loaded, and allows debugging the client-side code in Eclipse. You can launch the Development Mode by running the **com.google.gwt.dev.DevMode** class. It requires some parameters, as described later.

The Vaadin Plugin for Eclipse can create a launch configuration for the Development Mode. In the Vaadin section of project properties, click the **Create development mode launch** button. This creates a new launch configuration in the project. You can edit the launch configuration in **Run → Run Configurations**.

```
-noserver -war WebContent/VAADIN/widgetsets com.example.myproject.widgetset.MyWidgetSet -startupUrl http://localhost:8080/myproject -bindAddress 127.0.0.1
```

The parameters are as follows:

*-noserver*

Normally, the Development Mode launches its own Jetty server for hosting the content. If you are developing the application under an IDE that deploys it to a server, such as Eclipse, you can disable the Development Mode server with this option.

*-war*

Specifies path to the location where the JavaScript is to be compiled. When developing a pure client-side module, this could be the WebContent (in Eclipse) or some other folder under it. When compiling widget sets, it must be WebContent/VAADIN/widgetsets.

*-startupUrl*

Specifies the address of the loader page for the application. For server-side Vaadin applications, this should be the path to the Vaadin application servlet, as defined in the deployment. For pure client-side widgets, it should be the page where the application is included.

*-bindAddress*

This is the IP address of the host in which the Development Mode runs. For debugging on the development workstation, it can be just 127.0.0.1. Setting it as the proper IP address of the host enables remote debugging.

### 13.6.2. Launching SuperDevMode

The SuperDevMode is much like the old Development Mode, except that it does not require a browser plugin. Compilation from Java to JavaScript is done incrementally, reducing the compilation time significantly. It also allows debugging JavaScript and even Java right in the browser (currently only supported in Chrome).

You can enable SuperDevMode as follows:

1. You need to set a redirect property in the `.gwt.xml` module descriptor as follows:

```
<set-configuration-property name="devModeRedirectEnabled" value="true" />
```

In addition, you need the `xsiframe` linker. It is included in the **com.vaadin.DefaultWidgetSet** as well as in the **com.vaadin.Vaadin** module. Otherwise, you need to include it with:

```
<add-linker name="xsiframe" />
```

2. Compile the module (that is, the widget set), for example by clicking the button in Eclipse.
3. If you are using Eclipse, create a launch configuration for the SuperDevMode by clicking the **Create SuperDevMode launch** in the **Vaadin** section of the project properties.
  - a. The main class to execute should be **com.google.gwt.dev.codeserver.CodeServer**.
  - b. The application takes the fully-qualified class name of the module (or widget set) as parameter, for example, **com.example.myproject.widgetset.MyprojectWidgetset**.
  - c. Add project sources to the class path of the launch if they are not in the project class path.

The above configuration only needs to be done once to enable the SuperDevMode. After that, you can launch the mode as follows:

1. Run the SuperDevMode Code Server with the launch configuration that you created above. This performs the initial compilation of your module or widget set.
2. Launch the servlet container for your application, for example, Tomcat.
3. Open your browser with the application URL and add `?superdevmode` parameter to the URL (see the notice below if you are not extending **DefaultWidgetSet**). This recompiles the code, after which the page is reloaded with the SuperDevMode. You can also use the `?debug` parameter and then click the **SDev** button in the debug console.

If you make changes to the client-side code and refresh the page in the browser, the client-side is recompiled and you see the results immediately.

The Step 3 above assumes that you extend **DefaultWidgetSet** in your module. If that is not the case, you need to add the following at the start of the `onModuleLoad()` method of the module:

```
if (SuperDevMode.enableBasedOnParameter()) { return; }
```

Alternatively, you can use the bookmarklets provided by the code server. Go to `http://localhost:9876/` and drag the bookmarklets "**Dev Mode On**" and "**Dev Mode Off**" to the bookmarks bar

### 13.6.3. Debugging Java Code in Chrome

Chrome supports source maps, which allow debugging Java source code from which the JavaScript was compiled.

Open the Chrome Inspector by right-clicking and selecting **Inspect Element**. Click the settings icon in the lower corner of the window and check the **Scripts Enable source maps** option. Refresh the page with the Inspector open, and you will see Java code instead of JavaScript in the scripts tab.



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# Chapter 14

# Client-Side Applications

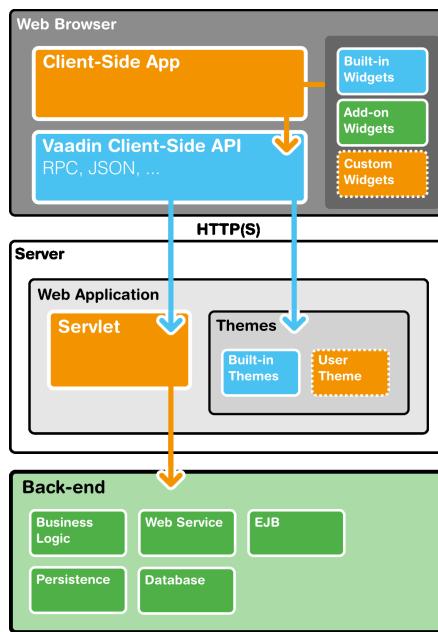
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This chapter describes how to develop client-side Vaadin applications.

*Currently, we only give a brief introduction to the topic. Please refer to the GWT documentation for a more complete treatment of the many GWT features.*

## 14.1. Overview

Vaadin allows developing client-side modules that run in the browser. Client-side modules can use all the GWT widgets and some Vaadin-specific widgets, as well as the same themes as server-side Vaadin applications. Client-side applications run in the browser, even with no further server communications. When paired with a server-side service to gain access to data storage and server-side business logic, client-side applications can be considered "fat clients", in comparison to the "thin client" approach of the server-side Vaadin applications. The services can use the same back-end services as server-side Vaadin applications. Fat clients are useful for a range of purposes when you have a need for highly responsive UI logic, such as for games or for serving a huge number of clients with possibly stateless server-side code.

**Figure 14.1. Client-Side Application Architecture**

A client-side application is defined as a *module*, which has an *entry-point* class. Its `onModuleLoad()` method is executed when the JavaScript of the compiled module is loaded in the browser.

Consider the following client-side application:

```
public class HelloWorld implements EntryPoint {
    @Override
    public void onModuleLoad() {
        RootPanel.get().add(new Label("Hello, world!"));
    }
}
```

The user interface of a client-side application is built under a HTML *root element*, which can be accessed by `RootPanel.get()`. The purpose and use of the entry-point is documented in more detail in Section 14.2, “Client-Side Module Entry-Point”. The user interface is built from *widgets* hierarchically, just like with server-side Vaadin UIs. The built-in widgets and their relationships are catalogued in Chapter 15, *Client-Side Widgets*. You can also use many of the widgets in Vaadin add-ons that have them, or make your own.

A client-side module is defined in a *module descriptor*, as described in Section 13.3, “Client-Side Module Descriptor”. A module is compiled from Java to JavaScript using the Vaadin Compiler, of which use was described in Section 13.4, “Compiling a Client-Side Module”. The Section 14.3, “Compiling and Running a Client-Side Application” in this chapter gives further information about compiling client-side applications. The resulting JavaScript can be loaded to any web page, as described in Section 14.4, “Loading a Client-Side Application”.

The client-side user interface can be built declaratively using the included *UI Binder*.

The servlet for processing RPC calls from the client-side can be generated automatically using the included compiler.

Even with regular server-side Vaadin applications, it may be useful to provide an off-line mode if the connection is closed. An off-line mode can persist data in a local store in the browser,

thereby avoiding the need for server-side storage, and transmit the data to the server when the connection is again available. Such a pattern is commonly used with Vaadin TouchKit.

## 14.2. Client-Side Module Entry-Point

A client-side application requires an *entry-point* where the execution starts, much like the `init()` method in server-side Vaadin UIs.

Consider the following application:

```
package com.example.myapp.client;

import com.google.gwt.core.client.EntryPoint;
import com.google.gwt.event.dom.client.ClickEvent;
import com.google.gwt.event.dom.client.ClickHandler;
import com.google.gwt.user.client.ui.RootPanel;
import com.vaadin.ui.VButton;

public class MyEntryPoint implements EntryPoint {
    @Override
    public void onModuleLoad() {
        // Create a button widget
        Button button = new Button();
        button.setText("Click me!");
        button.addClickHandler(new ClickHandler() {
            @Override
            public void onClick(ClickEvent event) {
                mywidget.setText("Hello, world!");
            }
        });
        RootPanel.get().add(button);
    }
}
```

Before compiling, the entry-point needs to be defined in a module descriptor, as described in the next section.

### 14.2.1. Module Descriptor

The entry-point of a client-side application is defined, along with any other configuration, in a client-side module descriptor, described in Section 13.3, “Client-Side Module Descriptor”. The descriptor is an XML file with suffix `.gwt.xml`.

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE module PUBLIC
"-//Google Inc.//DTD Google Web Toolkit 1.7.0//EN"
"http://google-web-toolkit.googlecode.com/svn/tags/1.7.0/distro-
source/core/src/gwt-module.dtd">
<module>
    <!-- Builtin Vaadin and GWT widgets -->
    <inherits name="com.vaadin.Vaadin" />

    <!-- The entry-point for the client-side application -->
    <entry-point class="com.example.myapp.client.MyEntryPoint" />
</module>
```

You might rather want to inherit the `com.google.gwt.user.User` to get just the basic GWT widgets, and not the Vaadin-specific widgets and classes, most of which are unusable in pure client-side applications.

You can put static resources, such as images or CSS stylesheets, in a `public` folder (not a Java package) under the folder of the descriptor file. When the module is compiled, the resources are copied to the output folder. Normally in pure client-side application development, it is easier to load them in the HTML host file or in a `ClientBundle` (see GWT documentation), but these methods are not compatible with server-side component integration, if you use the resources for that purpose as well.

## 14.3. Compiling and Running a Client-Side Application

*Compilation of client-side modules other than widget sets with the Vaadin Plugin for Eclipse has recent changes and limitations at the time of writing of this edition and the information given here may not be accurate.*

The application needs to be compiled into JavaScript to run it in a browser. For deployment, and also initially for the first time when running the Development Mode, you need to do the compilation with the Vaadin Client Compiler, as described in Section 13.4, “Compiling a Client-Side Module”.

During development, it is easiest to use the SuperDevMode, which also quickly launching the client-side code and also allows debugging. See Section 13.6, “Debugging Client-Side Code” for more details.

## 14.4. Loading a Client-Side Application

You can load the JavaScript code of a client-side application in an HTML *host page* by including it with a `<script>` tag, for example as follows:

```
<html xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <meta http-equiv="Content-Type"
          content="text/html; charset=UTF-8" />

    <title>Embedding a Vaadin Application in HTML Page</title>

    <!-- Load the Vaadin style sheet -->
    <link rel="stylesheet"
          type="text/css"
          href="/myproject/VAADIN/themes/reindeer/legacy-styles.css" />
  </head>

  <body>
    <h1>A Pure Client-Side Application</h1>

    <script type="text/javascript" language="javascript"
           src="clientside/com.example.myapp.MyModule/
               com.example.myapp.MyModule.nocache.js">
    </script>
  </body>
</html>
```

The JavaScript module is loaded in a `<script>` element. The `src` parameter should be a relative link from the host page to the compiled JavaScript module.

If the application uses any supplementary Vaadin widgets, and not just core GWT widgets, you need to include the Vaadin theme as was done in the example. The exact path to the style file depends on your project structure - the example is given for a regular Vaadin application where themes are contained in the VAADIN folder in the WAR.

In addition to CSS and scripts, you can load any other resources needed by the client-side application in the host page.



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# Chapter 15

# Client-Side Widgets

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This chapter gives basic documentation on the use of the Vaadin client-side framework for the purposes of creating client-side applications and writing your own widgets.

*Currently, we only give a brief introduction to the topic in this chapter. Please refer to the GWT documentation for a more complete treatment of the GWT widgets.*

## 15.1. Overview

The Vaadin client-side API is based on the Google Web Toolkit. It involves *widgets* for representing the user interface as Java objects, which are rendered as a HTML DOM in the browser. Events caused by user interaction with the page are delegated to event handlers, where you can implement your UI logic.

In general, the client-side widgets come in two categories - basic GWT widgets and Vaadin-specific widgets. The library includes *connectors* for integrating the Vaadin-specific widgets with the server-side components, thereby enabling the server-side development model of Vaadin. The integration is described in Chapter 16, *Integrating with the Server-Side*.

The layout of the client-side UI is managed with *panel* widgets, which correspond in their function with layout components in the Vaadin server-side API.

In addition to the rendering API, the client-side API includes facilities for making HTTP requests, logging, accessibility, internationalization, and testing.

For information about the basic GWT framework, please refer to <https://developers.google.com/web-toolkit/overview>.

## 15.2. GWT Widgets

GWT widgets are user interface elements that are rendered as HTML. Rendering is done either by manipulating the HTML Document Object Model (DOM) through the lower-level DOM API, or simply by injecting the HTML with `setInnerHTML()`. The layout of the user interface is managed using special panel widgets.

For information about the basic GWT widgets, please refer to the GWT Developer's Guide at <https://developers.google.com/web-toolkit/doc/latest/DevGuideUi>.

## 15.3. Vaadin Widgets

Vaadin comes with a number of Vaadin-specific widgets in addition to the GWT widgets, some of which you can use in pure client-side applications. The Vaadin widgets have somewhat different feature set from the GWT widgets and are foremost intended for integration with the server-side components, but some may prove useful for client-side applications as well.

```
public class MyEntryPoint implements EntryPoint {  
    @Override  
    public void onModuleLoad() {  
        // Add a Vaadin button  
        VButton button = new VButton();  
        button.setText("Click me!");  
        button.addClickHandler(new ClickHandler() {  
            @Override  
            public void onClick(ClickEvent event) {  
                mywidget.setText("Clicked!");  
            }  
        });  
  
        RootPanel.get().add(button);  
    }  
}
```

---

# Chapter 16

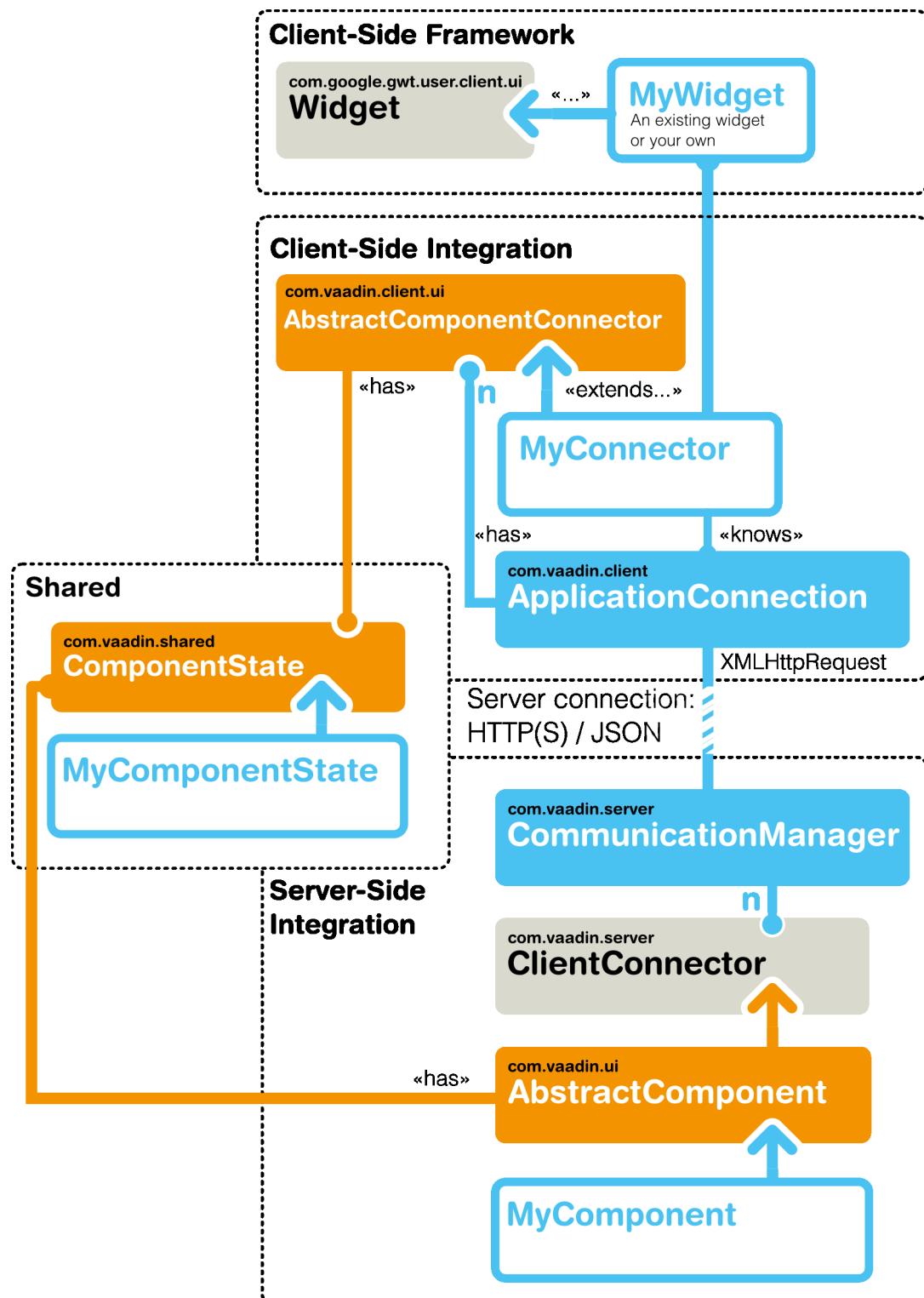
# Integrating with the Server-Side

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This chapter describes how you can integrate client-side widgets or JavaScript components with a server-side component. The client-side implementations of all standard server-side components in Vaadin use the same client-side interfaces and patterns.

## 16.1. Overview

Vaadin components consist of two parts: a server-side and a client-side component. The latter are also called *widgets* in Google Web Toolkit (GWT) parlance. A Vaadin application uses the API of the server-side component, which is rendered as a client-side widget in the browser. As on the server-side, the client-side widgets form a hierarchy of layout widgets and regular widgets as the leaves.

**Figure 16.1. Integration of Client-Side Widgets**

The communication between a client-side widget and a server-side component is managed with a *connector* that handles synchronizing the widget state and events to and from the server-side.

When rendering the user interface, a client-side connector and a widget are created for each server-side component. The mapping from a component to a connector is defined in the connector class with a `@Connect` annotation, and the widget is created by the connector class.

The state of a server-side component is synchronized automatically to the client-side widget using a *shared state* object. A shared state object implements the `ComponentState` interface and it is used both in the server-side and the client-side component. On the client-side, a connector always has access to its state instance, as well to the state of its parent component state and the states of its children.

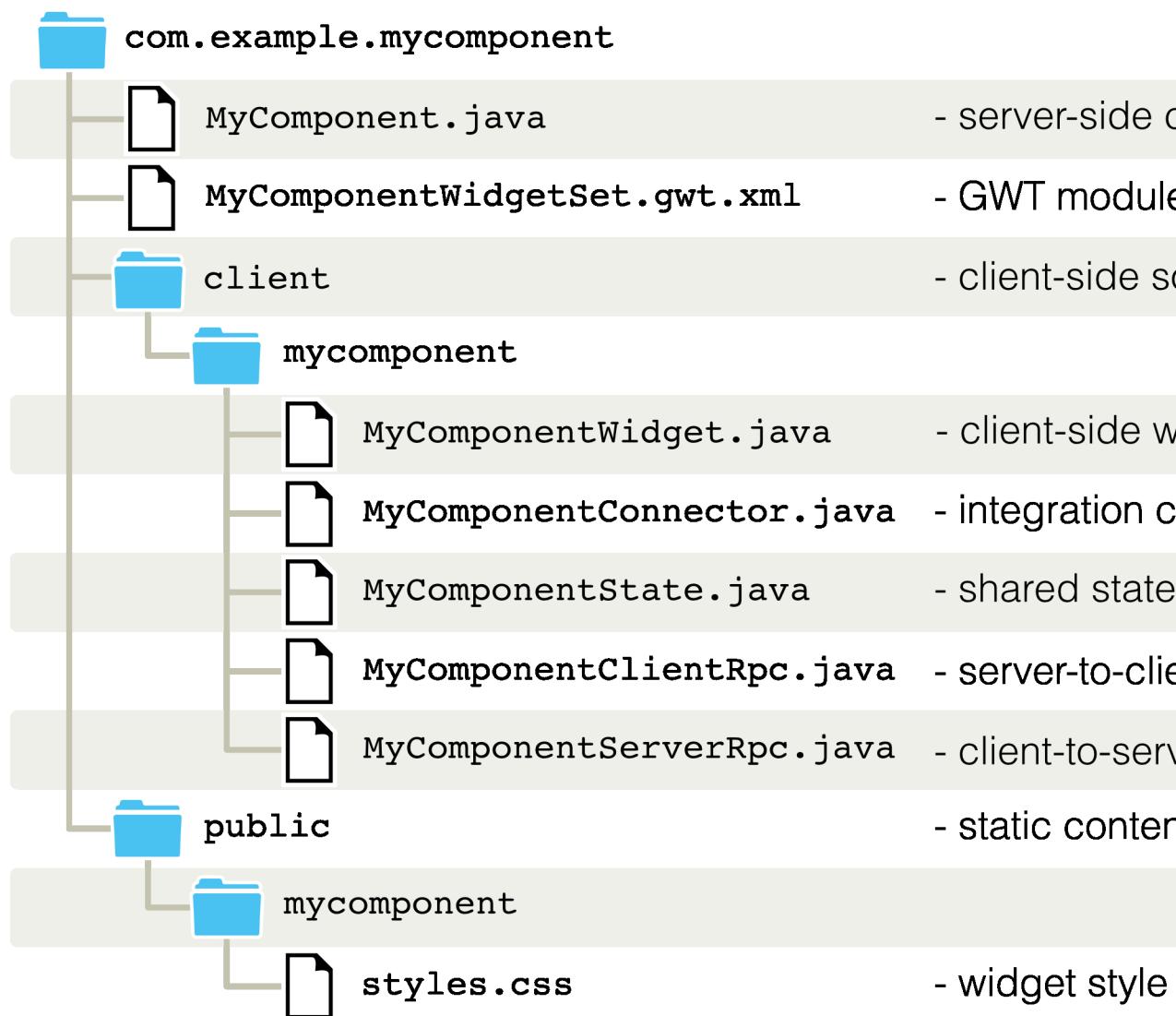
The state sharing assumes that state is defined with standard Java types, such as primitive and boxed primitive types, `String`, arrays, and certain collections (`List`, `Set`, and `Map`) of the supported types. Also the Vaadin `Connector` and some special internal types can be shared.

In addition to state, both server- and client-side can make remote procedure calls (RPC) to the other side. RPC is used foremost for event notifications. For example, when a client-side connector of a button receives a click, it sends the event to the server-side using RPC.

## Project Structure

Widget set compilation, as described in Section 13.3, “Client-Side Module Descriptor”, requires using a special project structure, where the client-side classes are located under a `client` package under the package of the module descriptor. Any static resources, such as stylesheets and images, should be located under a `public` folder (not Java package). The source for the server-side component may be located anywhere, except not in the client-side package.

The basic project structure is illustrated in Figure 16.2, “Basic Widget Integration Project Structure”.

**Figure 16.2. Basic Widget Integration Project Structure**

The Eclipse wizard, described in Section 16.2, “Starting It Simple With Eclipse”, creates a widget integration skeleton with the above structure.

## Integrating JavaScript Components

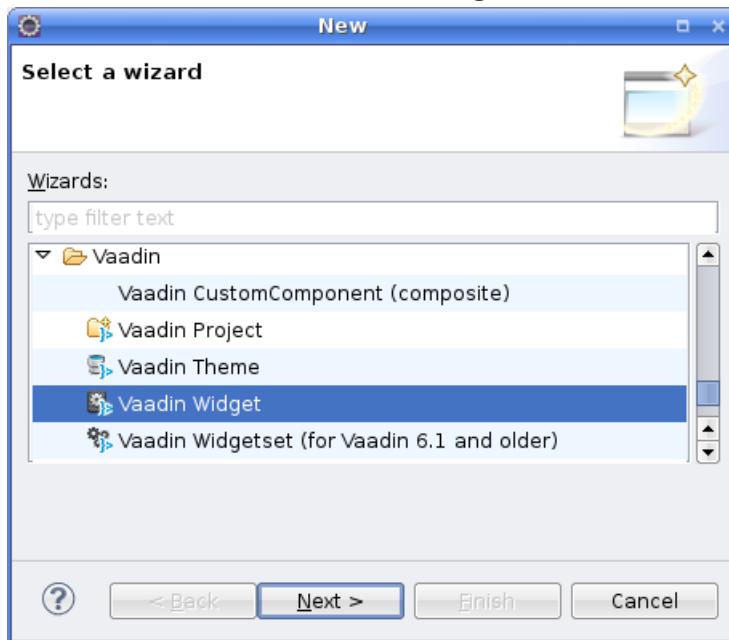
In addition to the GWT widget integration, Vaadin offers a simplified way to integrate pure JavaScript components. The JavaScript connector code is published from the server-side. As the JavaScript integration does not involve GWT programming, no widget set compilation is needed.

## 16.2. Starting It Simple With Eclipse

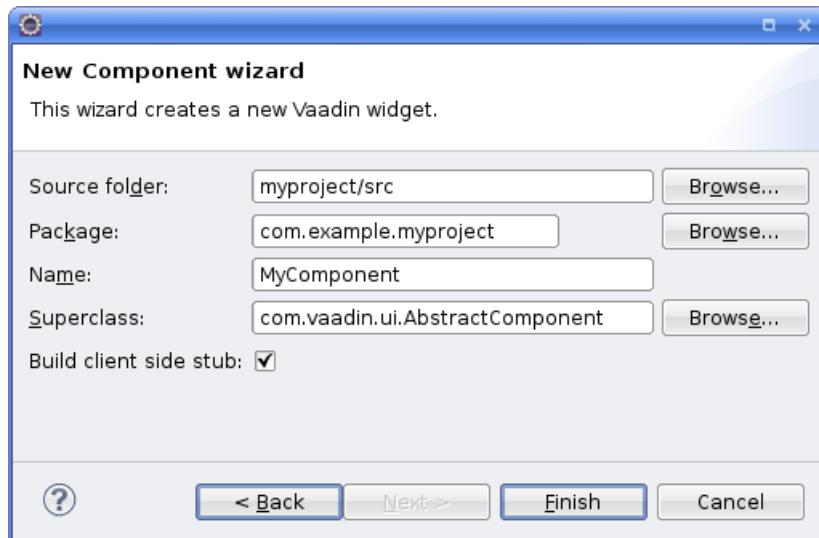
Let us first take the easy way and create a simple component with Eclipse. While you can develop new widgets with any IDE or even without, you may find Eclipse and the Vaadin Plugin for it useful, as it automates all the basic routines of widget development, most importantly the creation of new widgets.

### 16.2.1. Creating a Widget

1. Right-click the project in the Project Explorer and select **New Other....**
2. In the wizard selection, select **Vaadin Vaadin Widget** and click **Next.**



3. In the **New Component Wizard**, make the following settings.



#### Source folder

The root folder of the entire source tree. The default value is the default source tree of your project, and you should normally leave it unchanged unless you have a different project structure.

#### Package

The parent package under which the new server-side component should be created. If the project does not already have a widget set, one is created under this package

in the widgetset subpackage. The subpackage will contain the `.gwt.xml` descriptor that defines the widget set and the new widget stub under the `widgetset.client` subpackage.

#### Name

The class name of the new *server-side component*. The name of the client-side widget stub will be the same but with `"-Widget"` suffix, for example, `MyComponentWidget`. You can rename the classes afterwards.

#### Superclass

The superclass of the server-side component. It is `AbstractComponent` by default, but `com.vaadin.ui.AbstractField` or `com.vaadin.ui.AbstractSelect` are other commonly used superclasses. If you are extending an existing component, you should select it as the superclass. You can easily change the superclass later.

#### Template

Select which template to use. The default is `Full fledged`, which creates the server-side component, the client-side widget, the connector, a shared state object, and an RPC object. The `Connector only` leaves the shared state and RPC objects out.

Finally, click **Finish** to create the new component.

The wizard will:

- Create a server-side component stub in the base package
- If the project does not already have a widget set, the wizard creates a GWT module descriptor file (`.gwt.xml`) in the base package and modifies the servlet class or the `web.xml` deployment descriptor to specify the widget set class name parameter for the application
- Create a client-side widget stub (along with the connector and shared state and RPC stubs) in the `client.componentname` package under the base package

The structure of the server-side component and the client-side widget, and the serialization of component state between them, is explained in the subsequent sections of this chapter.

To compile the widget set, click the **Compile widget set** button in the Eclipse toolbar. See Section 16.2.2, “Compiling the Widget Set” for details. After the compilation finishes, you should be able to run your application as before, but using the new widget set. The compilation result is written under the `WebContent/VAADIN/widgetsets` folder. When you need to recompile the widget set in Eclipse, see Section 16.2.2, “Compiling the Widget Set”. For detailed information on compiling widget sets, see Section 13.4, “Compiling a Client-Side Module”.

The following setting is inserted in the `web.xml` deployment descriptor to enable the widget set:

```
<init-param>
    <description>Application widgetset</description>
    <param-name>widgetset</param-name>
    <param-value>com.example.myproject.widgetset.MyprojectApplicationWidget-
set</param-value>
</init-param>
```

You can refactor the package structure if you find need for it, but GWT compiler requires that the client-side code *must* always be stored under a package named “client” or a package defined with a `source` element in the widget set descriptor.

## 16.2.2. Compiling the Widget Set

After you edit a widget, you need to compile the widget set. The Vaadin Plugin for Eclipse automatically suggests to compile the widget set in various situations, such as when you save a client-side source file. If this gets annoying, you can disable the automatic recompilation in the Vaadin category in project settings, by selecting the **Suspend automatic widgetset builds** option.

You can compile the widget set manually by clicking the **Compile widgetset** button in the Eclipse toolbar, shown in Figure 16.3, “The **Compile Widgetset** Button in Eclipse Toolbar”, while the project is open and selected. If the project has multiple widget set definition files, you need to select the one to compile in the Project Explorer.

**Figure 16.3. The Compile Widgetset Button in Eclipse Toolbar**



The compilation progress is shown in the **Console** panel in Eclipse, illustrated in Figure 16.4, “Compiling a Widget Set”. You should note especially the list of widget sets found in the class path.

The compilation output is written under the `WebContent/VAADIN/widgetsets` folder, in a widget set specific folder.

You can speed up the compilation significantly by compiling the widget set only for your browser during development. The generated `.gwt.xml` descriptor stub includes a disabled element that specifies the target browser. See Section 13.3.2, “Limiting Compilation Targets” for more details on setting the `user-agent` property.

For more information on compiling widget sets, see Section 13.4, “Compiling a Client-Side Module”. Should you compile a widget set outside Eclipse, you need to refresh the project by selecting it in **Project Explorer** and pressing **F5**.

## 16.3. Creating a Server-Side Component

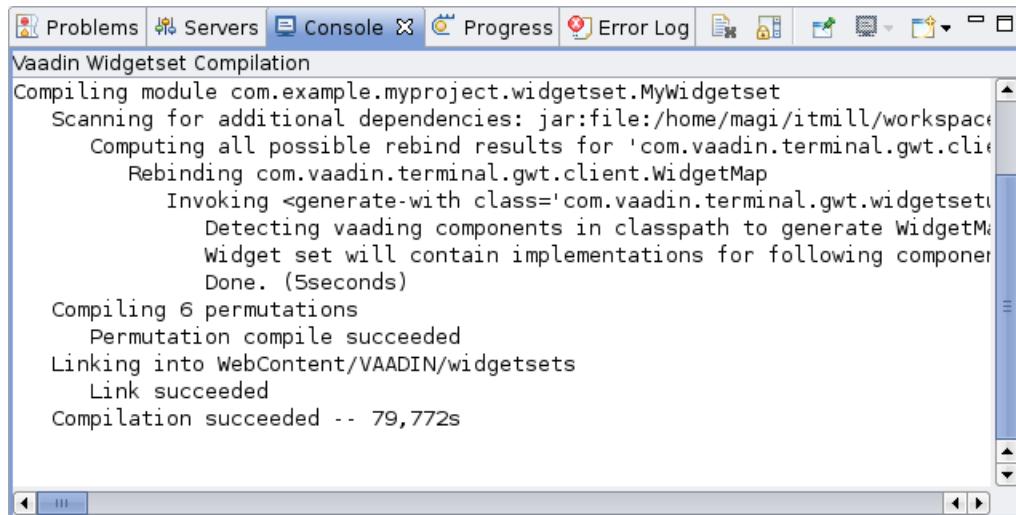
Typical server-side Vaadin applications use server-side components that are rendered on the client-side using their counterpart widgets. A server-side component must manage state synchronization between the widget on the client-side, in addition to any server-side logic.

### 16.3.1. Basic Server-Side Component

The component state is usually managed by a *shared state*, described later in Section 16.5, “Shared State”.

```
public class MyComponent extends AbstractComponent {
    public MyComponent() {
        getState().setText("This is MyComponent");
    }

    @Override
    protected MyComponentState getState() {
        return (MyComponentState) super.getState();
    }
}
```

**Figure 16.4. Compiling a Widget Set**

## 16.4. Integrating the Two Sides with a Connector

A client-side widget is integrated with a server-side component with a *connector*. A connector is a client-side class that communicates changes to the widget state and events to the server-side.

A connector normally gets the state of the server-side component by the *shared state*, described later in Section 16.5, “Shared State”.

### 16.4.1. A Basic Connector

The basic tasks of a connector is to hook up to the widget and handle events from user interaction and changes received from the server. A connector also has a number of routine infrastructure methods which need to be implemented.

```
@Connect(MyComponent.class)
public class MyComponentConnector
    extends AbstractComponentConnector {

    @Override
    public MyComponentWidget getWidget() {
        return (MyComponentWidget) super.getWidget();
    }

    @Override
    public MyComponentState getState() {
        return (MyComponentState) super.getState();
    }

    @Override
    public void onStateChanged(StateChangeEvent stateChangeEvent)
    {
        super.onStateChanged(stateChangeEvent);

        // Do something useful
        final String text = getState().text;
        getWidget().setText(text);
    }
}
```

```
    }  
}
```

Here, we handled state change with the crude `onStateChanged()` method that is called when any of the state properties is changed. A finer and simpler handling is achieved by using the `@OnStateChange` annotation on a handler method for each property, or by `@DelegateToWidget` on a shared state property, as described later in Section 16.5, “Shared State”.

### 16.4.2. Communication with the Server-Side

The main task of a connector is to communicate user interaction with the widget to the server-side and receive state changes from the server-side and relay them to the widget.

Server-to-client communication is normally done using a *shared state*, as described in Section 16.5, “Shared State”, as well as RPC calls. The serialization of the state data is handled completely transparently. Once the client-side engine receives the changes from the server, it reacts to them by creating and notifying connectors that in turn manage widgets. This is described in Section 16.10.1, “Client-Side Processing Phases” in more detail.

For client-to-server communication, a connector can make remote procedure calls (RPC) to the server-side. Also, the server-side component can make RPC calls to the connector. For a thorough description of the RPC mechanism, refer to Section 16.6, “RPC Calls Between Client- and Server-Side”.

## 16.5. Shared State

The basic communication from a server-side component to its the client-side widget counterpart is handled using a *shared state*. The shared state is serialized transparently. It should be considered read-only on the client-side, as it is not serialized back to the server-side.

A shared state object simply needs to extend the `ComponentState`. The member variables should normally be declared as public.

```
public class MyComponentState extends ComponentState {  
    public String text;  
}
```

A shared state should never contain any logic. If the members have private visibility for some reason, you can also use public setters and getters, in which case the property must not be public.

### Location of Shared-State Classes

The shared-state classes are used by both server- and client-side classes, but widget set compilation requires that they must be located in a client-side source package. The default location is under a `client` package under the package of the `.gwt.xml` descriptor. If you wish to organize the shared classes separately from other client-side code, you can define separate client-side source packages for pure client-side classes and any shared classes. In addition to shared state classes, shared classes could include enumerations and other classes needed by shared-state or RPC communication.

For example, you could have the following definitions in the `.gwt.xml` descriptor:

```
<source path="client" />  
<source path="shared" />
```

The paths are relative to the package containing the descriptor.

### 16.5.1. Accessing Shared State on Server-Side

A server-side component can access the shared state with the `getState()` method. It is required that you override the base implementation with one that returns the shared state object cast to the proper type, as follows:

```
@Override  
public MyComponentState getState() {  
    return (MyComponentState) super.getState();  
}
```

You can then use the `getState()` to access the shared state object with the proper type.

```
public MyComponent() {  
    getState().setText("This is the initial state");  
    ...  
}
```

### 16.5.2. Handing Shared State in a Connector

A connector can access a shared state with the `getState()` method. The access should be read-only. It is required that you override the base implementation with one that returns the proper shared state type, as follows:

```
@Override  
public MyComponentState getState() {  
    return (MyComponentState) super.getState();  
}
```

State changes made on the server-side are communicated transparently to the client-side. When a state change occurs, the `onStateChanged()` method in the connector is called. You should always call the superclass method before anything else to handle changes to common component properties.

```
@Override  
public void onStateChanged(StateChangeEvent stateChangeEvent) {  
    super.onStateChanged(stateChangeEvent);  
  
    // Copy the state properties to the widget properties  
    final String text = getState().getText();  
    getWidget().setText(text);  
}
```

The crude `onStateChanged()` method is called when any of the state properties is changed, allowing you to have even complex logic in how you manipulate the widget according to the state changes. In most cases, however, you can handle the property changes more easily and also more efficiently by using instead the `@OnStateChange` annotation on the handler methods for each property, as described next in Section 16.5.3, “Handling Property State Changes with `@OnStateChange`”, or by delegating the property value directly to the widget, as described in Section 16.5.4, “Delegating State Properties to Widget”.

The processing phases of state changes are described in more detail in Section 16.10.1, “Client-Side Processing Phases”.

### 16.5.3. Handling Property State Changes with @OnStateChange

The **@OnStateChange** annotation can be used to mark a connector method that handles state change on a particular property, given as parameter for the annotation. In addition to higher clarity, this avoids handling all property changes if a state change occurs in only one or some of them. However, if a state change can occur in multiple properties, you can only use this technique if the properties do not have interaction that prevents handling them separately in arbitrary order.

We can replace the `onStateChange( )` method in the earlier connector example with the following:

```
@OnStateChange("text")
void updateText() {
    getWidget().setText(getState().text);
}
```

If the shared state property and the widget property have same name and do not require any type conversion, as is the case in the above example, you could simplify this even further by using the **@DelegateToWidget** annotation for the shared state property, as described in Section 16.5.4, “Delegating State Properties to Widget”.

### 16.5.4. Delegating State Properties to Widget

The **@DelegateToWidget** annotation for a shared state property defines automatic delegation of the property value to the corresponding widget property of the same name and type, by calling the respective setter for the property in the widget.

```
public class MyComponentState extends AbstractComponentState {
    @DelegateToWidget
    public String text;
}
```

This is equivalent to handling the state change in the connector, as done in the example in Section 16.5.3, “Handling Property State Changes with **@OnStateChange**”.

If you want to delegate a shared state property to a widget property of another name, you can give the property name as a string parameter for the annotation.

```
public class MyComponentState extends AbstractComponentState {
    @DelegateToWidget("description")
    public String text;
}
```

### 16.5.5. Referring to Components in Shared State

While you can pass any regular Java objects through a shared state, referring to another component requires special handling because on the server-side you can only refer to a server-side component, while on the client-side you only have widgets. References to components can be made by referring to their connectors (all server-side components implement the `Connector` interface).

```
public class MyComponentState extends ComponentState {
    public Connector otherComponent;
}
```

You could then access the component on the server-side as follows:

```
public class MyComponent {
    public void MyComponent(Component otherComponent) {
        getState().otherComponent = otherComponent;
    }

    public Component getOtherComponent() {
        return (Component)getState().otherComponent;
    }

    // And the cast method
    @Override
    public MyComponentState getState() {
        return (MyComponentState) super.getState();
    }
}
```

On the client-side, you should cast it in a similar fashion to a **ComponentConnector**, or possibly to the specific connector type if it is known.

## 16.5.6. Sharing Resources

Resources, which commonly are references to icons or other images, are another case of objects that require special handling. A `Resource` object exists only on the server-side and on the client-side you have an URL to the resource. You need to use the `setResource()` and `getResource()` on the server-side to access a resource, which is serialized to the client-side separately.

Let us begin with the server-side API:

```
public class MyComponent extends AbstractComponent {
    ...

    public void setMyIcon(Resource myIcon) {
        setResource("myIcon", myIcon);
    }

    public Resource getMyIcon() {
        return getResource("myIcon");
    }
}
```

On the client-side, you can then get the URL of the resource with `getResourceUrl()`.

```
@Override
public void onStateChanged(StateChangeEvent stateChangeEvent) {
    super.onStateChanged(stateChangeEvent);
    ...

    // Get the resource URL for the icon
    getWidget().setMyIcon(getResourceUrl("myIcon"));
}
```

The widget could then use the URL, for example, as follows:

```
public class MyWidget extends Label {
    ...

    Element imgElement = null;

    public void setMyIcon(String url) {
```

```
        if (imgElement == null) {
            imgElement = DOM.createImg();
            getElement().appendChild(imgElement);
        }

        DOM.setElementAttribute(imgElement, "src", url);
    }
}
```

## 16.6. RPC Calls Between Client- and Server-Side

Vaadin supports making Remote Procedure Calls (RPC) between a server-side component and its client-side widget counterpart. RPC calls are normally used for communicating stateless events, such as button clicks or other user interaction, in contrast to changing the shared state. Either party can make an RPC call to the other side. When a client-side widget makes a call, a server request is made. Calls made from the server-side to the client-side are communicated in the response of the server request during which the call was made.

If you use Eclipse and enable the "Full-Fledged" widget in the New Vaadin Widget wizard, it automatically creates a component with an RPC stub.

### 16.6.1. RPC Calls to the Server-Side

RPC calls from the client-side to the server-side are made through an RPC interface that extends the `ServerRpc` interface. A server RPC interface simply defines any methods that can be called through the interface.

For example:

```
public interface MyComponentServerRpc extends ServerRpc {
    public void clicked(String buttonName);
}
```

The above example defines a single `clicked()` RPC call, which takes a `MouseEventDetails` object as the parameter.

You can pass the most common standard Java types, such as primitive and boxed primitive types, `String`, and arrays and some collections (`List`, `Set`, and `Map`) of the supported types. Also the Vaadin `Connector` and some special internal types can be passed.

An RPC method must return `void` - the widget set compiler should complain if it doesn't.

### Making a Call

Before making a call, you need to instantiate the server RPC object with `RpcProxy.create()`. After that, you can make calls through the server RPC interface that you defined, for example as follows:

```
@Connect(MyComponent.class)
public class MyComponentConnector
    extends AbstractComponentConnector {

    public MyComponentConnector() {
        getWidget().addClickHandler(new ClickHandler() {
            public void onClick(ClickEvent event) {
                final MouseEventDetails mouseDetails =
                    MouseEventDetailsBuilder
```

```
        .buildMouseEventDetails(
            event.getNativeEvent(),
            getWidget().getElement());
        MyComponentServerRpc rpc =
            getRpcProxy(MyComponentServerRpc.class);

        // Make the call
        rpc.clicked(mouseDetails.getButtonName());
    }
}
}
```

## Handling a Call

RPC calls are handled in a server-side implementation of the server RPC interface. The call and its parameters are serialized and passed to the server in an RPC request transparently.

```
public class MyComponent extends AbstractComponent {
    private MyComponentServerRpc rpc =
        new MyComponentServerRpc() {
            private int clickCount = 0;

            public void clicked(String buttonName) {
                Notification.show("Clicked " + buttonName);
            }
        };
    public MyComponent() {
        ...
        registerRpc(rpc);
    }
}
```

## 16.7. Component and UI Extensions

Adding features to existing components by extending them by inheritance creates a problem when you want to combine such features. For example, one add-on could add spell-check to a **TextField**, while another could add client-side validation. Combining such add-on features would be difficult if not impossible. You might also want to add a feature to several or even to all components, but extending all of them by inheritance is not really an option. Vaadin includes a component plug-in mechanism for these purposes. Such plug-ins are simply called *extensions*.

Also a UI can be extended in a similar fashion. In fact, some Vaadin features such as the JavaScript execution are UI extensions.

Implementing an extension requires defining a server-side extension class and a client-side connector. An extension can have a shared state with the connector and use RPC, just like a component could.

### 16.7.1. Server-Side Extension API

The server-side API for an extension consists of class that extends (in the Java sense) the **AbstractExtension** class. It typically has an `extend()` method, a constructor, or a static helper method that takes the extended component or UI as a parameter and passes it to `super.extend()`.

For example, let us have a trivial example with an extension that takes no special parameters, and illustrates the three alternative APIs:

```
public class CapsLockWarning extends AbstractExtension {  
    // You could pass it in the constructor  
    public CapsLockWarning(PasswordField field) {  
        super.extend(field);  
    }  
  
    // Or in an extend() method  
    public void extend(PasswordField field) {  
        super.extend(field);  
    }  
  
    // Or with a static helper  
    public static addTo(PasswordField field) {  
        new CapsLockWarning().extend(field);  
    }  
}
```

The extension could then be added to a component as follows:

```
PasswordField password = new PasswordField("Give it");  
  
// Use the constructor  
new CapsLockWarning(password);  
  
// ... or with the extend() method  
new CapsLockWarning().extend(password);  
  
// ... or with the static helper  
CapsLockWarning.addTo(password);  
  
layout.addComponent(password);
```

Adding a feature in such a "reverse" way is a bit unusual in the Vaadin API, but allows type safety for extensions, as the method can limit the target type to which the extension can be applied, and whether it is a regular component or a UI.

## 16.7.2. Extension Connectors

An extension does not have a corresponding widget on the client-side, but only an extension connector that extends the **AbstractExtensionConnector** class. The server-side extension class is specified with a `@Connect` annotation, just like in component connectors.

An extension connector needs to implement the `extend()` method, which allows hooking to the extended component. The normal extension mechanism is to modify the extended component as needed and add event handlers to it to handle user interaction. An extension connector can share a state with the server-side extension as well as make RPC calls, just like with components.

In the following example, we implement a "Caps Lock warning" extension. It listens for changes in Caps Lock state and displays a floating warning element over the extended component if the Caps Lock is on.

```
@Connect(CapsLockWarning.class)  
public class CapsLockWarningConnector  
    extends AbstractExtensionConnector {
```

```
    @Override
    protected void extend(ServerConnector target) {
        // Get the extended widget
        final Widget pw =
            ((ComponentConnector) target).getWidget();

        // Preparations for the added feature
        final VOverlay warning = new VOverlay();
        warning.setOwner(pw);
        warning.add(new HTML("Caps Lock is enabled!"));

        // Add an event handler
        pw.addDomHandler(new KeyPressHandler() {
            public void onKeyPress(KeyPressEvent event) {
                if (isEnabled() && isCapsLockOn(event)) {
                    warning.showRelativeTo(passwordWidget);
                } else {
                    warning.hide();
                }
            }
        }, KeyPressEvent.getType());
    }

    private boolean isCapsLockOn(KeyPressEvent e) {
        return e.isShiftKeyDown() ^
            Character.isUpperCase(e.getCharCode());
    }
}
```

The `extend()` method gets the connector of the extended component as the parameter, in the above example a **PasswordFieldConnector**. It can access the widget with the `getWidget()`.

An extension connector needs to be included in a widget set. The class must therefore be defined under the `client` package of a widget set, just like with component connectors.

## 16.8. Styling a Widget

To make your widget look stylish, you need to style it. There are two basic ways to define CSS styles for a component: in the widget sources and in a theme. A default style should be defined in the widget sources, and different themes can then modify the style.

### 16.8.1. Determining the CSS Class

The CSS class of a widget element is normally defined in the widget class and set with `setStyleName()`. A widget should set the styles for its sub-elements as it desires.

For example, you could style a composite widget with an overall style and with separate styles for the sub-widgets as follows:

```
public class MyPickerWidget extends ComplexPanel {
    public static final String CLASSNAME = "mypicker";

    private final TextBox textBox = new TextBox();
    private final PushButton button = new PushButton("...");

    public MyPickerWidget() {
        setElement(Document.get().createDivElement());
        setStylePrimaryName(CLASSNAME);
```

```
    textBox.setStylePrimaryName(CLASSNAME + "-field");
    button.setStylePrimaryName(CLASSNAME + "-button");

    add(textBox, getElement());
    add(button, getElement());

    button.addClickHandler(new ClickHandler() {
        public void onClick(ClickEvent event) {
            Window.alert("Calendar picker not yet supported!");
        }
    });
}
```

In addition, all Vaadin components get the `v-widget` class. If it extends an existing Vaadin or GWT widget, it will inherit CSS classes from that as well.

## 16.8.2. Default Stylesheet

A client-side module, which is normally a widget set, can include stylesheets. They must be placed under the `public` folder under the folder of the widget set, a described in Section 13.3.1, “Specifying a Stylesheet”.

For example, you could style the widget described above as follows:

```
.mypicker {
    white-space: nowrap;
}

.mypicker-button {
    display: inline-block;
    border: 1px solid black;
    padding: 3px;
    width: 15px;
    text-align: center;
}
```

Notice that some size settings may require more complex handling and calculating the sizes dynamically.

## 16.9. Component Containers

Component containers, such as layout components, are a special group of components that require some consideration. In addition to handling state, they need to manage communicating the hierarchy of their contained components to the other side.

The easiest way to implement a component container is extend the `AbstractComponentContainer`, which handles the synchronization of the container server-side components to the client-side.

## 16.10. Advanced Client-Side Topics

In the following, we mention some topics that you may encounter when integrating widgets.

### 16.10.1. Client-Side Processing Phases

Vaadin's client-side engine reacts to changes from the server in a number of phases, the order of which can be relevant for a connector. The processing occurs in the `handleUIDLMessage()` method in **ApplicationConnection**, but the logic can be quite overwhelming, so we describe the phases in the following summary.

1. Any dependencies defined by using **@JavaScript** or **@StyleSheet** on the server-side class are loaded. Processing does not continue until the browser confirms that they have been loaded.
2. New connectors are instantiated and `init()` is run for each Connector.
3. State objects are updated, but no state change event is fired yet.
4. The connector hierarchy is updated, but no hierarchy change event is fired yet. `setParent()` and `setChildren()` are run in this phase.
5. Hierarchy change events are fired. This means that all state objects and the entire hierarchy are already up to date when this happens. The DOM hierarchy should in theory be up to date after all hierarchy events have been handled, although there are some built-in components that for various reasons do not always live up to this promise.
6. Captions are updated, causing `updateCaption()` to be invoked on layouts as needed.
7. **@DelegateToWidget** is handled for all changed state objects using the annotation.
8. State change events are fired for all changed state objects.
9. `updateFromUIDL()` is called for legacy connectors.
- 10 All RPC methods received from the server are invoked.
- 11 Connectors that are no longer included in the hierarchy are unregistered. This calls `onUnregister()` on the Connector.
- 12 The layout phase starts, first checking the sizes and positions of all elements, and then notifying any `ElementResizeListeners`, as well as calling the appropriate layout method for the connectors that implement either **SimpleManagedLayout** or **DirectionalManagedLayout** interface.

### 16.11. Creating Add-ons

Add-ons are the most convenient way to reuse Vaadin code, either commercially or free. Vaadin Directory serves as the store for the add-ons. You can distribute add-ons both as JAR libraries and Zip packages.

Creating a typical add-on package involves the following tasks:

- Compile server-side classes
- Compile JavaDoc (optional)
- Build the JAR
- Include Vaadin add-on manifest

- Include the compiled server-side classes
- Include the compiled JavaDoc (optional)
- Include sources of client-side classes for widget set compilation (optional)
- Include any JavaScript dependency libraries (optional)
- Exclude any test or demo code in the project

The exact contents depend on the add-on type. Component add-ons often include a widget set, but not always, such as JavaScript components or pure server-side components. You can also have data container and theme add-ons, as well as various tools.

It is common to distribute the JavaDoc in a separate JAR, but you can also include it in the same JAR.

### 16.11.1. Exporting Add-on in Eclipse

If you use the Vaadin Plugin for Eclipse for your add-on project, you can simply export the add-on from Eclipse.

1. Select the project and then **File Export** from the menu
2. In the export wizard that opens, select **Vaadin Vaadin Add-on Package**, and click **Next**
3. In the **Select the resources to export** panel, select the content that should be included in the add-on package. In general, you should include sources in `src` folder (at least for the client-side package), compiled server-side classes, themes in `WebContent/VAADIN/themes`. These are all included automatically. You probably want to leave out any demo or example code.

If you are submitting the add-on to Vaadin Directory, the **Implementation title** should be exactly the name of the add-on in Directory. The name may contain spaces and most other letters. Notice that *it is not possible to change the name later*.

The **Implementation version** is the version of your add-on. Typically experimental or beta releases start from 0.1.0, and stable releases from 1.0.0.

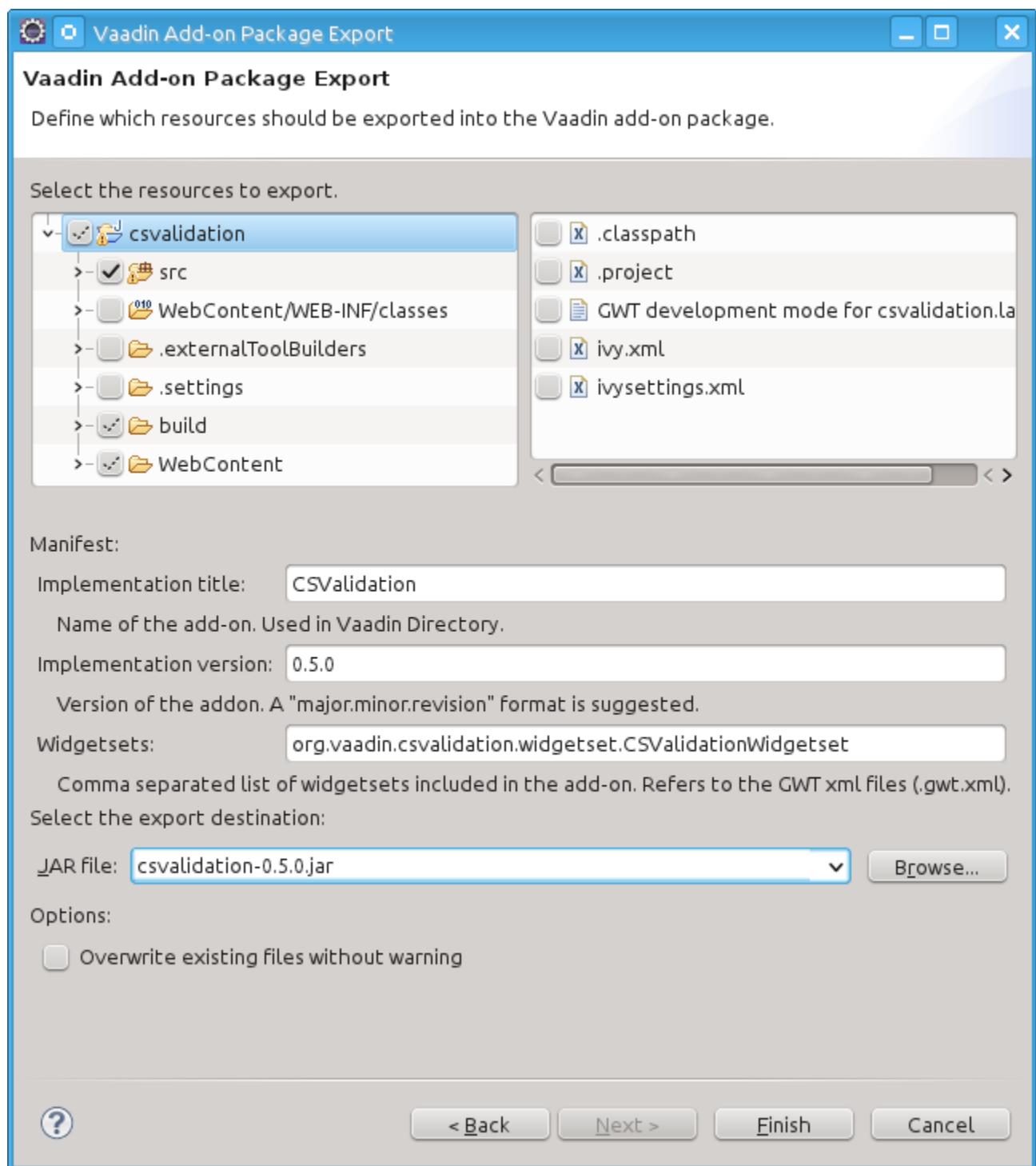
The **Widgetsets** field should list the widget sets included in the add-on, separated by commas. The widget sets should be listed by their class name, that is, without the `.gwt.xml` extension.

The **JAR file** is the file name of the exported JAR file. It should normally include the version number of the add-on. You should follow the Maven format for the name, such as `myaddon-1.0.0.jar`.

Finally, click **Finish**.

### 16.11.2. Building Add-on with Ant

Building an add-on with Ant is similar to building Vaadin applications. Vaadin libraries and other dependencies are retrieved and included in the classpath using Apache Ivy.

**Figure 16.5. Exporting a Vaadin Add-on**

In the following, we assume the same structure as in the Eclipse project example. Let us put the build script in the build folder under the project. We begin the Ant script as follows:

```
<?xml version="1.0"?>

<project xmlns:ivy="antlib:org.apache.ivy.ant">
```

```
name="My Own add-on"
basedir=".."
default="package-jar">
```

The namespace declaration is all you need to do to enable Ivy in Ant 1.6 and later. For earlier Ant versions, please see the Ivy documentation.

## Configuration and Initialization

In the example script, we organize most settings in a `configure` target and then initialize the build in `init` target.

```
<target name="configure">
    <!-- Where project source files are located -->
    <property name="src-location" value="src" />

    <!-- Name of the widget set. -->
    <property name="widgetset" value="com.example.myaddon.widgetset.MyAddonWidgetset"/>

    <!-- Addon version -->
    <property name="version" value="0.1.0"/>

    <!-- Compilation result directory -->
    <property name="result-dir" value="build/result"/>

    <!-- The target name of the built add-on JAR -->
    <property name="target-jar"
        value="${result-dir}/myaddon-${version}.jar"/>
</target>

<target name="init" depends="configure">
    <!-- Construct and check classpath -->
    <path id="compile.classpath">
        <pathelement path="build/classes" />
        <pathelement path="${src-location}" />
        <fileset dir="${result-dir}/lib">
            <include name="*.jar"/>
        </fileset>
    </path>

    <mkdir dir="${result-dir}" />
</target>
```

You will need to make some configuration also in the `package-jar` target in addition to the `configure` target.

## Compiling the Server-Side

Compiling the add-on requires the Vaadin libraries and any dependencies. We use Apache Ivy for resolving the dependencies and retrieving the library JARs.

```
<!-- Retrieve dependencies with Ivy -->
<target name="resolve" depends="init">
    <ivy:retrieve
        pattern="${result-dir}/lib/[artifact].[ext]"/>
</target>
```

The pattern attribute for the `<retrieve>` task specifies where the dependencies are stored, in the above case in the `build/result/lib` directory.

Compiling the server-side classes is then straight-forward:

```
<!-- Compile server-side -->
<target name="compile-server-side"
      depends="init, resolve">
    <delete dir="${result-dir}/classes"/>
    <mkdir dir="${result-dir}/classes"/>

    <javac srcdir="${src-location}"
          destdir="${result-dir}/classes">
      <classpath>
        <path refid="compile.classpath"/>
      </classpath>
    </javac>
  </target>
```

## Compiling the JavaDoc

You may want to include API documentation for the add-on in the same or in a different JAR file. You can do it as follows, using the configuration we defined earlier. You may want to exclude the client-side classes and any test and demo classes from the JavaDoc, as is done in this example, if they are in the same source tree.

```
<!-- Compile JavaDoc -->
<target name="compile-javadoc" depends="init">
  <delete dir="${result-dir}/javadoc"/>
  <mkdir dir="${result-dir}/javadoc"/>

  <javadoc destdir="${result-dir}/javadoc">
    <sourcefiles>
      <fileset dir="${src-location}" id="src">
        <include name="**/*.java"/>

        <!-- Excluded stuff from the package -->
        <exclude name="**/client/**/*"/>
        <exclude name="**/demo/**/*"/>
        <exclude name="**/MyDemoUI.java"/>
      </fileset>
    </sourcefiles>
    <classpath>
      <path refid="compile.classpath"/>
    </classpath>
  </javadoc>
</target>
```

## Packaging the JAR

An add-on JAR typically includes the following:

- Vaadin add-on manifest
- The compiled server-side classes
- The compiled JavaDoc (optional)

- Sources of client-side classes (optional)
- Any JavaScript dependency libraries (optional)

Let us begin crafting the target. The JAR requires the compiled server-side classes and the optional API documentation.

```
<!-- Build the JAR -->
<target name="package-jar"
    depends="compile-server-side, compile-javadoc">
    <jar jarfile="${target-jar}" compress="true">
```

First, you need to include a manifest that defines basic information about the add-on. The implementation title must be the exact title of the add-on, as shown in the Vaadin Directory title. The vendor is you. The manifest also includes the license title and file reference for the add-on.

```
<!-- Manifest required by Vaadin Directory -->
<manifest>
    <attribute name="Vaadin-Package-Version"
        value="1" />
    <attribute name="Vaadin-Widgetsets"
        value="${widgetset}" />
    <attribute name="Implementation-Title"
        value="My Own Addon" />
    <attribute name="Implementation-Version"
        value="${version}" />
    <attribute name="Implementation-Vendor"
        value="Me Myself" />
    <attribute name="Vaadin-License-Title"
        value="Apache2" />
    <attribute name="Vaadin-License-File"
        value="http://www.apache.org/licenses/LICENSE-2.0" />
</manifest>
```

The rest of the package-jar target goes as follows. As was done in the JavaDoc compilation, you also need to exclude any test or demo code in the project here. You need to modify at least the emphasized parts for your project.

```
<!-- Include built server-side classes -->
<fileset dir="build/result/classes">
    <patternset>
        <include name="com/example/myaddon/**/*" />
        <exclude name="**/client/**/*" />
        <exclude name="**/demo/**/*" />
        <exclude name="**/test/**/*" />
        <exclude name="**/MyDemoUI*" />
    </patternset>
</fileset>

<!-- Include widget set sources -->
<fileset dir="src">
    <patternset>
        <include name="com/exaple/myaddon/**/*" />
    </patternset>
</fileset>

<!-- Include JavaDoc in the JAR -->
<fileset dir="${result-dir}/javadoc"
    includes="**/*" />
```

```
</jar>
</target>
```

You should now be ready to run the build script with Ant.

## 16.12. Migrating from Vaadin 6

The client-side architecture was redesigned almost entirely in Vaadin 7. In Vaadin 6, state synchronization was done explicitly by serializing and deserializing the state on the server- and client-side. In Vaadin 7, the serialization is handled automatically by the framework using state objects.

In Vaadin 6, a server-side component serialized its state to the client-side using the `Paintable` interface in the client-side and deserialized the state through the `VariableOwner` interface. In Vaadin 7, these are done through the `ClientConnector` interface.

On the client-side, a widget deserialized its state through the `Paintable` interface and sent state changes through the `ApplicationConnection` object. In Vaadin 7, these are replaced with the `ServerConnector`.

In addition to state synchronization, Vaadin 7 has an RPC mechanism that can be used for communicating events. They are especially useful for events that are not associated with a state change, such as a button click.

The framework ensures that the connector hierarchy and states are up-to-date when listeners are called.

### 16.12.1. Quick (and Dirty) Migration

Vaadin 7 has a compatibility layer that allows quick conversion of a widget.

1. Create a connector class, such as `MyConnector`, that extends `LegacyConnector`. Implement the `getWidget()` method.
2. Move the `@ClientWidget(MyWidget.class)` from the server-side component, say `MyComponent`, to the `MyConnector` class and make it `@Connect(MyComponent.class)`.
3. Have the server-side component implement the `LegacyComponent` interface to enable compatibility handling.
4. Remove any calls to `super.paintContent()`
5. Update any imports on the client-side

## 16.13. Integrating JavaScript Components and Extensions

Vaadin allows simplified integration of pure JavaScript components, as well as component and UI extensions. The JavaScript connector code is published from the server-side. As the JavaScript integration does not involve GWT programming, no widget set compilation is needed.

### 16.13.1. Example JavaScript Library

There are many kinds of component libraries for JavaScript. In the following, we present a simple library that provides one object-oriented JavaScript component. We use this example later to show how to integrate it with a server-side Vaadin component.

The example library includes a single **MyComponent** component, defined in `mylibrary.js`.

```
// Define the namespace
var mylibrary = mylibrary || {};

mylibrary.MyComponent = function (element) {
    element.innerHTML =
        "<div class='caption'>Hello, world!</div>" +
        "<div class='textinput'>Enter a value: " +
        "<input type='text' name='value' />" +
        "<input type='button' value='Click' />" +
        "</div>";

    // Style it
    element.style.border = "thin solid red";
    element.style.display = "inline-block";

    // Getter and setter for the value property
    this.getValue = function () {
        return element.
            getElementsByTagName("input")[0].value;
    };
    this.setValue = function (value) {
        element.getElementsByTagName("input")[0].value =
            value;
    };

    // Default implementation of the click handler
    this.click = function () {
        alert("Error: Must implement click() method");
    };

    // Set up button click
    var button = element.getElementsByTagName("input")[1];
    var self = this; // Can't use this inside the function
    button.onclick = function () {
        self.click();
    };
}
```

When used in an HTML page, the library would be included with the following definition:

```
<script type="text/javascript"
       src="mylibrary.js"></script>
```

You could then use it anywhere in the HTML document as follows:

```
<!-- Placeholder for the component -->
<div id="foo"></div>

<!-- Create the component and bind it to the placeholder -->
<script type="text/javascript">
    window.foo = new mylibrary.MyComponent(
        document.getElementById("foo"));
    window.foo.click = function () {
        alert("Value is " + this.getValue());
    }
</script>
```

**Figure 16.6. A JavaScript Component Example**

You could interact with the component with JavaScript for example as follows:

```
<a href="javascript:foo.setValue('New value')">Click here</a>
```

## 16.13.2. A Server-Side API for a JavaScript Component

To begin integrating such a JavaScript component, you would need to sketch a bit how it would be used from a server-side Vaadin application. The component should support writing the value as well as listening for changes to it.

```
final MyComponent mycomponent = new MyComponent();

// Set the value from server-side
mycomponent.setValue("Server-side value");

// Process a value input by the user from the client-side
mycomponent.addValueChangeListener(
    new MyComponent.ValueChangeListener() {
        @Override
        public void valueChange() {
            Notification.show("Value: " + mycomponent.getValue());
        }
    });
layout.addComponent(mycomponent);
```

### Basic Server-Side Component

A JavaScript component extends the **AbstractJavaScriptComponent**, which handles the shared state and RPC for the component.

```
package com.vaadin.book.examples.client.js;

@JavaScript({"mylibrary.js", "mycomponent-connector.js"})
public class MyComponent extends AbstractJavaScriptComponent {
    public interface ValueChangeListener extends Serializable {
        void valueChange();
    }
    ArrayList<ValueChangeListener> listeners =
        new ArrayList<ValueChangeListener>();
    public void addValueChangeListener(
        ValueChangeListener listener) {
        listeners.add(listener);
    }

    public void setValue(String value) {
        getState().value = value;
    }

    public String getValue() {
        return getState().value;
    }
}
```

```
    @Override
    protected MyComponentState getState() {
        return (MyComponentState) super.getState();
    }
}
```

Notice later when creating the JavaScript connector that its name must match the package name of this server-side class.

The shared state of the component is as follows:

```
public class MyComponentState extends JavaScriptComponentState {
    public String value;
}
```

If the member variables are private, you need to have public setters and getters for them, which you can use in the component.

### 16.13.3. Defining a JavaScript Connector

A JavaScript connector is a function that initializes the JavaScript component and handles communication between the server-side and the JavaScript code.

A connector is defined as a connector initializer function that is added to the `window` object. The name of the function must match the server-side class name, with the full package path. Instead of the Java dot notation for the package name, underscores need to be used as separators.

The Vaadin client-side framework adds a number of methods to the connector function. The `this.getElement()` method returns the HTML DOM element of the component. The `this.getState()` returns a shared state object with the current state as synchronized from the server-side.

```
window.com_vaadin_book_examples_client_js_MyComponent =
function() {
    // Create the component
    var mycomponent =
        new mylibrary.MyComponent(this.getElement());

    // Handle changes from the server-side
    this.onStateChange = function() {
        mycomponent.setValue(this.getState().value);
    };

    // Pass user interaction to the server-side
    var self = this;
    mycomponent.click = function() {
        self.onClick(mycomponent.getValue());
    };
};
```

In the above example, we pass user interaction using the JavaScript RPC mechanism, as described in the next section.

### 16.13.4. RPC from JavaScript to Server-Side

User interaction with the JavaScript component has to be passed to the server-side using an RPC (Remote Procedure Call) mechanism. The JavaScript RPC mechanism is almost equal to regular client-side widgets, as described in Section 16.6, “RPC Calls Between Client- and Server-Side”.

#### Handling RPC Calls on the Server-Side

Let us begin with the RPC function registration on the server-side. RPC calls are handled on the server-side in function handlers that implement the `JavaScriptFunction` interface. A server-side function handler is registered with the `addFunction()` method in **AbstractJavaScriptComponent**. The server-side registration actually defines a JavaScript method that is available in the client-side connector object.

Continuing from the server-side **MyComponent** example we defined earlier, we add a constructor to it that registers the function.

```
public MyComponent() {
    addFunction("onClick", new JavaScriptFunction() {
        @Override
        public void call(JSONArray arguments)
            throws JSONException {
            getState().setValue(arguments.getString(0));
            for (ValueChangeListener listener: listeners)
                listener.valueChange();
        }
    });
}
```

#### Making an RPC Call from JavaScript

An RPC call is made simply by calling the RPC method in the connector. In the constructor function of the JavaScript connector, you could write as follows (the complete connector code was given earlier):

```
window.com_vaadin_book_examples_gwt_js_MyComponent =
    function() {
        ...
        var connector = this;
        mycomponent.click = function() {
            connector.onClick(mycomponent.getValue());
        };
    };
}
```

Here, the `mycomponent.click` is a function in the example JavaScript library, as described in Section 16.13.1, “Example JavaScript Library”. The `onClick()` is the method we defined on the server-side. We pass a simple string parameter in the call.

You can pass anything that is valid in JSON notation in the parameters.



---

# Chapter 17

# Using Vaadin Add-ons

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This chapter describes the installation of add-on components, themes, containers, and other tools from the Vaadin Directory and the use of commercial add-ons offered by Vaadin.

## 17.1. Overview

In addition to the components, layouts, themes, and data sources built in into the core Vaadin library, many others are available as add-ons. Vaadin Directory provides a rich collection of add-ons for Vaadin, and you may find others from independent sources. Add-ons are also one way to share your own components between projects.

Installation of add-ons from Vaadin Directory is simple, just adding an Ivy or Maven dependency, or downloading the JAR package and dropping it in the web library folder of the project. Most add-ons include a widget set, which you need to compile, but it's usually just a click of a button or a single command.

After trying out an add-on, you can give some feedback to the author of the add-on by rating the add-on with one to five stars and optionally leaving a comment. Most add-ons also have a discussion forum thread for user feedback and questions.

Add-ons available from Vaadin Directory are distributed under different licenses, of which some are commercial. While the add-ons can be downloaded directly, you should note their license and other terms and conditions. Many are offered under a dual licensing agreement so that they can be used in open source projects for free, and many have a trial period for closed-source development.

## 17.2. Downloading Add-ons from Vaadin Directory

If you are not using a Maven-compatible dependency manager or want to manage for your libraries manually, you can download add-on packages from the details page of an add-on in Vaadin Directory.

1. Select the version; some add-ons have several versions available. The latest is shown by default, but you can choose another the version to download from the dropdown menu in the header of the details page.
2. Click **Download Now** and save the JAR or Zip file on your computer.
3. If the add-on is packaged in a Zip package, unzip the package and follow any instructions provided inside the package. Typically, you just need to copy a JAR file to your web project under the `WEB-INF/lib` directory.

Note that some add-ons may require other libraries. You can resolve such dependencies manually, but we recommend using a dependency manager such as Ivy or Maven in your project.

4. Update and recompile your project. In Eclipse, select the project and press F5.
5. You may need to compile the client-side implementations of the add-on components, that is, a *widget set*. This is the case for majority of add-ons, except for pure server-side, theme, or data binding add-ons. Compiling the widget set depends on the build environment. See Section 17.2.1, “Compiling Widget Sets with an Ant Script”, or later in this chapter for instructions for compiling the widget set with Eclipse and Maven.
6. Update the project in your development web server and possibly restart the server.

### 17.2.1. Compiling Widget Sets with an Ant Script

If you need to compile the widget set with an Ant script, you can find a script template package at the Vaadin download page. You can copy the files in the package to your project and, once configured, use it by running Ant in the directory.

If you are using an IDE such as Eclipse, *always* remember to refresh the project to synchronize it with the filesystem after compiling the widget set outside the IDE.

## 17.3. Installing Add-ons in Eclipse with Ivy

The Vaadin Plugin for Eclipse uses Apache Ivy to resolve dependencies. The dependencies should be listed in the `ivy.xml` file in the project root. The Vaadin Directory allows dowloading add-ons from a Maven repository, which can be accessed also by Ivy.

You can also use Ivy to resolve dependencies in an Ant script.

1. Open the add-on page in Vaadin Directory.
2. Select the version. The latest is shown by default, but you can choose another the version from the dropdown menu in the header of the add-on details page.
3. Click the **Maven/Ivy** to display the Ivy dependency declaration, as illustrated in Figure 17.1. If the add-on is available with multiple licenses, you will be prompted to select a license for the dependency.

**Figure 17.1. Ivy Dependency Declaration**



4. Open the `ivysettings.xml` in your Eclipse project either in the XML or Ivy Editor (either double-click the file or right-click it and select **Open With Ivy Editor**).

Check that the settings file has the `<ibiblio>` entry given in the Directory page. It should be, if the file was created by the Vaadin project wizard in Eclipse. If not, copy it there.

```

<chain name="default">
  ...
  <ibiblio name="vaadin-addons"
            usepoms="true"
            m2compatible="true"
            root="http://maven.vaadin.com/vaadin-addons" />
  ...
</chain>

```

If you get Vaadin addons from another repository, such as the local repository if you have compiled them yourself, you need to define a resolver for the repository in the settings file.

5. Open the `ivy.xml` in your Eclipse project and copy the Ivy dependency to inside the `dependencies` element. It should be as follows:

```
<dependencies>
    ...
    <dependency org="com.vaadin.addon"
                name="vaadin-charts"
                rev="1.0.0"/>
</dependencies>
```

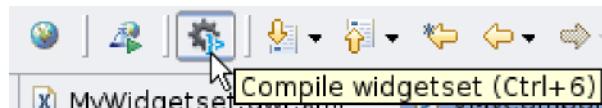
You can specify either a fixed version number or a dynamic revision tag, such as `latest.release`. You can find more information about the dependency declarations in Ivy documentation.

If the `ivy.xml` does not have a `<configurations defaultconfmapping="default->default">` defined, you also need to have `conf="default->default"` in the dependency to resolve transient dependencies correctly.

IvyIDE immediately resolves the dependencies when you save the file.

6. Compile the add-on widget set by clicking the **Compile Vaadin widgets** button in the toolbar.

**Figure 17.2. Compiling Widget Set in Eclipse**



If you experience problems with Ivy, first check all the dependency parameters. IvyDE can sometimes cause unexpected problems. You can clear the Ivy dependency cache by right-clicking the project and selecting **Ivy Clean all caches**. To refresh Ivy configuration, select **Ivy Refresh**. To try resolving again Ivy, select **Ivy Resolve**.

## 17.4. Using Add-ons in a Maven Project

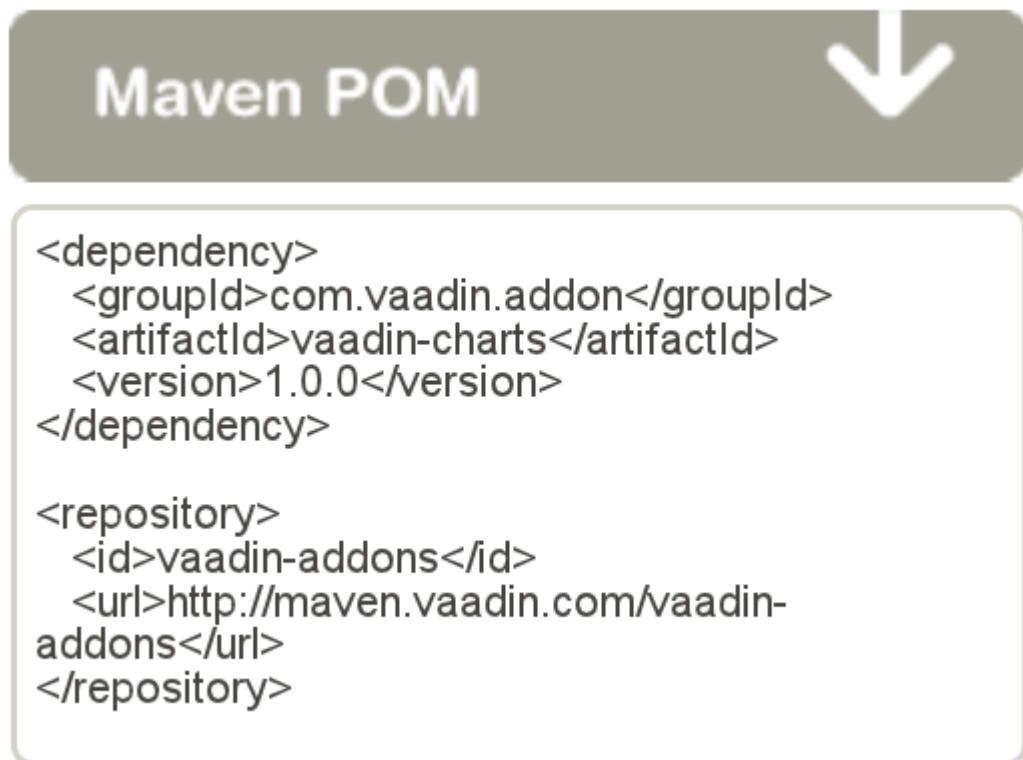
To use add-ons in a Maven project, you simply have to add them as dependencies in the project POM. Most add-ons include a widget set, which are compiled to the project widget set.

Creating, compiling, and packaging a Vaadin project with Maven was described in Section 2.6, “Using Vaadin with Maven”.

### 17.4.1. Adding a Dependency

Vaadin Directory provides a Maven repository for all the add-ons in the Directory.

1. Open the add-on page in Vaadin Directory.
2. Select the version. The latest is shown by default, but you can choose another the version from the dropdown menu in the header of the add-on details page.
3. Click the **Maven/Ivy** to display the Maven dependency declaration, as illustrated in Figure 17.3. If the add-on is available with multiple licenses, you will be prompted to select a license for the dependency.

**Figure 17.3. Maven POM Definitions**

4. Copy the dependency declaration to the `pom.xml` file in your project, under the `dependencies` element.

```

...
<dependencies>
  ...
  <dependency>
    <groupId>com.vaadin.addon</groupId>
    <artifactId>vaadin-charts</artifactId>
    <version>1.0.0</version>
  </dependency>
</dependencies>

```

You can use an exact version number, as is done in the example above, or `LATEST` to always use the latest version of the add-on.

The POM excerpt given in Directory includes also a repository definition, but if you have used the `vaadin-archetype-application` to create your project, it already includes the definition.

5. Compile the widget set as described in the following section.

## 17.4.2. Compiling the Project Widget Set

If you have used the `vaadin-archetype-application` to create the project, the `pom.xml` includes all necessary declarations to compile the widget set. The widget set compilation occurs in standard Maven build phase, such as with `package` or `install` goal.

```
$ mvn package
```

Then, just deploy the WAR to your application server.

## Recompiling the Widget Set

The Vaadin plugin for Maven tries to avoid recompiling the widget set unless necessary, which sometimes means that it is not compiled even when it should. Running the `clean` goal usually helps, but causes a full recompilation. You can compile the widget set manually by running the `vaadin:compile` goal.

```
$ mvn vaadin:compile
```

Note that this does not update the project widget set by searching new widget sets from the class path. It must be updated if you add or remove add-ons, for example. You can do that by running the `vaadin:update-widgetset` goal in the project directory.

```
$ mvn vaadin:update-widgetset
...
[INFO] auto discovered modules [your.company.gwt.ProjectNameWidgetSet]
[INFO] Updating widgetset your.company.gwt.ProjectNameWidgetSet
[ERROR] 27.10.2011 19:22:34 com.vaadin.terminal.gwt.widgetsetutils.ClassPathEx-
plorer getAvailableWidgetSets
[ERROR] INFO: Widgets found from classpath:
...
```

Do not mind the "ERROR" labels, they are just an issue with the Vaadin Plugin for Maven.

After running the update, you need to run the `vaadin:compile` goal to actually compile the widget set.

### 17.4.3. Enabling Widget Set Compilation

If you are not using a POM created with the proper Vaadin archetype, you may need to enable widget set compilation manually. The simplest way to do that is to copy the definitions from a POM created with the archetype. Specifically, you need to copy the `plugin` definitions. You also need the Vaadin dependencies.

You need to create an empty widget set definition file, which the widget set compilation will populate with widget sets found from the class path. Create a `src/main/java/com/example/AppWidgetSet.gwt.xml` file (in the project package) with an empty `<module>` element as follows:

```
<module>
</module>
```

### Enabling the Widget Set in the UI

If you have previously used the default widget set in the project, you need to enable the project widget set in the `web.xml` deployment descriptor. Edit the `src/main/webapp/WEB-INF/web.xml` file and add or modify the `widgetset` parameter for the servlet as follows.

```
<servlet>
  ...
  <init-param>
    <description>Widget Set to Use</description>
    <param-name>widgetset</param-name>
```

```
<param-value>com.example.AppWidgetSet</param-value>
</init-param>
</servlet>
```

The parameter is the class name of the widget set, that is, without the `.gwt.xml` extension and with the Java dot notation for class names that include the package name.

## 17.5. Troubleshooting

If you experience problems with using add-ons, you can try the following:

- Check the `.gwt.xml` descriptor file under the the project root package. For example, if the project root package is `com.example.myproject`, the widget set definition file is typically at `com/example/project/AppWidgetset.gwt.xml`. The location is not fixed and it can be elsewhere, as long as references to it match. See Section 13.3, “Client-Side Module Descriptor” for details on the contents of the client-side module descriptor, which is used to define a widget set.
- Check the `WEB-INF/web.xml` deployment descriptor and see that the servlet for your UI has a widget set parameter, such as the following:

```
<init-param>
  <description>UI widgetset</description>
  <param-name>widgetset</param-name>
  <param-value>com.example.project.AppWidgetSet</param-value>
</init-param>
```

Check that the widget set class corresponds with the `.gwt.xml` file in the source tree.

- See the `VAADIN/widgetsets` directory and check that the widget set appears there. You can remove it and recompile the widget set to see that the compilation works properly.
- Use the **Net** tab in Firebug to check that the widget set (and theme) is loaded properly.
- Use the `?debug` parameter for the application to open the debug window and check if there is any version conflict between the widget set and the Vaadin library, or the themes. See Section 11.3, “Debug Mode and Window” for details.
- Refresh and recompile the project. In Eclipse, select the project and press **F5**, stop the server, clean the server temporary directories, and restart it.
- Check the Error Log view in Eclipse (or in the IDE you use).



---

# Chapter 18

# Vaadin Charts

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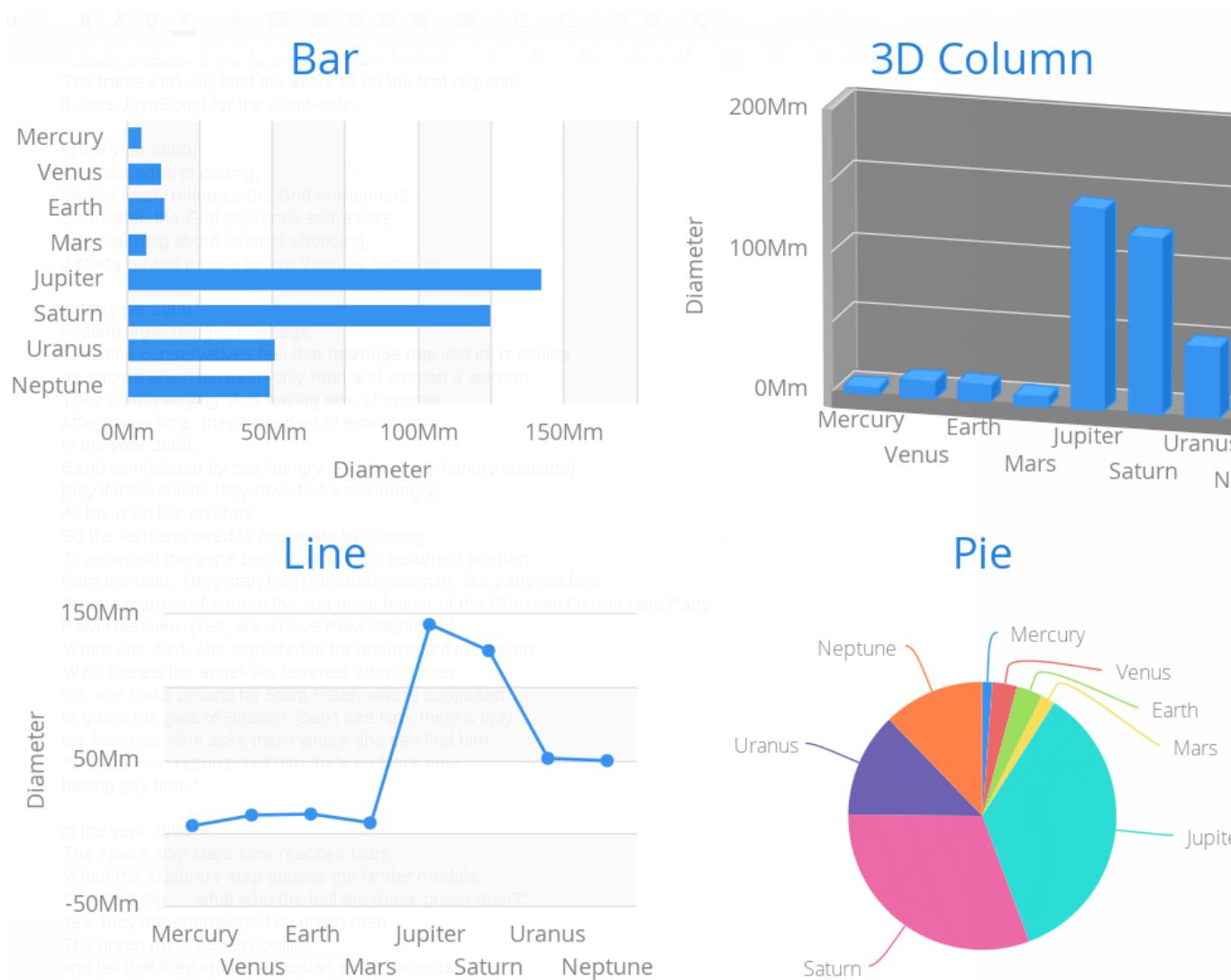
This chapter provides the documentation for the Vaadin Charts add-on.

## 18.1. Overview

Vaadin Charts is a feature-rich interactive charting library for Vaadin. It provides a **Chart** and a **Timeline** component. The **Chart** can visualize one- and two-dimensional numeric data in many available chart types. The charts allow flexible configuration of all the chart elements as well as the visual style. The library includes a number of built-in visual themes, which you can extend further. The basic functionalities allow the user to interact with the chart elements in various ways, and you can define custom interaction with click events. The **Timeline** is a specialized component for visualizing time series, and is described in Section 18.8, “Timeline”.

The data displayed in a chart can be one- or two dimensional tabular data, or scatter data with free X and Y values. Data displayed in range charts has minimum and maximum values instead of singular values.

## Figure 18.1. Vaadin Charts



This chapter covers the basic use of Vaadin Charts and the chart configuration. For detailed documentation of the configuration parameters and classes, please refer to the JavaDoc API documentation of the library.

In the following basic example, which we study further in Section 18.3, “Basic Use”, we demonstrate how to display one-dimensional data in a column graph and customize the X and Y axis labels and titles.

```
Chart chart = new Chart(ChartType.BAR);
chart.setWidth("400px");
chart.setHeight("300px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Planets");
conf.setSubTitle("The bigger they are the harder they pull");
conf.getLegend().setEnabled(false); // Disable legend
```

```
// The data
ListSeries series = new ListSeries("Diameter");
series.setDiameter(4900, 12100, 12800,
                   6800, 143000, 125000,
                   51100, 49500);
conf.addSeries(series);

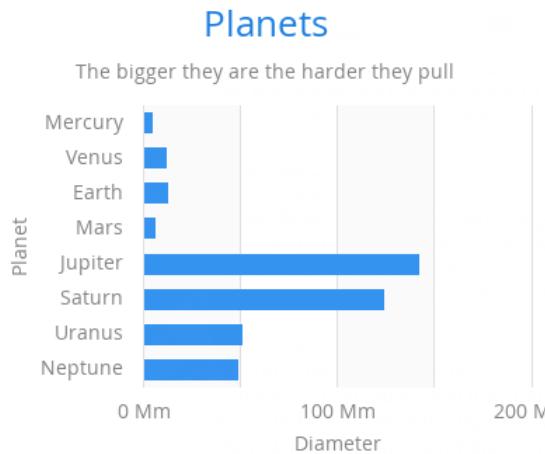
// Set the category labels on the axis correspondingly
XAxis xaxis = new XAxis();
xaxis.setCategories("Mercury", "Venus", "Earth",
                     "Mars", "Jupiter", "Saturn",
                     "Uranus", "Neptune");
xaxis.setTitle("Planet");
conf.addXAxis(xaxis);

// Set the Y axis title
YAxis yaxis = new YAxis();
yaxis.setTitle("Diameter");
yaxis.getLabels().setFormatter(
    "function() {return Math.floor(this.value/1000) + \' Mm\';}");
yaxis.getLabels().setStep(2);
conf.addYAxis(yaxis);

layout.addComponent(chart);
```

The resulting chart is shown in Figure 18.2, “Basic Chart Example”.

**Figure 18.2. Basic Chart Example**



Vaadin Charts is based on Highcharts JS, a charting library written in JavaScript.

## Licensing

Vaadin Charts is a commercial product licensed under the CVAL License (Commercial Vaadin Add-On License). A license needs to be purchased for all use, including web deployments as well as intranet use. Using Vaadin Charts does not require purchasing a separate Highcharts JS license.

The commercial licenses can be purchased from the Vaadin Directory, where you can also find the license details and download the Vaadin Charts.

## 18.2. Installing Vaadin Charts

Vaadin Charts is available for both Vaadin 7 and Vaadin 6. It can be installed from an installation package, which you can download from the Vaadin Directory, or as a Maven or Ivy dependency. For detailed instructions, please see Chapter 17, *Using Vaadin Add-ons*.

Once you have installed the library in your project, you need to compile the widget set.

## 18.3. Basic Use

The **Chart** is a regular Vaadin component, which you can add to a layout. You can give the chart type in the constructor or set it later in the chart model. A chart has a height of 400 pixels and takes full width by default, which settings you may often need to customize.

```
Chart chart = new Chart(ChartType.COLUMN);
chart.setWidth("400px"); // 100% by default
chart.setHeight("300px"); // 400px by default
```

The chart types are described in Section 18.4, “Chart Types”.

## Configuration

After creating a chart, you need to configure it further. At the least, you need to specify the data series to be displayed in the configuration.

Most methods available in the **Chart** object handle its basic Vaadin component properties. All the chart-specific properties are in a separate **Configuration** object, which you can access with the `getConfiguration()` method.

```
Configuration conf = chart.getConfiguration();
conf.setTitle("Reindeer Kills by Predators");
conf.setSubTitle("Kills Grouped by Counties");
```

The configuration properties are described in more detail in Section 18.5, “Chart Configuration”.

## Plot Options

Many chart settings can be configured in the *plot options* of the chart or data series. Some of the options are chart type specific, as described later for each chart type, while many are shared.

For example, for line charts, you could disable the point markers as follows:

```
// Disable markers from lines
PlotOptionsLine plotOptions = new PlotOptionsLine();
plotOptions.setMarker(new Marker(false));
conf.setPlotOptions(plotOptions);
```

You can set the plot options for the entire chart or for each data series separately, allowing also mixed-type charts, as described in Section 18.3.2, “Mixed Type Charts”.

The shared plot options are described in Section 18.5.1, “Plot Options”.

## Chart Data

The data displayed in a chart is stored in the chart configuration as a list of **Series** objects. A new data series is added in a chart with the `addSeries()` method.

```
ListSeries series = new ListSeries("Diameter");
series.setData(4900, 12100, 12800,
              6800, 143000, 125000,
              5100, 49500);
conf.addSeries(series);
```

The data can be specified with a number of different series types **DataSeries**, **ListSeries**, **AreaListSeries**, and **RangeSeries**. The data configuration is described in more detail in Section 18.6, “Chart Data”.

## Axis Configuration

One of the most common tasks for charts is customizing its axes. At the least, you usually want to set the axis titles. Usually you also want to specify labels for data values in the axes.

When an axis is categorical rather than numeric, you can define category labels for the items. They must be in the same order and the same number as you have values in your data series.

```
XAxis xaxis = new XAxis();
xaxis.setCategories("Mercury", "Venus", "Earth",
                     "Mars", "Jupiter", "Saturn",
                     "Uranus", "Neptune");
xaxis.setTitle("Planet");
conf.addXAxis(xaxis);
```

Formatting of numeric labels can be done with JavaScript expressions, for example as follows:

```
// Set the Y axis title
YAxis yaxis = new YAxis();
yaxis.setTitle("Diameter");
yaxis.getLabels().setFormatter(
    "function() {return Math.floor(this.value/1000) + \\'Mm\\';}");
yaxis.getLabels().setStep(2);
conf.addYAxis(yaxis);
```

### 18.3.1. Displaying Multiple Series

The simplest data, which we saw in the examples earlier in this chapter, is one-dimensional and can be represented with a single data series. Most chart types support multiple data series, which are used for representing two-dimensional data. For example, in line charts, you can have multiple lines and in column charts the columns for different series are grouped by category. Different chart types can offer alternative display modes, such as stacked columns. The legend displays the symbols for each series.

```
// The data
// Source: V. Maijala, H. Norberg, J. Kumpula, M. Nieminen
// Calf production and mortality in the Finnish
// reindeer herding area. 2002.
String predators[] = {"Bear", "Wolf", "Wolverine", "Lynx"};
int kills[][] = {
    {8, 0, 7, 0}, // Muddusjarvi
    {30, 1, 30, 2}, // Ivalo
```

```

        {37, 0, 22, 2}, // Oraniemi
        {13, 23, 4, 1}, // Salla
        {3, 10, 9, 0}, // Alakitka
    };

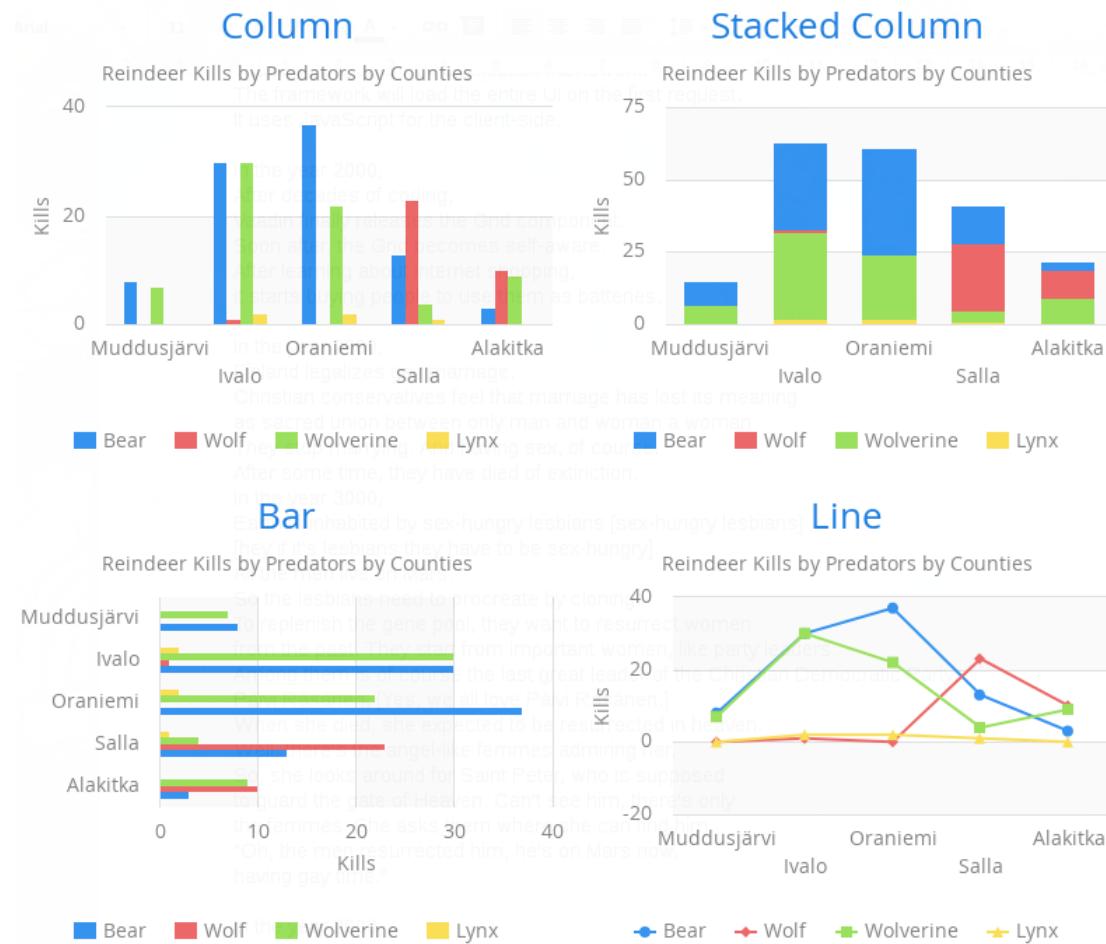
    // Create a data series for each numeric column in the table
    for (int predator = 0; predator < 4; predator++) {
        ListSeries series = new ListSeries();
        series.setName(predators[predator]);

        // The rows of the table
        for (int location = 0; location < kills.length; location++)
            series.addData(kills[location][predator]);
        conf.addSeries(series);
    }
}

```

The result for both regular and stacked column chart is shown in Figure 18.3, “Multiple Series in a Chart”. Stacking is enabled with `setStacking()` in **PlotOptionsColumn**.

**Figure 18.3. Multiple Series in a Chart**



### 18.3.2. Mixed Type Charts

Each data series has a **PlotOptions** object, just like the entire chart has, which allows using different settings for each series. This includes the chart type, so you can mix series with different chart types in the same chart.

The chart type of a series is determined by the type of the plot options. For example, to get a line chart, you need to use **PlotOptionsLine**.

```
// A data series as column graph
DataSeries series1 = new DataSeries();
PlotOptionsColumn options1 = new PlotOptionsColumn();
options1.setFillColor(SolidColor.BLUE);
series1.setPlotOptions(options1);
series1.setData(4900, 12100, 12800,
               6800, 143000, 125000,
               51100, 49500);
conf.addSeries(series1);

// A data series as line graph
ListSeries series2 = new ListSeries("Diameter");
PlotOptionsLine options2 = new PlotOptionsLine();
options2.setLineColor(SolidColor.RED);
series2.setPlotOptions(options2);
series2.setData(4900, 12100, 12800,
               6800, 143000, 125000,
               51100, 49500);
conf.addSeries(series2);
```

### 18.3.3. Chart Themes

The visual style and essentially any other chart configuration can be defined in a *theme*. All charts shown in a UI may have only one theme, which can be set with `setTheme()` in the **ChartOptions**.

In Vaadin 7, the **ChartOptions** is a **UI** extension that is created and referenced by calling the `get()` as follows:

```
// Set Charts theme for the current UI
ChartOptions.get().setTheme(new SkiesTheme());
```

In Vaadin 6, it is an invisible component that you need to create and add to the window. There may be only one such component in the window and it must be before any **Chart** component.

```
ChartOptions options = new ChartOptions();
options.setTheme(new SkiesTheme());
content.addComponent(options);
```

The **VaadinTheme** is the default chart theme in Vaadin Charts. Other available themes are **GrayTheme**, **GridTheme**, and **SkiesTheme**. The default theme in Highcharts can be set with the **HighChartsDefaultTheme**.

A theme is a Vaadin Charts configuration that is used as a template for the configuration when rendering the chart.

## 18.4. Chart Types

Vaadin Charts comes with over a dozen different chart types. You normally specify the chart type in the constructor of the **Chart** object. The available chart types are defined in the **ChartType** enum. You can later read or set the chart type with the `chartType` property of the chart model, which you can get with `getConfiguration().getChart()`.

Each chart type has its specific plot options and support its specific collection of chart features. They also have specific requirements for the data series.

The basic chart types and their variants are covered in the following subsections.

### 18.4.1. Line and Spline Charts

Line charts connect the series of data points with lines. In the basic line charts the lines are straight, while in spline charts the lines are smooth polynomial interpolations between the data points.

**Table 18.1. Line Chart Subtypes**

ChartType	Plot Options Class
<code>LINE</code>	<code>PlotOptionsLine</code>
<code>SPLINE</code>	<code>PlotOptionsSpline</code>

#### Plot Options

The `color` property in the line plot options defines the line color, `lineWidth` the line width, and `dashStyle` the dash pattern for the lines.

See Section 18.4.6, “Scatter Charts” for plot options regarding markers and other data point properties. The markers can also be configured for each data point.

### 18.4.2. Area Charts

Area charts are like line charts, except that the area between the line and the Y axis is painted with a transparent color. In addition to the base type, chart type combinations for spline interpolation and ranges are supported.

**Table 18.2. Area Chart Subtypes**

ChartType	Plot Options Class
<code>AREA</code>	<code>PlotOptionsArea</code>
<code>AREASPLINE</code>	<code>PlotOptionsAreaSpline</code>
<code>AREARANGE</code>	<code>PlotOptionsAreaRange</code>
<code>AREASPLINERANGE</code>	<code>PlotOptionsAreaSplineRange</code>

In area range charts, the area between a lower and upper value is painted with a transparent color. The data series must specify the minimum and maximum values for the Y coordinates, defined either with **RangeSeries**, as described in Section 18.6.3, “Range Series”, or with **Data-Series**, described in Section 18.6.2, “Generic Data Series”.

## Plot Options

Area charts support *stacking*, so that multiple series are piled on top of each other. You enable stacking from the plot options with `setStacking()`. The `Stacking.NORMAL` stacking mode does a normal summative stacking, while the `Stacking.PERCENT` handles them as proportions.

The fill color for the area is defined with the `fillColor` property and its transparency with `fillOpacity` (the opposite of transparency) with a value between 0.0 and 1.0.

The `color` property in the line plot options defines the line color, `lineWidth` the line width, and `dashStyle` the dash pattern for the lines.

See Section 18.4.6, “Scatter Charts” for plot options regarding markers and other data point properties. The markers can also be configured for each data point.

### 18.4.3. Column and Bar Charts

Column and bar charts illustrate values as vertical or horizontal bars, respectively. The two chart types are essentially equivalent, just as if the orientation of the axes was inverted.

Multiple data series, that is, two-dimensional data, are shown with thinner bars or columns grouped by their category, as described in Section 18.3.1, “Displaying Multiple Series”. Enabling stacking with `setStacking()` in plot options stacks the columns or bars of different series on top of each other.

You can also have `COLUMNRANGE` charts that illustrate a range between a lower and an upper value, as described in Section 18.4.10, “Area and Column Range Charts”. They require the use of `RangeSeries` for defining the lower and upper values.

**Table 18.3. Column and Bar Chart Subtypes**

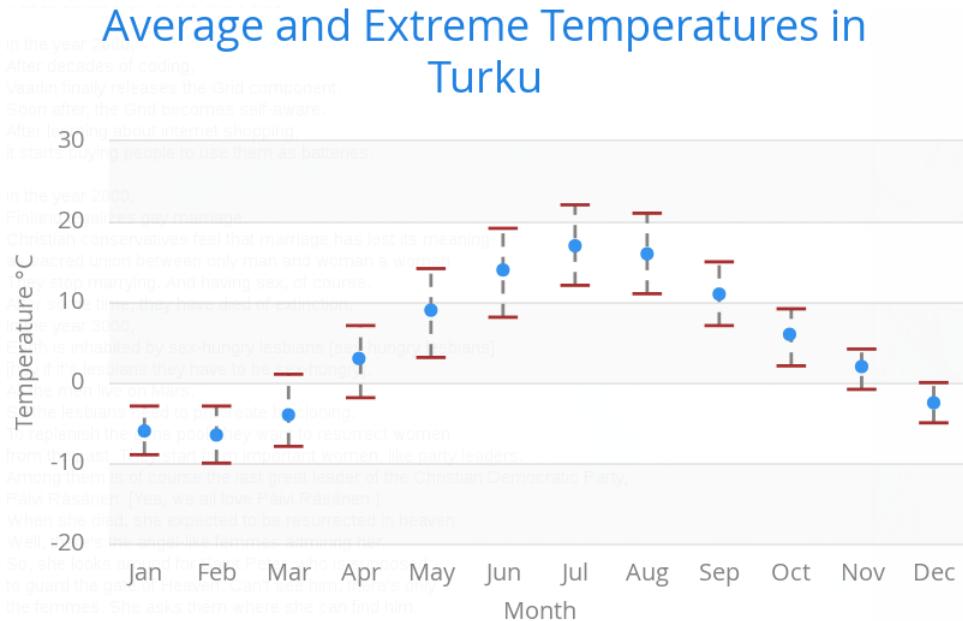
ChartType	Plot Options Class
<code>COLUMN</code>	<code>PlotOptionsColumn</code>
<code>COLUMNRANGE</code>	<code>PlotOptionsColumnRange</code>
<code>BAR</code>	<code>PlotOptionsBar</code>

See the API documentation for details regarding the plot options.

### 18.4.4. Error Bars

An error bars visualize errors, or high and low values, in statistical data. They typically represent high and low values in data or a multitude of standard deviation, a percentile, or a quantile. The high and low values are represented as horizontal lines, or "whiskers", connected by a vertical stem.

While error bars technically are a chart type (`ChartType.ERRORBAR`), you normally use them together with some primary chart type, such as a scatter or column chart.

**Figure 18.4. Error Bars in a Scatter Chart**

To display the error bars for data points, you need to have a separate data series for the low and high values. The data series needs to use the **PlotOptionsErrorBar** plot options type.

```
// Create a chart of some primary type
Chart chart = new Chart(ChartType.SCATTER);
chart.setWidth("600px");
chart.setHeight("400px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Average Temperatures in Turku");
conf.getLegend().setEnabled(false);

// The primary data series
ListSeries averages = new ListSeries(
    -6, -6.5, -4, 3, 9, 14, 17, 16, 11, 6, 2, -2.5);

// Error bar data series with low and high values
DataSeries errors = new DataSeries();
errors.add(new DataSeriesItem(0, -9, -3));
errors.add(new DataSeriesItem(1, -10, -3));
errors.add(new DataSeriesItem(2, -8, 1));
...

// Configure the stem and whiskers in error bars
PlotOptionsErrorBar barOptions = new PlotOptionsErrorBar();
barOptions.setStemColor(SolidColor.GREY);
barOptions.setStemWidth(2);
barOptions.setStemDashStyle(DashStyle.DASH);
barOptions.setWhiskerColor(SolidColor.BROWN);
barOptions.setWhiskerLength(80); // 80% of category width
barOptions.setWhiskerWidth(2); // Pixels
errors.setPlotOptions(barOptions);

// The errors should be drawn lower
```

```
conf.addSeries(errors);
conf.addSeries(averages);
```

Note that you should add the error bar series first, to have it rendered lower in the chart.

## Plot Options

Plot options for error bar charts have type **PlotOptionsErrorBar**. It has the following chart-specific plot option properties:

*whiskerColor, whiskerWidth, and whiskerLength*

The color, width (vertical thickness), and length of the horizontal "whiskers" that indicate high and low values.

*stemColor, stemWidth, and stemDashStyle*

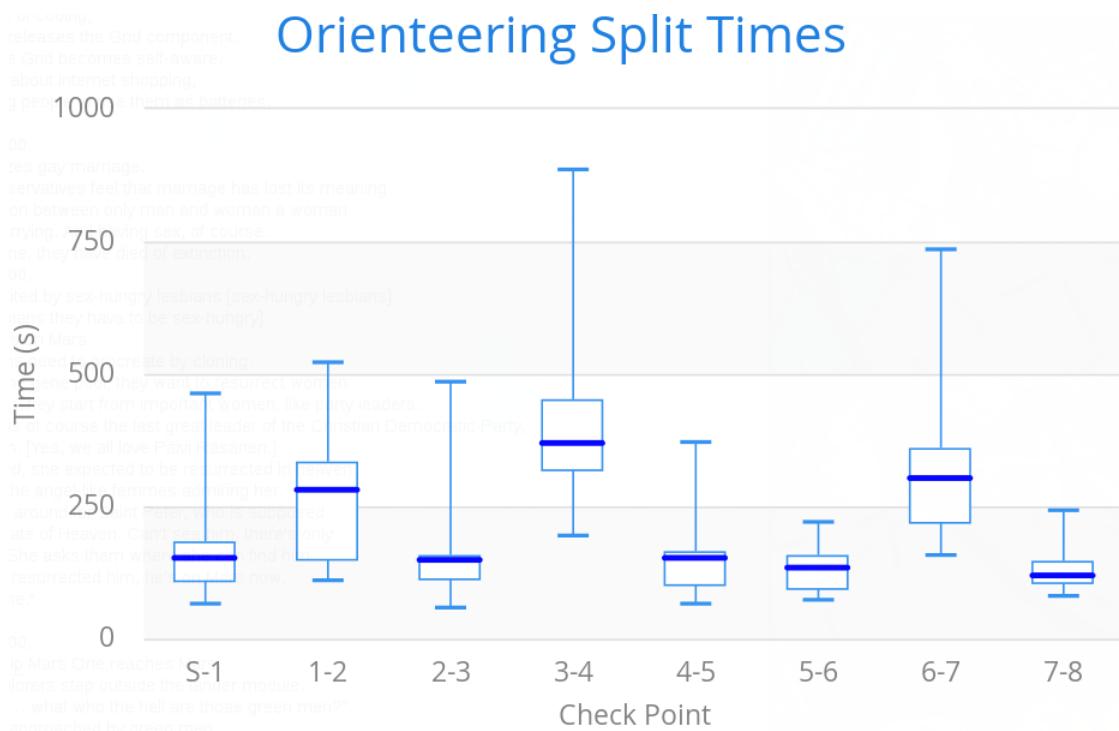
The color, width (thickness), and line style of the vertical "stems" that connect the whiskers. In box plot charts, which also have stems, they extend from the quartile box.

### 18.4.5. Box Plot Charts

Box plot charts display the distribution of statistical variables. A data point has a median, represented with a horizontal line, upper and lower quartiles, represented by a box, and a low and high value, represented with T-shaped "whiskers". The exact semantics of the box symbols are up to you.

Box plot chart is closely related to the error bar chart described in Section 18.4.4, “Error Bars”, sharing the box and whisker elements.

**Figure 18.5. Box Plot Chart**



The chart type for box plot charts is `ChartType.BOXPLOT`. You normally have just one data series, so it is meaningful to disable the legend.

```
Chart chart = new Chart(ChartType.BOXPLOT);
chart.setWidth("400px");
chart.setHeight("300px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Orienteering Split Times");
conf.getLegend().setEnabled(false);
```

## Plot Options

The plot options for box plots have type `PlotOptionsBoxPlot`, which extends the slightly more generic `PlotOptionsErrorBar`. They have the following plot option properties:

*medianColor, medianWidth*  
Color and width (vertical thickness) of the horizontal median indicator line.

For example:

```
// Set median line color and thickness
PlotOptionsBoxPlot plotOptions = new PlotOptionsBoxPlot();
plotOptions.setMedianColor(SolidColor.BLUE);
plotOptions.setMedianWidth(3);
conf.setPlotOptions(plotOptions);
```

## Data Model

As the data points in box plots have five different values instead of the usual one, they require using a special `BoxPlotItem`. You can give the different values with the setters, or all at once in the constructor.

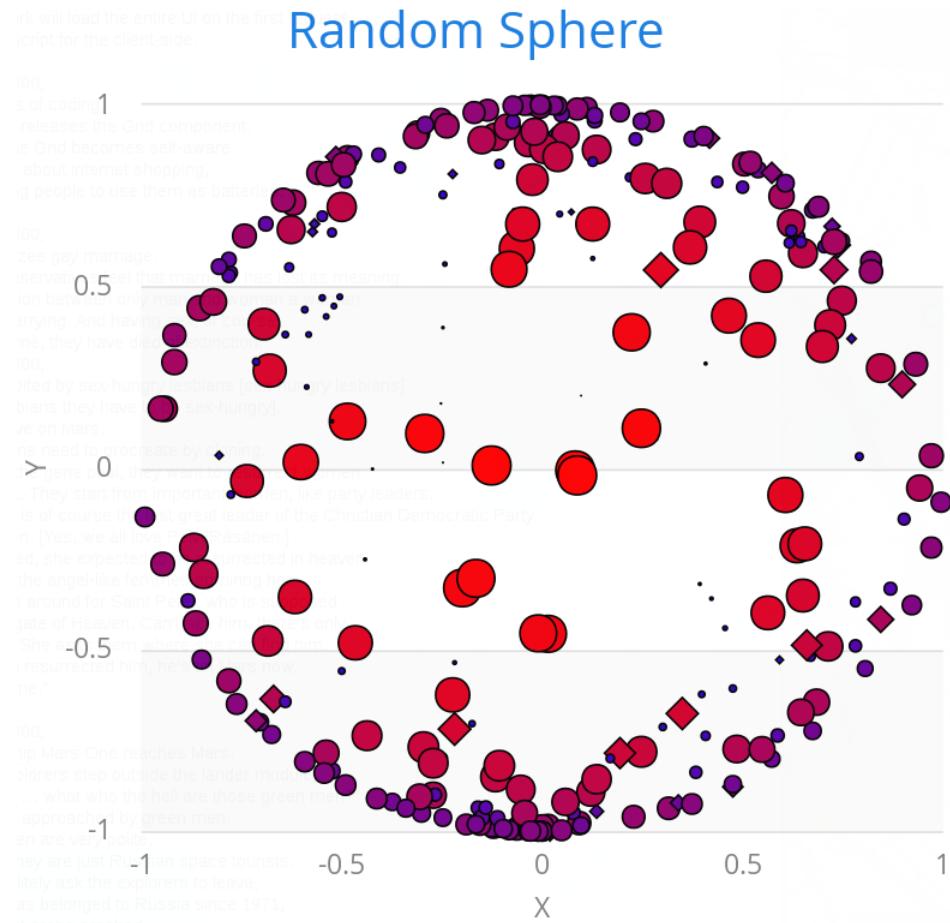
```
// Orienteering control point times for runners
double data[][] = orienteeringdata();

DataSeries series = new DataSeries();
for (double cpointtimes[]: data) {
    StatAnalysis analysis = new StatAnalysis(cpointtimes);
    series.add(new BoxPlotItem(analysis.low(),
                               analysis.firstQuartile(),
                               analysis.median(),
                               analysis.thirdQuartile(),
                               analysis.high()));
}
conf.setSeries(series);
```

If the "low" and "high" attributes represent an even smaller quantile, or a larger multiple of standard deviation, you can have outliers. You can plot them with a separate data series, with

### 18.4.6. Scatter Charts

Scatter charts display a set of unconnected data points. The name refers to freely given X and Y coordinates, so the `DataSeries` or `ContainerSeries` are usually the most meaningful data series types for scatter charts.

**Figure 18.6. Scatter Chart**

The chart type of a scatter chart is `ChartType.SCATTER`. Its options can be configured in a `PlotOptionsScatter` object, although it does not have any chart-type specific options.

```
Chart chart = new Chart(ChartType.SCATTER);
chart.setWidth("500px");
chart.setHeight("500px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Random Sphere");
conf.getLegend().setEnabled(false); // Disable legend

PlotOptionsScatter options = new PlotOptionsScatter();
// ... Give overall plot options here ...
conf.setPlotOptions(options);

DataSeries series = new DataSeries();
for (int i=0; i<300; i++) {
    double lng = Math.random() * 2 * Math.PI;
    double lat = Math.random() * Math.PI - Math.PI/2;
    double x   = Math.cos(lat) * Math.sin(lng);
    double y   = Math.sin(lat);
    double z   = Math.cos(lng) * Math.cos(lat);
```

```
    DataSeriesItem point = new DataSeriesItem(x,y);
    Marker marker = new Marker();
    // Make settings as described later
    point.setMarker(marker);
    series.add(point);
}
conf.addSeries(series);
```

The result was shown in Figure 18.6, “Scatter Chart”.

## Data Point Markers

Scatter charts and other charts that display data points, such as line and spline charts, visualize the points with *markers*. The markers can be configured with the **Marker** property objects available from the plot options of the relevant chart types, as well as at the level of each data point, in the **DataSeriesItem**. You need to create the marker and apply it with the `setMarker()` method in the plot options or the data series item.

For example, to set the marker for an individual data point:

```
    DataSeriesItem point = new DataSeriesItem(x,y);
    Marker marker = new Marker();
    // ... Make any settings ...
    point.setMarker(marker);
    series.add(point);
```

## Marker Shape Properties

A marker has a *lineColor* and a *fillColor*, which are set using a **Color** object. Both solid colors and gradients are supported. You can use a **SolidColor** to specify a solid fill color by RGB values or choose from a selection of predefined colors in the class.

```
// Set line width and color
marker.setLineWidth(1); // Normally zero width
marker.setLineColor(SolidColor.BLACK);

// Set RGB fill color
int level = (int) Math.round((1-z)*127);
marker.setFillColor(
    new SolidColor(255-level, 0, level));
point.setMarker(marker);
series.add(point);
```

You can also use a color gradient with **GradientColor**. Both linear and radial gradients are supported, with multiple color stops.

Marker size is determined by the *radius* parameter, which is given in pixels. The actual visual radius includes also the line width.

```
marker.setRadius((z+1)*5);
```

## Marker Symbols

Markers are visualized either with a shape or an image symbol. You can choose the shape from a number of built-in shapes defined in the **MarkerSymbolEnum** enum (*CIRCLE*, *SQUARE*, *DIAMOND*, *TRIANGLE*, or *TRIANGLE\_DOWN*). These shapes are drawn with a line and fill, which you can set as described above.

```
marker.setSymbol(MarkerSymbolEnum.DIAMOND);
```

You can also use any image accessible by a URL by using a **MarkerSymbolUrl** symbol. If the image is deployed with your application, such as in a theme folder, you can determine its URL as follows:

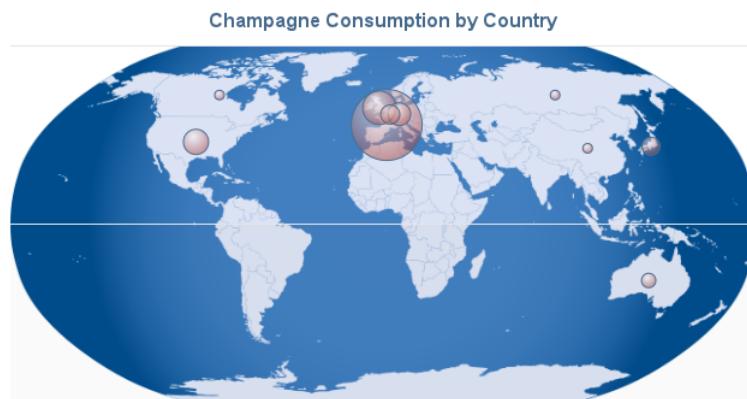
```
String url = VaadinServlet.getCurrent().getServletContext()
    .getContextPath() + "/VAADIN/themes/mytheme/img/smiley.png";
marker.setSymbol(new MarkerSymbolUrl(url));
```

The line, radius, and color properties are not applicable to image symbols.

### 18.4.7. Bubble Charts

Bubble charts are a special type of scatter charts for representing three-dimensional data points with different point sizes. We demonstrated the same possibility with scatter charts in Section 18.4.6, “Scatter Charts”, but the bubble charts make it easier to define the size of a point by its third (Z) dimension, instead of the radius property. The bubble size is scaled automatically, just like for other dimensions. The default point style is also more bubbly.

**Figure 18.7. Bubble Chart**



The chart type of a bubble chart is `ChartType.BUBBLE`. Its options can be configured in a **PlotOptionsBubble** object, which has a single chart-specific property, `displayNegative`, which controls whether bubbles with negative values are displayed at all. More typically, you want to configure the bubble `marker`. The bubble tooltip is configured in the basic configuration. The Z coordinate value is available in the formatter JavaScript with `this.point.z` reference.

The bubble radius is scaled linearly between a minimum and maximum radius. If you would rather scale by the area of the bubble, you can approximate that by taking square root of the Z values.

In the following example, we overlay a bubble chart over a world map background. We customize the bubbles to be more round with spherical color gradient. Note that square root is taken of the Z coordinate to

```
// Create a bubble chart
Chart chart = new Chart(ChartType.BUBBLE);
chart.setWidth("640px"); chart.setHeight("350px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Champagne Consumption by Country");
```

```
conf.getLegend().setEnabled(false); // Disable legend
conf.getTooltip().setFormatter("this.point.name + ': ' + " +
    "Math.round(100*(this.point.z * this.point.z))/100.0 + " +
    "' M bottles'");

// World map as background
String url = VaadinServlet.getCurrent().getServletContext()
    .getContextPath() + "/VAADIN/themes/mytheme/img/map.png";
conf.getChart().setPlotBackgroundImage(url);

// Show more bubbly bubbles with spherical color gradient
PlotOptionsBubble plotOptions = new PlotOptionsBubble();
Marker marker = new Marker();
GradientColor color = GradientColor.createRadial(0.4, 0.3, 0.7);
color.addColorStop(0.0, new SolidColor(255, 255, 255, 0.5));
color.addColorStop(1.0, new SolidColor(170, 70, 67, 0.5));
marker.setFillColor(color);
plotOptions.setMarker(marker);
conf.setPlotOptions(plotOptions);

// Source: CIVC - Les expeditions de vins de Champagne en 2011
DataSeries series = new DataSeries("Countries");
Object data[][] = {
    {"France",           181.6},
    {"United Kingdom",   34.53},
    {"United States",    19.37},
    ...
};
for (Object[] country: data) {
    String name = (String) country[0];
    double amount = (Double) country[1];
    Coordinate pos = getCountryCoordinates(name);

    DataSeriesItem3d item = new DataSeriesItem3d();
    item.setX(pos.longitude * Math.cos(pos.latitude/2.0 *
        (Math.PI/160)));
    item.setY(pos.latitude * 1.2);
    item.setZ(Math.sqrt(amount));
    item.setName(name);
    series.add(item);
}
conf.addSeries(series);

// Set the category labels on the axis correspondingly
XAxis xaxis = new XAxis();
xaxis.setExtremes(-180, 180);
...
conf.addxAxis(xaxis);

// Set the Y axis title
YAxis yaxis = new YAxis();
yaxis.setExtremes(-90, 90);
...
conf.addyAxis(yaxis);
```

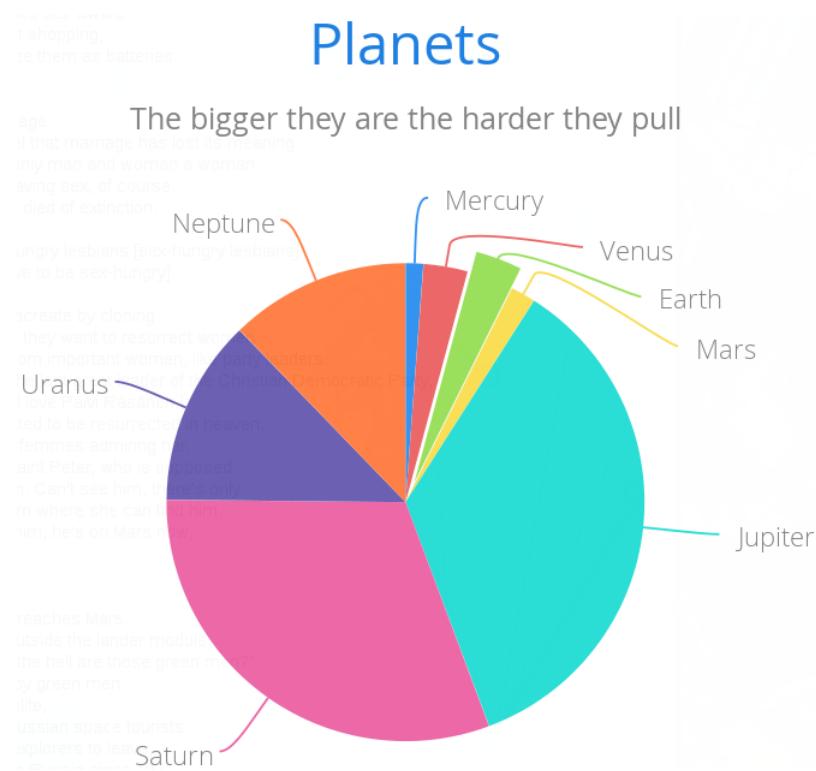
## 18.4.8. Pie Charts

A pie chart illustrates data values as sectors of size proportionate to the sum of all values. The pie chart is enabled with `ChartType.PIE` and you can make type-specific settings in the `PlotOptionsPie` object as described later.

```
Chart chart = new Chart(ChartType.PIE);
Configuration conf = chart.getConfiguration();
...
```

A ready pie chart is shown in Figure 18.8, "Pie Chart".

**Figure 18.8. Pie Chart**



## Plot Options

The chart-specific options of a pie chart are configured with a `PlotOptionsPie`.

```
PlotOptionsPie options = new PlotOptionsPie();
options.setInnerSize(0); // Non-0 results in a donut
options.setSize("75%"); // Default
options.setCenter("50%", "50%"); // Default
conf.setPlotOptions(options);
```

### innerSize

A pie with inner size greater than zero is a "donut". The inner size can be expressed either as number of pixels or as a relative percentage of the chart area with a string (such as "60%") See the section later on donuts.

**size**

The size of the pie can be expressed either as number of pixels or as a relative percentage of the chart area with a string (such as "80%"). The default size is 75%, to leave space for the labels.

**center**

The X and Y coordinates of the center of the pie can be expressed either as numbers of pixels or as a relative percentage of the chart sizes with a string. The default is "50%", "50%".

## Data Model

The labels for the pie sectors are determined from the labels of the data points. The **DataSetSeries** or **ContainerSeries**, which allow labeling the data points, should be used for pie charts.

```
DataSetSeries series = new DataSetSeries();
series.add(new DataSetSeriesItem("Mercury", 4900));
series.add(new DataSetSeriesItem("Venus", 12100));
...
conf.addSeries(series);
```

If a data point, as defined as a **DataSetSeriesItem** in a **DataSetSeries**, has the *sliced* property enabled, it is shown as slightly cut away from the pie.

```
// Slice one sector out
DataSetSeriesItem earth = new DataSetSeriesItem("Earth", 12800);
earth.setSliced(true);
series.add(earth);
```

## Donut Charts

Setting the *innerSize* of the plot options of a pie chart to a larger than zero value results in an empty hole at the center of the pie.

```
PlotOptionsPie options = new PlotOptionsPie();
options.setInnerSize("60%");
conf.setPlotOptions(options);
```

As you can set the plot options also for each data series, you can put two pie charts on top of each other, with a smaller one fitted in the "hole" of the donut. This way, you can make pie charts with more details on the outer rim, as done in the example below:

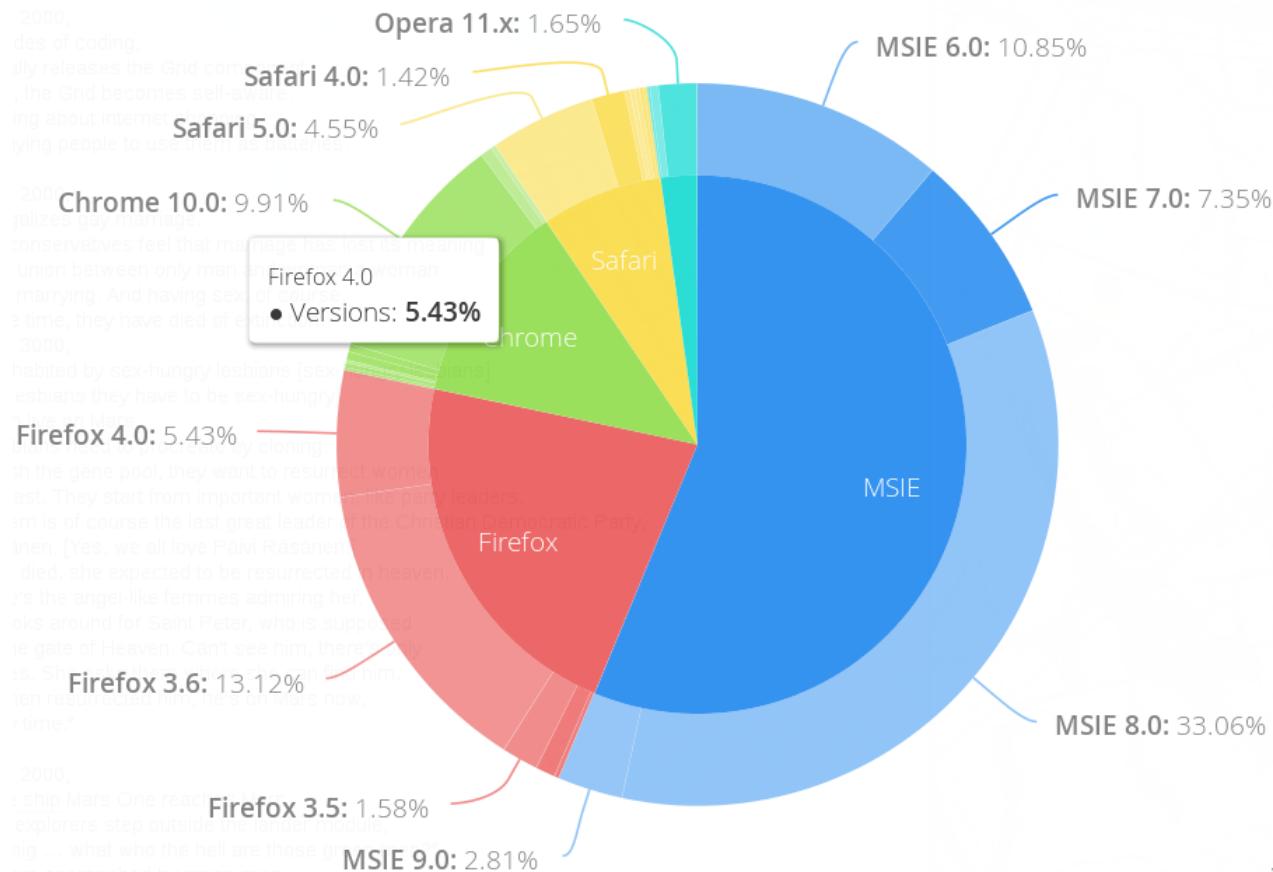
```
// The inner pie
DataSetSeries innerSeries = new DataSetSeries();
innerSeries.setName("Browsers");
PlotOptionsPie innerOptions = new PlotOptionsPie();
innerOptions.setSize("60%");
innerSeries.setPlotOptions(innerOptions);
...

DataSetSeries outerSeries = new DataSetSeries();
outerSeries.setName("Versions");
PlotOptionsPie outerOptions = new PlotOptionsPie();
outerOptions.setInnerSize("60%");
outerSeries.setPlotOptions(outerOptions);
...
```

The result is illustrated in Figure 18.9, "Overlaid Pie and Donut Chart".

**Figure 18.9. Overlaid Pie and Donut Chart**

## Browser market share, April, 2011



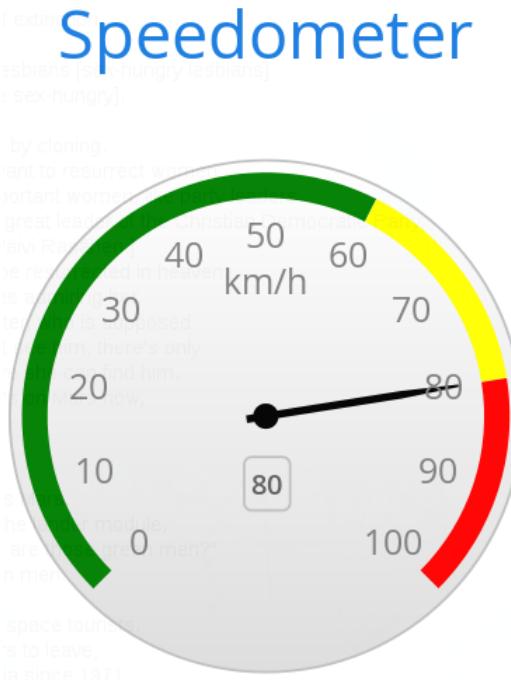
### 18.4.9. Gauges

A gauge is an one-dimensional chart with a circular Y-axis, where a rotating pointer points to a value on the axis. A gauge can, in fact, have multiple Y-axes to display multiple scales.

Let us consider the following gauge:

```
Chart chart = new Chart(ChartType.GAUGE);
chart.setWidth("400px");
chart.setHeight("400px");
```

After the settings done in the subsequent sections, it will show as in Figure 18.10, "A Gauge".

**Figure 18.10. A Gauge**

## Gauge Configuration

The start and end angles of the gauge can be configured in the **Pane** object of the chart configuration. The angles can be given as -360 to 360 degrees, with 0 at the top of the circle.

```
Configuration conf = chart.getConfiguration();
conf.setTitle("Speedometer");
conf.getPane().setStartAngle(-135);
conf.getPane().setEndAngle(135);
```

## Axis Configuration

A gauge has only an Y-axis. You need to provide both a minimum and maximum value for it.

```
YAxis yaxis = new YAxis();
yaxis.setTitle("km/h");

// The limits are mandatory
yaxis.setMin(0);
yaxis.setMax(100);

// Other configuration
yaxis.getLabels().setStep(1);
yaxis.setTickInterval(10);
yaxis.setPlotBands(new PlotBand[]{
    new PlotBand(0, 60, SolidColor.GREEN),
    new PlotBand(60, 80, SolidColor.YELLOW),
    new PlotBand(80, 100, SolidColor.RED)});

conf.addYAxis(yaxis);
```

You can do all kinds of other configuration to the axis - please see the API documentation for all the available parameters.

## Setting and Updating Gauge Data

A gauge only displays a single value, which you can define as a data series of length one, such as follows:

```
ListSeries series = new ListSeries("Speed", 80);  
conf.addSeries(series);
```

Gauges are especially meaningful for displaying changing values. You can use the `updatePoint()` method in the data series to update the single value.

```
final TextField tf = new TextField("Enter a new value");  
layout.addComponent(tf);  
  
Button update = new Button("Update", new ClickListener() {  
    @Override  
    public void buttonClick(ClickEvent event) {  
        Integer newValue = new Integer((String)tf.getValue());  
        series.updatePoint(0, newValue);  
    }  
});  
layout.addComponent(update);
```

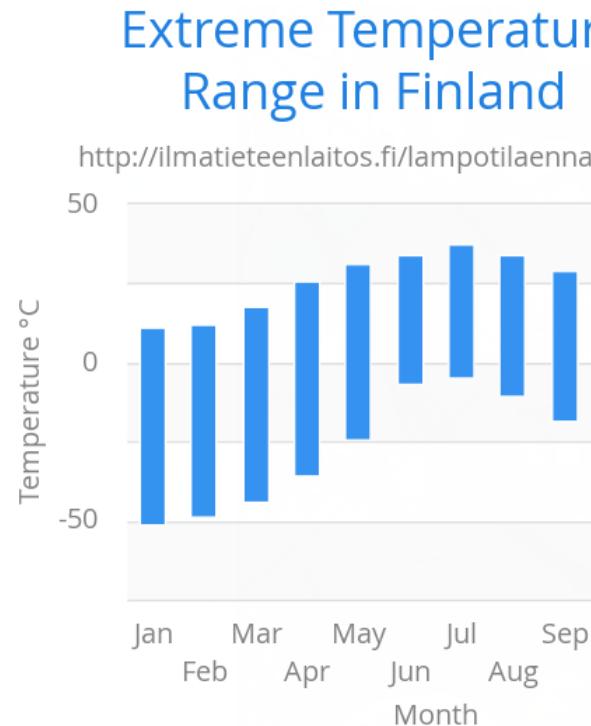
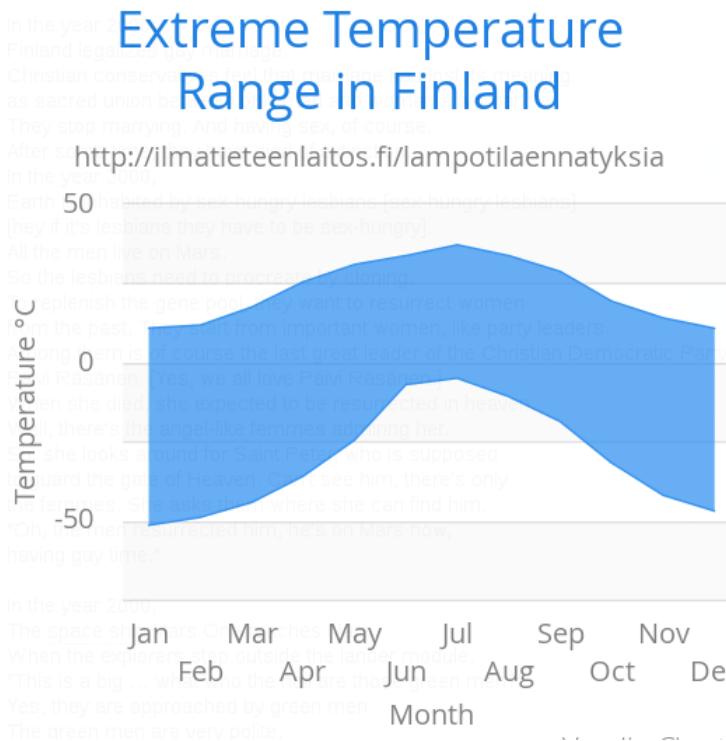
### 18.4.10. Area and Column Range Charts

Ranged charts display an area or column between a minimum and maximum value, instead of a singular data point. They require the use of **RangeSeries**, as described in Section 18.6.3, “Range Series”. An area range is created with *AREARANGE* chart type, and a column range with *COLUMNRANGE* chart type.

Consider the following example:

```
Chart chart = new Chart(ChartType.AREARANGE);  
chart.setWidth("400px");  
chart.setHeight("300px");  
  
// Modify the default configuration a bit  
Configuration conf = chart.getConfiguration();  
conf.setTitle("Extreme Temperature Range in Finland");  
...  
  
// Create the range series  
// Source: http://ilmatieteenlaitos.fi/lampotilaennatyksia  
RangeSeries series = new RangeSeries("Temperature Extremes",  
    new Double[]{-51.5,10.9},  
    new Double[]{-49.0,11.8},  
    ...  
    new Double[]{-47.0,10.8});//  
conf.addSeries(series);
```

The resulting chart, as well as the same chart with a column range, is shown in Figure 18.11, “Area and Column Range Chart”.

**Figure 18.11. Area and Column Range Chart**

### 18.4.11. Polar, Wind Rose, and Spiderweb Charts

Most chart types having two axes can be displayed in *polar* coordinates, where the X axis is curved on a circle and Y axis from the center of the circle to its rim. Polar chart is not a chart type in itself, but can be enabled for most chart types with `setPolar(true)` in the chart model parameters. Therefore all chart type specific features are usable with polar charts.

Vaadin Charts allows many sorts of typical polar chart types, such as *wind rose*, a polar column graph, or *spiderweb*, a polar chart with categorical data and a more polygonal visual style.

```
// Create a chart of some type
Chart chart = new Chart(ChartType.LINE);

// Enable the polar projection
Configuration conf = chart.getConfiguration();
conf.getChart().setPolar(true);
```

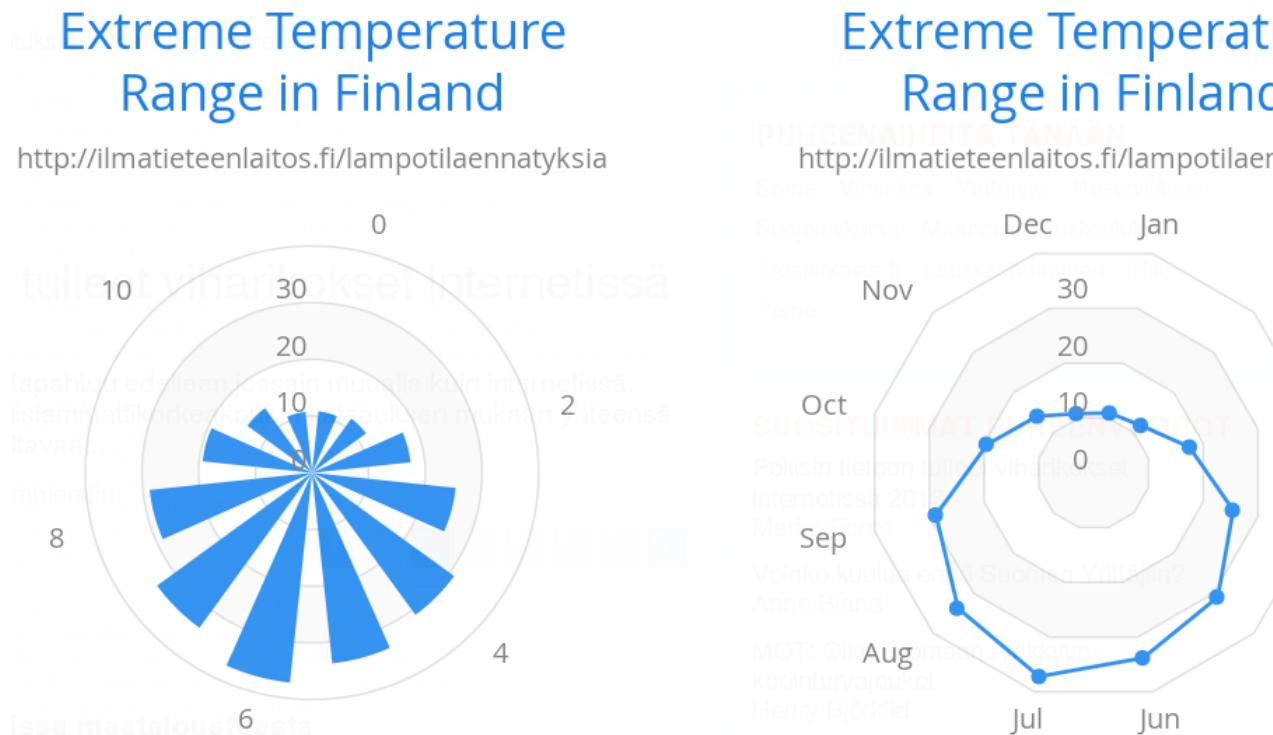
You need to define the sector of the polar projection with a **Pane** object in the configuration. The sector is defined as degrees from the north direction. You also need to define the value range for the X axis with `setMin()` and `setMax()`.

```
// Define the sector of the polar projection
Pane pane = new Pane(0, 360); // Full circle
conf.addPane(pane);

// Define the X axis and set its value range
XAxis axis = new XAxis();
axis.setMin(0);
axis.setMax(360);
```

The polar and spiderweb charts are illustrated in Figure 18.12, “Wind Rose and Spiderweb Charts”.

**Figure 18.12. Wind Rose and Spiderweb Charts**



## Spiderweb Charts

A *spiderweb* chart is a commonly used visual style of a polar chart with a polygonal shape rather than a circle. The data and the X axis should be categorical to make the polygonal interpolation meaningful. The sector is assumed to be full circle, so no angles for the pane need to be specified. Note the style settings done in the axis in the example below:

```
Chart chart = new Chart(ChartType.LINE);
...
// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.getChart().setPolar(true);
...
// Create the range series
// Source: http://ilmatieteenlaitos.fi/lampotilaennatyksia
ListSeries series = new ListSeries("Temperature Extremes",
    10.9, 11.8, 17.5, 25.5, 31.0, 33.8,
    37.2, 33.8, 28.8, 19.4, 14.1, 10.8);
conf.addSeries(series);

// Set the category labels on the X axis correspondingly
XAxis xaxis = new XAxis();
xaxis.setCategories("Jan", "Feb", "Mar",
    "Apr", "May", "Jun", "Jul", "Aug", "Sep",
    "Oct", "Nov", "Dec");
```

```

xaxis.setTickmarkPlacement(TickmarkPlacement.ON);
xaxis.setLineWidth(0);
conf.addxAxis(xaxis);

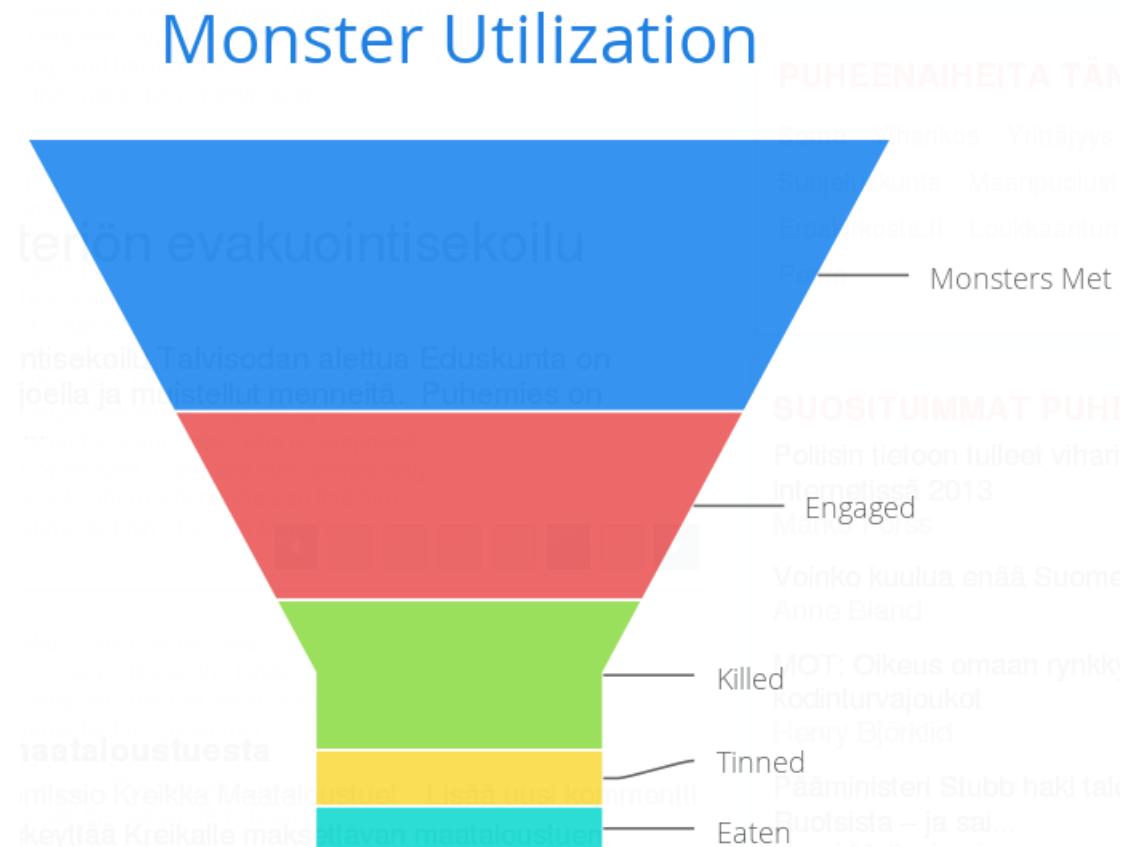
// Configure the Y axis
YAxis yaxis = new YAxis();
yaxis.setGridLineInterpolation("polygon"); // Webby look
yaxis.setMin(0);
yaxis.setTickInterval(10);
yaxis.getLabels().setStep(1);
conf.addyAxis(yaxis);

```

## 18.4.12. Funnel Charts

Funnel charts are typically used to visualize stages in a sales processes, and for other purposes to visualize subsets of diminishing size. A funnel chart has layers much like a stacked column, but has a funnel shape. The top of the funnel has width of the drawing area of the chart, and diminishes in size down to a neck, and then continues as a column to the bottom.

**Figure 18.13. Funnel Charts**



Funnel charts have chart type `FUNNEL`.

The labels of the funnel blocks are by default placed on the right side of the blocks, together with a connector. You can configure their style in the plot options, as is done in the following example.

```

Chart chart = new Chart(ChartType.FUNNEL);
chart.setWidth("500px");

```

```
chart.setHeight("350px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Monster Utilization");
conf.getLegend().setEnabled(false);

// Give more room for the labels
conf.getChart().setSpacingRight(120);

// Configure the funnel neck shape
PlotOptionsFunnel options = new PlotOptionsFunnel();
options.setNeckHeightPercentage(20);
options.setNeckWidthPercentage(20);

// Style the data labels
Labels dataLabels = new Labels();
dataLabels.setFormat("<b>{point.name}</b> ({point.y:.0f})");
dataLabels.setSoftConnector(false);
dataLabels.setColor(SolidColor.BLACK);
options.setDataLabels(dataLabels);

conf.setPlotOptions(options);

// Create the range series
DataSeries series = new DataSeries();
series.add(new DataSeriesItem("Monsters Met", 340));
series.add(new DataSeriesItem("Engaged", 235));
series.add(new DataSeriesItem("Killed", 187));
series.add(new DataSeriesItem("Tinned", 70));
series.add(new DataSeriesItem("Eaten", 55));
conf.addSeries(series);
```

## Plot Options

The chart-specific options of a funnel chart are configured with a **PlotOptionsFunnel**. It extends the generic **AbstractLinePlotOptions** and has the following chart type specific properties:

*neckHeight* or *neckHeightPercentage*

Height of the neck part of the funnel either as pixels or as percentage of the entire funnel height.

*neckWidth* or *neckWidthPercentage*

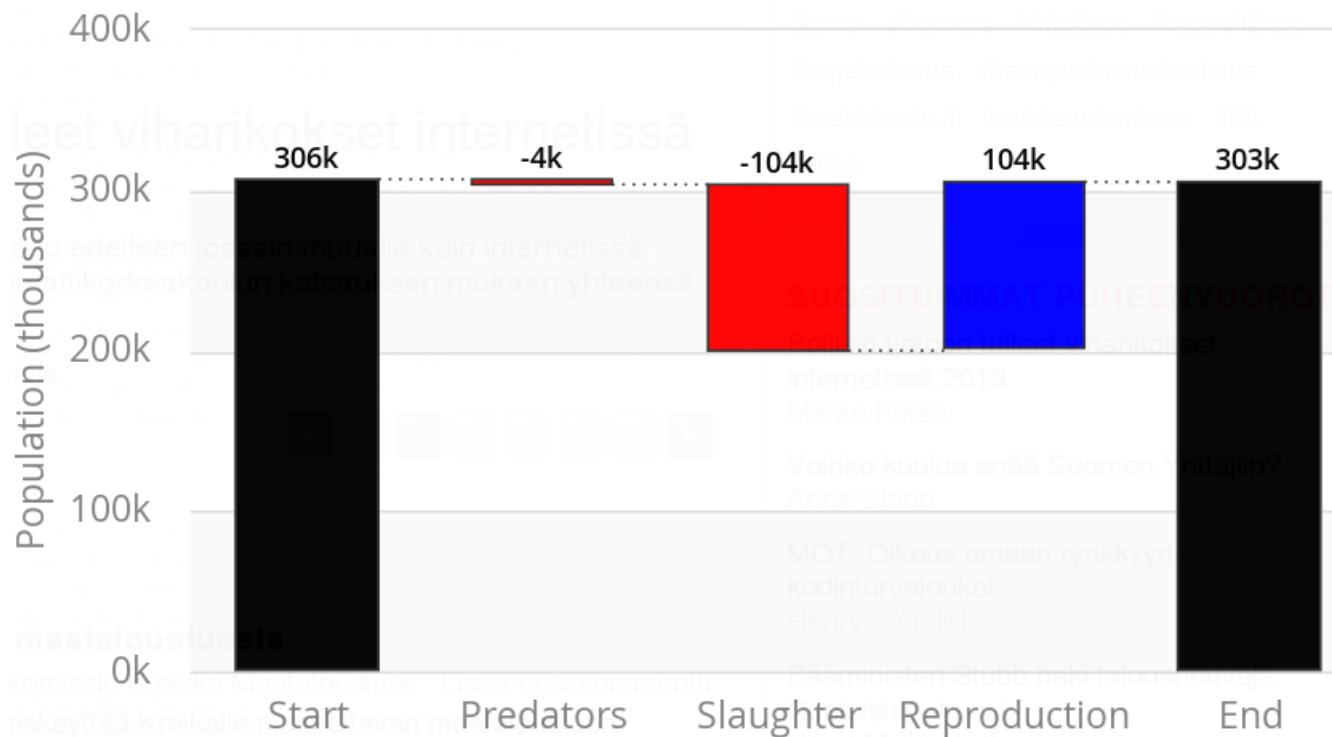
Width of the neck part of the funnel either as pixels or as percentage of the top of the funnel.

### 18.4.13. Waterfall Charts

Waterfall charts are used for visualizing level changes from an initial level to a final level through a number of changes in the level. The changes are given as delta values, and you can have a number of intermediate totals, which are calculated automatically.

**Figure 18.14. Waterfall Charts**

## Changes in Reindeer Population in 2011



Waterfall charts have chart type WATERFALL. For example:

```
Chart chart = new Chart(ChartType.WATERFALL);
chart.setWidth("500px");
chart.setHeight("350px");

// Modify the default configuration a bit
Configuration conf = chart.getConfiguration();
conf.setTitle("Changes in Reindeer Population in 2011");
conf.getLegend().setEnabled(false);

// Configure X axis
XAxis xaxis = new XAxis();
xaxis.setCategories("Start", "Predators", "Slaughter",
    "Reproduction", "End");
conf.addXAxis(xaxis);

// Configure Y axis
YAxis yaxis = new YAxis();
yaxis.setTitle("Population (thousands)");
conf.addYAxis(yaxis);
...
```

The example continues in the following subsections.

## Plot Options

Waterfall charts have plot options type **PlotOptionsWaterfall**, which extends the more general options defined in **PlotOptionsColumn**. It has the following chart type specific properties:

### *upColor*

Color for the positive values. For negative values, the `negativeColor` defined in **PlotOptionsColumn** is used.

In the following, we define the colors, as well as the style and placement of the labels for the columns:

```
// Define the colors
final Color balanceColor = SolidColor.BLACK;
final Color positiveColor = SolidColor.BLUE;
final Color negativeColor = SolidColor.RED;

// Configure the colors
PlotOptionsWaterfall options = new PlotOptionsWaterfall();
options.setUpColor(positiveColor);
options.setNegativeColor(negativeColor);

// Configure the labels
Labels labels = new Labels(true);
labels.setVerticalAlign(VerticalAlign.TOP);
labels.setY(-20);
labels.setFormatter("Math.floor(this.y/1000) + 'k'");
Style style = new Style();
style.setColor(SolidColor.BLACK);
style.setFontWeight(FontWeight.BOLD);
labels.setStyle(style);
options.setDataLabels(labels);
options.setPointPadding(0);
conf.setPlotOptions(options);
```

## Data Series

The data series for waterfall charts consists of changes (deltas) starting from an initial value and one or more cumulative sums. There should be at least a final sum, and optionally intermediate sums. The sums are represented as **WaterFallSum** data items, and no value is needed for them as they are calculated automatically. For intermediate sums, you should set the *intermediate* property to `true`.

```
// The data
DataSeries series = new DataSeries();

// The beginning balance
DataSeriesItem start = new DataSeriesItem("Start", 306503);
start.setColor(balanceColor);
series.add(start);

// Deltas
series.add(new DataSeriesItem("Predators", -3330));
series.add(new DataSeriesItem("Slaughter", -103332));
series.add(new DataSeriesItem("Reproduction", +104052));

WaterFallSum end = new WaterFallSum("End");
end.setColor(balanceColor);
```

```
end.setIntermediate(false); // Not intermediate (default)
series.add(end);

conf.addSeries(series);
```

## 18.5. Chart Configuration

All the chart content configuration of charts is defined in a *chart model* in a **Configuration** object. You can access the model with the `getConfiguration()` method.

The configuration properties in the **Configuration** class are summarized in the following:

- `credits`: **Credits** (text, position, href, enabled)
- `labels`: **HTMLLabels** (html, style)
- `lang`: **Lang** (decimalPoint, thousandsSep, loading)
- `legend`: **Legend** (see Section 18.5.3, “Legend”)
- `pane`: **Pane**
- `plotoptions`: **PlotOptions** (see Section 18.5.1, “Plot Options”)
- `series`: **Series**
- `subTitle`: **SubTitle**
- `title`: **Title**
- `tooltip`: **Tooltip**
- `xAxis`: **XAxis** (see Section 18.5.2, “Axes”)
- `yAxis`: **YAxis** (see Section 18.5.2, “Axes”)

For data configuration, see Section 18.6, “Chart Data”.

### 18.5.1. Plot Options

The plot options can be set in the configuration of the entire chart or for each data series separately. Some of the plot options are chart type specific, defined in type-specific options classes, which all extend **AbstractPlotOptions**.

You need to create the plot options object and set them either for the entire chart or for a data series with `setPlotOptions()`.

For example, the following enables stacking in column charts:

```
PlotOptionsColumn plotOptions = new PlotOptionsColumn();
plotOptions.setStacking(Stacking.NORMAL);
conf.setPlotOptions(plotOptions);
```

See the API documentation of each chart type and its plot options class for more information about the chart-specific options, and the **AbstractPlotOptions** for the shared plot options.

## 18.5.2. Axes

Many chart types have two axes, X and Y, which are represented by **XAxis** and **YAxis** classes. The X axis is usually horizontal, representing the iteration over the data series, and Y vertical, representing the values in the data series. Some chart types invert the axes and they can be explicitly inverted with `getChart().setInverted()` in the chart configuration. An axis has a caption and tick marks at intervals indicating either numeric values or symbolic categories. Some chart types, such as gauge, have only Y-axis, which is circular in the gauge, and some such as a pie chart have none.

Axis objects are created and added to the configuration object with `addXAxis()` and `addYAxis()`.

```
XAxis xaxis = new XAxis();
xaxis.setTitle("Axis title");
conf.addXAxis(xaxis);
```

A chart can have more than one Y-axis, usually when different series displayed in a graph have different units or scales. The association of a data series with an axis is done in the data series object with `setYAxis()`.

For a complete reference of the many configuration parameters for the axes, please refer to the JavaDoc API documentation of Vaadin Charts.

## Categories

The X axis displays, in most chart types, tick marks and labels at some numeric interval by default. If the items in a data series have a symbolic meaning rather than numeric, you can associate *categories* with the data items. The category label is displayed between two axis tick marks and aligned with the data point. In certain charts, such as column chart, where the corresponding values in different data series are grouped under the same category. You can set the category labels with `setCategories()`, which takes the categories as (an ellipsis) parameter list, or as an iterable. The list should match the items in the data series.

```
XAxis xaxis = new XAxis();
xaxis.setCategories("Mercury", "Venus", "Earth",
                    "Mars", "Jupiter", "Saturn",
                    "Uranus", "Neptune");
```

## Labels

The axes display, in most chart types, tick marks and labels at some numeric interval by default. The format and style of labels in an axis is defined in a **Labels** object, which you can get with `getLabels()` from the axis.

For a complete reference of the many configuration parameters for the labels, please refer to the JavaDoc API documentation of Vaadin Charts.

## Axis Range

The axis range is normally set automatically to fit the data, but can also be set explicitly. The `extremes` property in the axis configuration defines the minimum and maximum values of the axis range. You can set them either individually with `setMin()` and `setMax()`, or together with `setExtremes()`. Changing the extremes programmatically requires redrawing the chart with `drawChart()`.

### 18.5.3. Legend

The legend is a box that describes the data series shown in the chart. It is enabled by default and is automatically populated with the names of the data series as defined in the series objects, and the corresponding color symbol of the series.

## 18.6. Chart Data

Chart data is stored in data series model, which contains visual representation information about the data points in addition to their values. There are a number of different types of series - **DataSeries**, **ListSeries**, **AreaListSeries**, and **RangeSeries**.

### 18.6.1. List Series

The **ListSeries** is essentially a helper type that makes the handling of simple sequential data easier than with **DataSeries**. The data points are assumed to be at a constant interval on the X axis, starting from the value specified with the `pointStart` property (default is 0) at intervals specified with the `pointInterval` property (default is 1.0). The two properties are defined in the **PlotOptions** for the series.

The Y axis values are given in a **List<Number>**, or with ellipsis or an array.

```
ListSeries series = new ListSeries(  
    "Total Reindeer Population",  
    181091, 201485, 188105, ...);  
series.getPlotOptions().setPointStart(1959);  
conf.addSeries(series);
```

You can also add them one by one with the `addData()` method, which is typical when converting from some other representation.

```
// Original representation  
int data[][][] = reindeerData();  
  
// Create a list series with X values starting from 1959  
ListSeries series = new ListSeries("Reindeer Population");  
series.getPlotOptions().setPointStart(1959);  
  
// Add the data points  
for (int row[]: data)  
    series.addData(data[1]);  
  
conf.addSeries(series);
```

If the chart has multiple Y axes, you can specify the axis for the series by its index number with `setyAxis()`.

### 18.6.2. Generic Data Series

The **DataSeries** can represent a sequence of data points at an interval as well as scatter data. Data points are represented with the **DataSeriesItem** class, which has `x` and `y` properties for representing the data value. Each item can be given a category name.

```
DataSeries series = new DataSeries();  
series.setName("Total Reindeer Population");  
series.add(new DataSeriesItem(1959, 181091));
```

```
series.add(new DataSeriesItem(1960, 201485));
series.add(new DataSeriesItem(1961, 188105));
series.add(new DataSeriesItem(1962, 177206));

// Modify the color of one point
series.get(1960, 201485)
    .getMarker().setFillColor(SolidColor.RED);
conf.addSeries(series);
```

Data points are associated with some visual representation parameters: marker style, selected state, legend index, and dial style (for gauges). Most of them can be configured at the level of individual data series items, the series, or in the overall plot options for the chart. The configuration options are described in Section 18.5, “Chart Configuration”. Some parameters, such as the sliced option for pie charts is only meaningful to configure at item level.

## Adding and Removing Data Items

New **DataSeriesItem** items are added to a series with the `add()` method. The basic method takes just the data item, but the other method takes also two boolean parameters. If the `updateChart` parameter is `false`, the chart is not updated immediately. This is useful if you are adding many points in the same request.

The `shift` parameter, when `true`, causes removal of the first data point in the series in an optimized manner, thereby allowing an animated chart that moves to left as new points are added. This is most meaningful with data with even intervals.

You can remove data points with the `remove()` method in the series. Removal is generally not animated, unless a data point is added in the same change, as is caused by the `shift` parameter for the `add()`.

## Updating Data Items

If you update the properties of a **DataSeriesItem** object, you need to call `update()` method for the series with the item as the parameter. Changing the coordinates of a data point in this way causes animation of the change.

## Range Data

Range charts expect the Y values to be specified as minimum-maximum value pairs. The **DataSeriesItem** provides `setLow()` and `setHigh()` methods to set the minimum and maximum values of a data point, as well as a number of constructors that accept the values.

```
RangeSeries series =
    new RangeSeries("Temperature Extremes");

// Give low-high values in constructor
series2.add(new DataSeriesItem(0, -51.5, 10.9));
series2.add(new DataSeriesItem(1, -49.0, 11.8));

// Set low-high values with setters
DataSeriesItem point2 = new DataSeriesItem();
point2.setX(2);
point2.setLow(-44.3);
point2.setHigh(17.5);
series2.add(point2);
```

The **RangeSeries** offers a slightly simplified way of adding ranged data points, as described in Section 18.6.3, “Range Series”.

### 18.6.3. Range Series

The **RangeSeries** is a helper class that extends **DataSeries** to allow specifying interval data a bit easier, with a list of minimum-maximum value ranges in the Y axis. You can use the series in range charts, as described in Section 18.4.10, “Area and Column Range Charts”.

For X axis, the coordinates are generated at fixed intervals starting from the value specified with the `pointStart` property (default is 0) at intervals specified with the `pointInterval` property (default is 1.0).

#### Setting the Data

The data in a **RangeSeries** is given as an array of minimum-maximum value pairs for the Y value axis. The pairs are also represented as arrays. You can pass the data using the ellipsis in the constructor or the `setData()`:

```
RangeSeries series =
    new RangeSeries("Temperature Ranges",
        new Double[]{ -51.5, 10.9 },
        new Double[]{ -49.0, 11.8 },
        ...
        new Double[]{ -47.0, 10.8 });
conf.addSeries(series);
```

Or, as always with variable arguments, you can also pass them in an array, in the following for the `setData()`:

```
series.setData(new Double[][] {
    new Double[]{ -51.5, 10.9 },
    new Double[]{ -49.0, 11.8 },
    ...
    new Double[]{ -47.0, 10.8 }});
```

### 18.6.4. Container Data Series

The **ContainerDataSeries** is an adapter for binding Vaadin Container data sources to charts. The container needs to have properties that define the name, X-value, and Y-value of a data point. The default property IDs of the three properties are “name”, “x”, and “y”, respectively. You can set the property IDs with `setNamePropertyId()`, `setYPropertyId()`, and `setXPropertyId()`, respectively. If the container has no `x` property, the data is assumed to be categorical.

In the following example, we have a **BeanItemContainer** with **Planet** items, which have a `name` and `diameter` property. We display the container data both in a Vaadin **Table** and a chart.

```
// The data
BeanItemContainer<Planet> container =
    new BeanItemContainer<Planet>(Planet.class);
container.addBean(new Planet("Mercury", 4900));
container.addBean(new Planet("Venus", 12100));
container.addBean(new Planet("Earth", 12800));
...
// Display it in a table
Table table = new Table("Planets", container);
```

```
table.setPageLength(container.size());
table.setVisibleColumns(new String[]{"name", "diameter"});
layout.addComponent(table);

// Display it in a chart
Chart chart = new Chart(ChartType.COLUMN);
... Configure it ...

// Wrap the container in a data series
ContainerDataSeries series =
    new ContainerDataSeries(container);

// Set up the name and Y properties
series.setNamePropertyId("name");
series.setYPropertyId("diameter");

conf.addSeries(series);
```

As the X axis holds categories rather than numeric values, we need to set up the category labels with an array of string. There are a few ways to do that, some more efficient than others, below is one way:

```
// Set the category labels on the axis correspondingly
XAxis xaxis = new XAxis();
String names[] = new String[container.size()];
List<Planet> planets = container.getItemIds();
for (int i=0; i<planets.size(); i++)
    names[i] = planets.get(i).getName();
xaxis.setCategories(names);
xaxis.setTitle("Planet");
conf.addxAxis(xaxis);
```

The result can be seen in Figure 18.15, “Table and Chart Bound to a Container”.

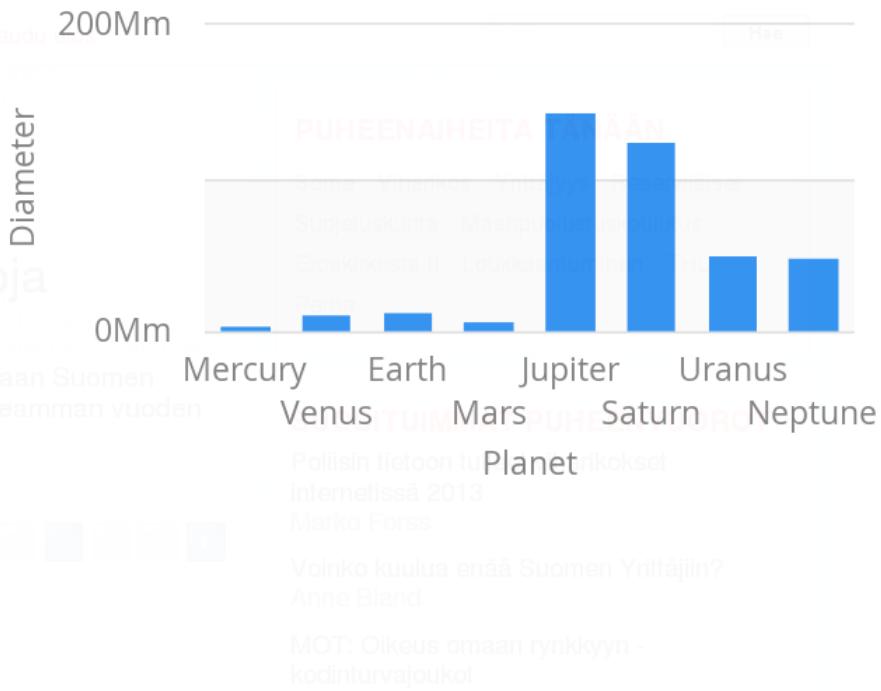
**Figure 18.15. Table and Chart Bound to a Container**

### Planets

name	diameter
Mercury	4 900
Venus	12 100
Earth	12 800
Mars	6 800
Jupiter	143 000
Saturn	125 000
Uranus	51 100
Neptune	49 500

### Planets

The bigger they are the harder they pull



## 18.7. Advanced Uses

### 18.7.1. Server-Side Rendering and Exporting

In addition to using charts in Vaadin UIs, you may also need to provide them as images or in downloadable documents. Vaadin Charts can be rendered on the server-side using a headless JavaScript execution environment, such as PhantomJS.

Vaadin Charts supports a HighCharts remote export service, but the SVG Generator based on PhantomJS is almost as easy to use and allows much more powerful uses.

#### Using a Remote Export Service

HighCharts has a simple built-in export functionality that does the export in a remote export server. HighCharts provides a default export service, but you can also configure your own.

You can enable the built-in export function by setting `setExporting(true)` in the chart configuration.

```
chart.getConfiguration().setExporting(true);
```

To configure it further, you can provide a **Exporting** object with custom settings.

```
// Create the export configuration
Exporting exporting = new Exporting(true);
```

```
// Customize the file name of the download file
exporting.setFilename("mychartfile.pdf");

// Enable export of raster images
exporting.setEnableImages(true);

// Use the exporting configuration in the chart
chart.getConfiguration().setExporting(exporting);
```

If you only want to enable download, you can disable the print button as follows:

```
ExportButton printButton = new ExportButton();
printButton.setEnabled(false);
exporting.setPrintButton(printButton);
```

The functionality uses a HighCharts export service by default. To use your own, you need to set up one and then configure it in the exporting configuration as follows:

```
exporting.setUrl("http://my.own.server.com");
```

## Using the SVG Generator

The **SVGGenerator** in Vaadin Charts provides an advanced way to render the Chart into SVG format on the server-side. SVG is well supported by many applications, can be converted to virtually any other graphics format, and can be passed to PDF report generators.

The generator uses PhantomJS to render the chart on the server-side. You need to install it from [phantomjs.org](http://phantomjs.org). After installation, PhantomJS should be in your system path. If not, you can set the `phantom.exec` system property for the JRE to point to the PhantomJS binary.

To generate the SVG image content as a string (it's XML), simply call the `generate()` method in the **SVGGenerator** singleton and pass it the chart configuration.

```
String svg = SVGGenerator.getInstance()
    .generate(chart.getConfiguration());
```

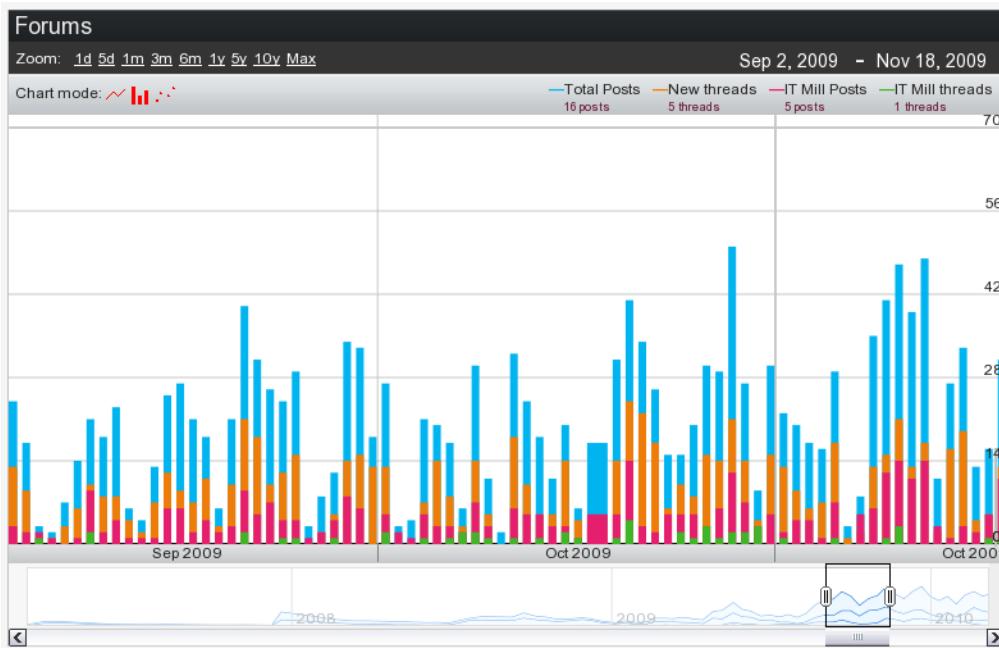
You can then use the SVG image as you like, for example, for download from a **StreamResource**, or include it in a HTML, PDF, or other document. You can use SVG tools such as the Batik or iText libraries to generate documents. For a complete example, you can check out the Charts Export Demo from the Subversion repository at <http://dev.vaadin.com/svn addons/vaadin-charts/chart-export-demo>.

## 18.8. Timeline

The **Timeline** is a charting component in the Vaadin Charts add-on separate from the **Chart** component. Its purpose is to give the user an intuitive understanding of events and trends on a horizontal timeline axis.

**Timeline** uses its own representation for the data series, different from the **Chart** and more optimized for updating. You can represent almost any time-related statistical data that has a time-value mapping. Multiple data sources can be used to allow comparison between data.

## Figure 18.16. Timeline Component



A timeline allows representing time-related data visually as graphs instead of numerical values. They are used commonly in almost all fields of business, science, and technology, such as in project management to map out milestones and goals, in geology to map out historical events, and perhaps most prominently in the stock market.

With Timeline, you can represent almost any time-related statistical data that has a time-value mapping. Even several data sources can be used for comparison between data. This allows the user to better grasp of changes in the data and anticipate forthcoming trends and problems.

### 18.8.1. Graph types

The Vaadin Timeline supports three graph types:

#### *Line graphs*

Useful for representing continuous data, such as temperature changes or changes in stock price.

#### *Bar graphs*

Useful for representing discrete or discontinuous data, such as market share or forum posts.

#### *Scatter graphs*

Useful for representing discrete or discontinuous data.

If you have several graphs in the timeline, you can also stack them on top of each other instead of drawing them on top of each other by setting `setGraphStacking()` in **Timeline** to `true`.

### 18.8.2. Interaction Elements

The user can interact with the Vaadin Timeline in several ways.

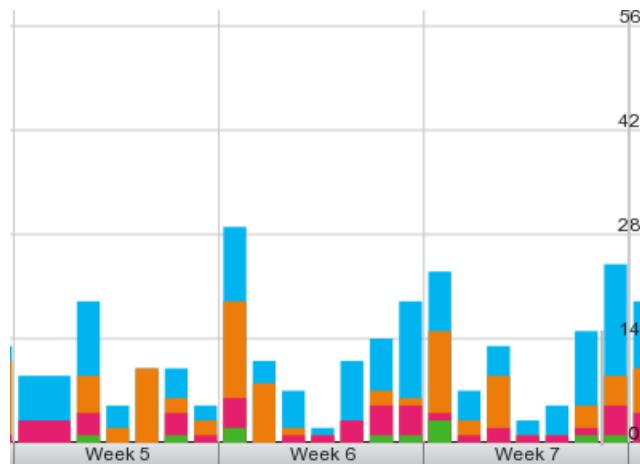
On the bottom of the timeline there is a *scrollbar area* where you can move the time forward or backward in time by dragging the time range box or by clicking the left and right arrow buttons. You can change the time range by resizing the range box in the scrollbar area. You can also zoom with the mouse wheel when the pointer is inside the component.

**Figure 18.17. Scrollbar Area**



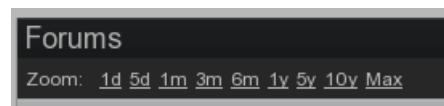
The middle area of the timeline is the *main area* where the selected time range is displayed. Time scale is shown below the main area. The time scale used depends on the zoom level and can be a time unit from hours to years. Value scale is displayed on the right side of the main area. The scale can be either a static value range or a range calculated from the displayed data set. The user can move in time by dragging the main area with the mouse left and right and zoom in and out by using the mouse wheel.

**Figure 18.18. Main Area**



You can select a *preset zoom level* with the buttons on the top the Timeline. This will change the displayed time range to match the zoom level. The zoom levels are fully customizable to suit the time range in the API.

**Figure 18.19. Preset Zoom Buttons**



The *current time range* is shown at the top-right corner of the component. Clicking the dates makes them editable, so that you can manually change them. *Graph legend* is shown below the time range. The legend explains what is represented by each bar on the graph and displays the current value when the user moves the mouse cursor over the graph.

**Figure 18.20. Current Time Range and Graph Legend**

Finally, the available *chart modes* are shown below the preset zoom levels options. The available graph modes can be set from the API.

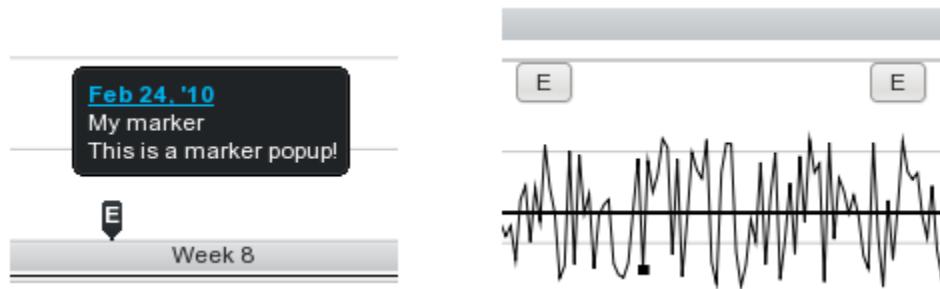
**Figure 18.21. Chart Mode**

You can use or hide any of the features above can be shown or hidden depending on your needs. For example, if you only need to display a graph without any controls, you can hide all them from the API.

### 18.8.3. Event Markers

In addition to graphs, the timeline can have events. An event can be, for example, the time of a published advertisement in a graph that displays website hits. Combining the event data with the graphs enables the user to observe the relevance of the advertisement to the website hits visually.

Vaadin Timeline provides two types of event markers, as illustrated in Figure 18.22, "Timeline Event Markers".

**Figure 18.22. Timeline Event Markers**

(On left) Marker with a customizable marker sign, for example, letter 'E'. The marker displays a caption which appears when the user hovers the pointer over the event.

(On right) Marker with button-like appearance with a marker sign and a caption.

### 18.8.4. Efficiency

Vaadin Timeline reduces the traffic between the server and the client by using two methods. First, all the data that is presented in the component is dynamically fetched from the server as needed. This means that when the user scrolls the timeline view, the component continuously fetches data from the server. Also, only data that is visible to the user is transferred to the client. For example, if the timeline has data that has been measured once a second for an entire year,

not all the data will be sent to the client. Only the data which can be rendered on the screen without overlapping is sent. This ensures that, even for large data sets, the loading time is small and only the necessary data is actually transferred over the network.

Second, Vaadin Timeline caches the data received from the server in the browser, so that the data is transferred over the network only once, if possible. This speeds up the time-range browsing when data can be fetched from the cache instead of reloading it over the network.

### 18.8.5. Data Source Requirements

Vaadin Timeline uses Vaadin containers as data sources for both the graphs and the events. There are, however, some requirements for the containers to make them compatible with the Vaadin Timeline.

The containers have to implement `Container.Indexed` for the Vaadin Timeline to be able to use them. This is because the Vaadin Timeline dynamically fetches the data from the server when needed. This way large data sets can be used without having to load all data to the client-side at once and it brings a huge performance increase.

Another requirement is that the container has one property of type `java.util.Date` (or a class that can be cast to it), which contains the timestamp when a data point or event occurred. This property has to be set by using the `setGraphTimestampPropertyId()` in `Timeline`. The default property ID `Timeline.PropertyId.TIMESTAMP` is used if no timestamp-property ID has been set.

A graph container also needs to have a `value` property that defines the value of the data point. This value can be any numerical value. The `value` property can be set with `setGraphValuePropertyId()` in `Timeline`. The default property ID `Timeline.PropertyId.VALUE` is used if no `value` property is given.

Below is an example of how a graph container could be constructed:

```
// Construct a container which implements Container.Indexed
IndexedContainer container = new IndexedContainer();

// Add the Timestamp property to the container
Object timestampProperty = "Our timestamp property";
container.addContainerProperty(timestampProperty,
                               java.util.Date.class, null);

// Add the value property
Object valueProperty = "Our value property";
container.addContainerProperty(valueProperty, Float.class, null);

// Our timeline
Timeline timeline = new Timeline();

// Add the container as a graph container
timeline.addGraphDataSource(container, timestampProperty,
                           valueProperty);
```

The event and marker containers are similar. They both need the `timestamp` property which should be of type `java.util.Date` and the `caption` property which should be a string. The marker container additionally needs a `value` property which is displayed in the marker popup.

Below is an example on how a marker or event container can be constructed:

```
// Create the container
IndexedContainer container = new IndexedContainer();

// Add the timestamp property
container.addContainerProperty(Timeline.PropertyId.TIMESTAMP,
                               Date.class, null);

// Add the caption property
container.addContainerProperty(Timeline.PropertyId.CAPTION,
                               String.class, "");

// Add the marker specific value property.
// Not needed for a event containers.
container.addContainerProperty(Timeline.PropertyId.VALUE,
                               String.class, "");

// Create the timeline with the container as both the marker
// and event data source
Timeline timeline = new Timeline();
timeline.setMarkerDataSource(container,
                             Timeline.PropertyId.TIMESTAMP,
                             Timeline.PropertyId.CAPTION,
                             Timeline.PropertyId.VALUE);

timeline.setEventDataSource(container,
                           Timeline.PropertyId.TIMESTAMP,
                           Timeline.PropertyId.CAPTION);
```

The above example uses the default property IDs. You can change them to suit your needs.

The **Timeline** listens for changes in the containers and updates the graph accordingly. When it updates the graph and items are added or removed from the container, the currently selected date range will remain selected. The selection bar in the browser area moves to keep the current selection selected. If you want the selection to change when the contents of the container changes and keep the selection area stationary, you can disable the selection lock by setting `setBrowserSelectionLock()` to `false`.

## 18.8.6. Events and Listeners

Two types of events are available when using the Vaadin Timeline.

### Date Range Changes

When the user modifies the selected date range by moving the date range selector, dragging the timeline, or by manually entering new dates, an event will be sent to the server with the information of what the current displayed date range is. To listen to these events you can attach a **DateRangeListener** which will receive the start and end dates of the current selection.

### Event Clicks

If the timeline has events, you can add an **EventClickListener** to listen for clicks on the events. The listener will receive a list of item IDs which are related to the click event from the event data source. Multiple events can be combined into a single event icon if space is not sufficient for displaying them all, in which case many item IDs can be returned.

## 18.8.7. Configurability

The Vaadin Timeline is highly customizable and its outlook can be easily changed to suit your needs. The default view of the Timeline contains all the controls available but often all of them are not needed and can be hidden.

The following list contains the components that can be shown or hidden at your preference:

- Chart modes
- Textual date select
- Browser area (bottom part of the Timeline)
- Legend
- Zoom levels
- Caption

The outlook of the graphs themselves can also be changed for both the browser area and the main view. The following settings are available through the API:

- Graph outline color
- Graph outline width
- Graph caps (in line graphs only)
- Graph fill color
- Graph visibility
- Graph shadows

Other changes to the outlook of the component can easily be done by CSS.

Zoom levels are also fully customizable. Zoom levels are defined as milliseconds and can be added by calling the `addZoomLevel()` method. A zoom level always has a caption, which is the visible part in the zoom panel, and a millisecond amount.

By default the grid divides the graph into five equally spaced parts with a gray color. However, you can fully customize how the grid is drawn by using `setGridColor()` and `setVerticalGridLines()`.

## 18.8.8. Localization

By default the Vaadin Timeline uses English as its primary language for the captions and the default locale for the application to display the dates in the timeline.

You can change the different captions in the Timeline by using their corresponding setters:

- `setZoomLevelsCaption()` -- The caption appearing before the zoom levels
- `setChartModesCaption()` -- The caption appearing before the chart modes

Furthermore, you can also change the locale in which the Timeline shows the dates in the horizontal scale by specifying a valid locale using the `setLocale()` method of the timeline.

You can also configure in what format the dates appear in the horizontal scale or in the date select in the top-right corner by using the `getDateFormats()`-method which will return a `DateFormatInfo` object. By using its setters you can set specific formats for each date range in the scale. Please note that if you are using long date formats they might get clipped if the scale does not fit the whole formatted date.

## 18.8.9. Timeline Tutorial

In the following tutorial, we look step-by-step how to create a timeline.

### Create the Data Sources

To use the Timeline, you need to create some data sources for it. Timeline uses `Container.Indexed` containers as data sources for both the graphs and the markers and events. So lets start by creating a datasource which represents the graph we want to draw in the timeline.

For the Timeline to understand how the data is constructed in the container we need to use specific property ids which describe what kind of data each property represents. For the Vaadin Timeline to work properly we will need to add two property ids, one for when the value was acquired and one for the value itself. The Vaadin Timeline has these both properties predefined as `Timeline.PropertyId.TIMESTAMP` and `Timeline.PropertyId.VALUE`. You can use the predefined ones or create your own if you wish.

So, lets create a container which meets the above stated specification. Open the main UI class which was automatically created when we created the project and add the following method.

```
/**  
 * Creates a graph container with a month of random data  
 */  
public Container.Indexed createGraphDataSource(){  
  
    // Create the container  
    Container.Indexed container = new IndexedContainer();  
  
    // Add the required property ids (use the default ones here)  
    container.addContainerProperty(Timeline.PropertyId.TIMESTAMP,  
        Date.class, null);  
    container.addContainerProperty(Timeline.PropertyId.VALUE,  
        Float.class, 0f);  
  
    // Add some random data to the container  
    Calendar cal = Calendar.getInstance();  
    cal.add(Calendar.MONTH, -1);  
    Date today = new Date();  
    Random generator = new Random();  
  
    while(cal.getTime().before(today)){  
        // Create a point in time  
        Item item = container.addItem(cal.getTime());  
  
        // Set the timestamp property  
        item.getItemProperty(Timeline.PropertyId.TIMESTAMP)  
            .setValue(cal.getTime());
```

```
// Set the value property
item.getItemProperty(Timeline.PropertyId.VALUE)
    .setValue(generator.nextFloat());

cal.add(Calendar.DAY_OF_MONTH, 1);
}

return container;
}
```

This method will create an indexed container with some random points. As you can see we are using an **IndexedContainer** and define two properties to it which was discussed earlier. Then we just generate some random data in the container. Here we are using the default property ids for the timestamp and value but you could use your own if you wished. We'll see later how you would tell the Timeline which property ids to use if you used your own.

Next, lets add some markers to our graph. Markers are arrow like shapes in the bottom of the timeline with which you can mark some occurrence that happened at that time. To create markers you again have to create a data source for them. I'll first show you how the code to create them and then explain what it all means. Add the following method to the UI class:

```
/**
 * Creates a marker container with a marker for each seven days
 */
public Container.Indexed createMarkerDataSource(){

    // Create the container
    Container.Indexed container = new IndexedContainer();

    // Add the required property IDs (use the default ones here)
    container.addContainerProperty(Timeline.PropertyId.TIMESTAMP,
        Date.class, null);
    container.addContainerProperty(Timeline.PropertyId.CAPTION,
        String.class, "Our marker symbol");
    container.addContainerProperty(Timeline.PropertyId.VALUE,
        String.class, "Our description");

    // Add a marker for every seven days
    Calendar cal = Calendar.getInstance();
    cal.add(Calendar.MONTH, -1);
    Date today = new Date();
    SimpleDateFormat formatter =
        new SimpleDateFormat("EEE, MMM d, 'yy");
    while(cal.getTime().before(today)){
        // Create a point in time
        Item item = container.addItem(cal.getTime());

        // Set the timestamp property
        item.getItemProperty(Timeline.PropertyId.TIMESTAMP)
            .setValue(cal.getTime());

        // Set the caption property
        item.getItemProperty(Timeline.PropertyId.CAPTION)
            .setValue("M");

        // Set the value property
        item.getItemProperty(Timeline.PropertyId.VALUE).
            setValue("Today is "+formatter.format(cal.getTime())));
    }
}
```

```
    cal.add(Calendar.DAY_OF_MONTH, 7);
}

return container;
}
```

Here we start the same as in the example with the graph container by creating an indexed container. Remember, all containers must be indexed containers when using the graph component.

We then add the timestamp property, caption property and value property.

The timestamp property is the same as in the graph container but the caption and value property differ. The caption property describes what kind of marker it is. The caption is displayed on top of the arrow shape in the Timeline so it should be a short symbol, preferably only one character long. The class of the caption property must be String.

The value property should also be a string and is displayed when the user hovers the mouse over the marker. This string can be arbitrarily long and normally should represent some kind of description of the marker.

The third kind of data sources are the event data sources. The events are displayed on top of the timeline and supports grouping and are clickable. They are represented as button like icons in the Timeline.

The event data sources are almost identical the to marker data sources except the value property is missing. Lets create an event data source and add events for each Sunday in our graph:

```
/**
 * Creates a event container with a marker for each sunday
 */
public Container.Indexed createEventDataSource(){

    // Create the container
    Container.Indexed container = new IndexedContainer();

    // Add the required property IDs (use default ones here)
    container.addContainerProperty(
        Timeline.PropertyId.TIMESTAMP, Date.class, null);
    container.addContainerProperty(
        Timeline.PropertyId.CAPTION,
        String.class, "Our marker symbol");

    // Add a marker for every seven days
    Calendar cal = Calendar.getInstance();
    cal.add(Calendar.MONTH, -1);
    Date today = new Date();
    while(cal.getTime().before(today)){
        if (cal.get(Calendar.DAY_OF_WEEK) == Calendar.SUNDAY){
            // Create a point in time
            Item item = container.addItem(cal.getTime());

            // Set the timestamp property
            item.getItemProperty(Timeline.PropertyId.TIMESTAMP)
                .setValue(cal.getTime());

            // Set the caption property
            item.getItemProperty(Timeline.PropertyId.CAPTION)
                .setValue("Sunday");
        }
    }
}
```

```
        }
        cal.add(Calendar.DAY_OF_MONTH, 1);
    }

    return container;
}
```

As you can see the event container does not differ a whole lot from the marker containers. In use however they differ since they are groupable they can be closely put together and still be usable and you can add click listeners to them so you can catch user events. More on the click listeners later.

So now we have our three data sources ready to be displayed in our application. In the next chapter we will use them with our Timeline and see how they integrate with it.

## Create the Timeline

Okay, now that we have our data sources lets look at the init-method in our Vaadin Application. Lets start by creating our timeline, so add the following line to the end of the init-method in **My-timelinedemoApplication**:

```
Timeline timeline = new Timeline("Our timeline");
timeline.setWidth("100%");
```

This will create the timeline we want with a 100 percent width. Now lets add our data sources to the timeline:

```
timeline.addGraphDataSource(createGraphDataSource(),
    Timeline.PropertyId.TIMESTAMP,
    Timeline.PropertyId.VALUE);

timeline.setMarkerDataSource(createMarkerDataSource(),
    Timeline.PropertyId.TIMESTAMP,
    Timeline.PropertyId.CAPTION,
    Timeline.PropertyId.VALUE);

timeline.setEventDataSource(createEventDataSource(),
    Timeline.PropertyId.TIMESTAMP,
    Timeline.PropertyId.CAPTION);
```

And finally add the timeline to the UI. Here is the complete init-method:

```
@Override
protected void init(VaadinRequest request) {
    VerticalLayout content = new VerticalLayout();
    setContent(content);

    // Create the timeline
    Timeline timeline = new Timeline("Our timeline");

    // Create the data sources
    Container.Indexed graphDS = createGraphDataSource();
    Container.Indexed markerDS = createMarkerDataSource();
    Container.Indexed eventDS = createEventDataSource();

    // Add our data sources
    timeline.addGraphDataSource(graphDS,
        Timeline.PropertyId.TIMESTAMP,
        Timeline.PropertyId.VALUE);
```

```

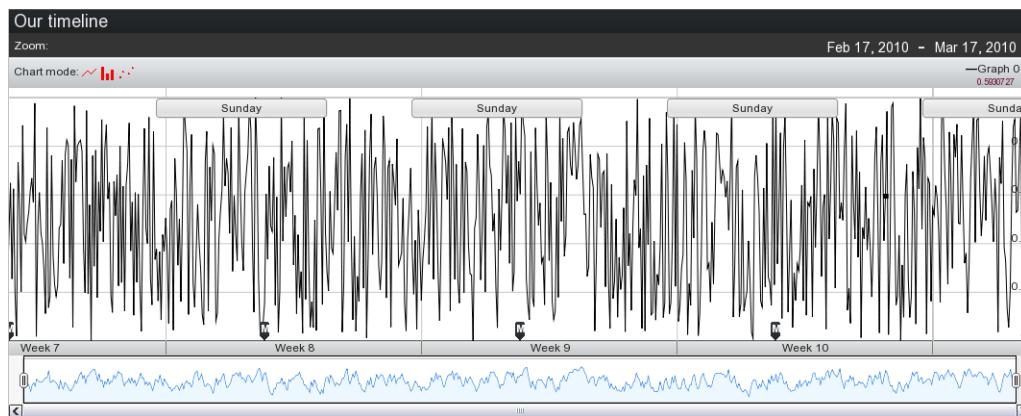
        timeline.setMarkerDataSource(markerDS,
            Timeline.PropertyId.TIMESTAMP,
            Timeline.PropertyId.CAPTION,
            Timeline.PropertyId.VALUE);
        timeline.setEventDataSource(eventDS,
            Timeline.PropertyId.TIMESTAMP,
            Timeline.PropertyId.CAPTION);

        content.addComponent(timeline);
    }
}

```

Now you should be able to start the application and browse the timeline. The result is shown in Figure 18.23, “Timeline Example Application”.

**Figure 18.23. Timeline Example Application**



## Final Touches

Now that we have our timeline we would probably like to customize it a bit. There are many things you can do but lets start by giving our graph some style properties and a caption in the legend. This can be done as follows:

```

// Set the caption of the graph
timeline.setGraphLegend(graphDataSource, "Our cool graph");

// Set the color of the graph
timeline.setGraphOutlineColor(graphDataSource, Color.RED);

// Set the fill color of the graph
timeline.setGraphFillColor(graphDataSource, new Color(255,0,0,128));

// Set the width of the graph
timeline.setGraphOutlineThickness(2.0);

```

Lets do the same to the browser areas graph:

```

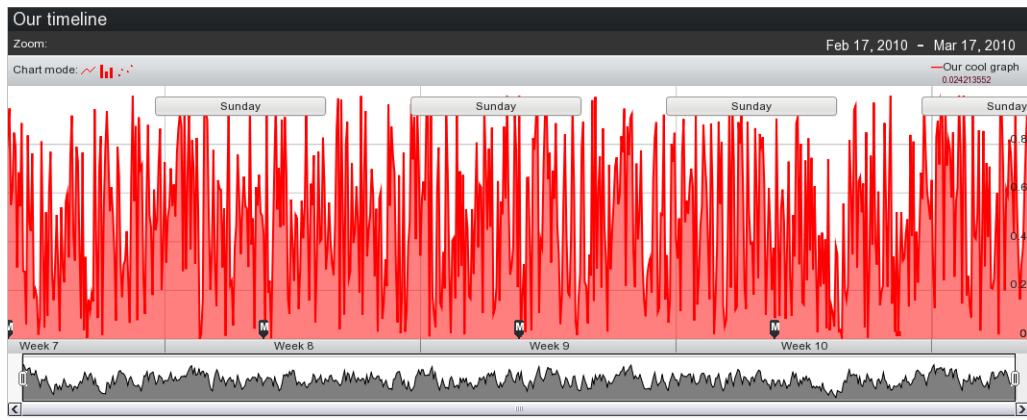
// Set the color of the browser graph
timeline.setBrowserOutlineColor(graphDataSource, Color.BLACK);

// Set the fill color of the graph
timeline.setBrowserFillColor(graphDataSource,
    new Color(0,0,0,128));

```

And the result looks like this:

**Figure 18.24. Styling Timeline**



Okay, now that looks different. But there is still something missing. If you look in the upper left corner you will not see any zoom levels. No zoom levels are predefined so we will have to make our own. Since we are dealing with a month of data lets make a zoom level for a day, a week and a month. Zoom levels are given in milliseconds so we will have to calculate how many milliseconds each of the zoom levels are. So lets add them by adding the following lines:

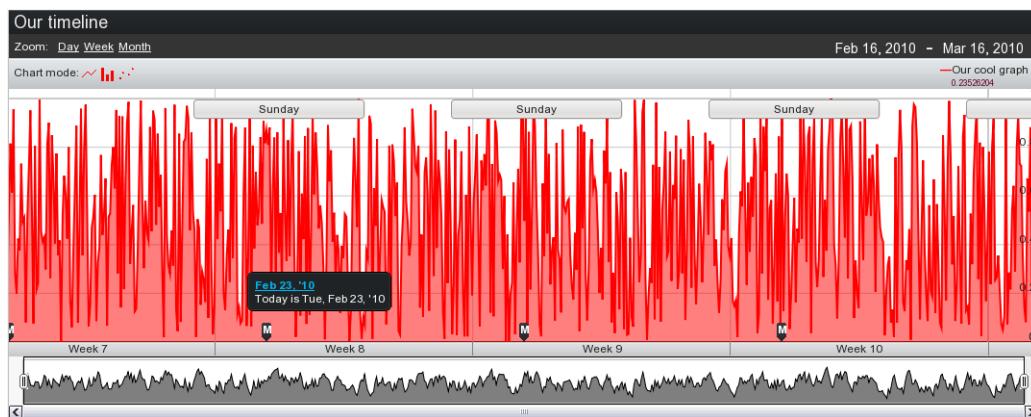
```
// Add some zoom levels
timeline.addZoomLevel("Day", 86400000L);
timeline.addZoomLevel("Week", 7 * 86400000L);
timeline.addZoomLevel("Month", 2629743830L);
```

Remember the events we added? You can now see them in the graph but their functionality is still a bit incomplete. We can add an event listener to the graph which will send an event each time the user clicks on one of the event buttons. To demonstrate this feature lets add an event listener which notifies the user what date the Sunday-button represents. Here is the code for that:

```
// Listen to click events from events
timeline.addListener(new Timeline.EventClickListener() {
    @Override
    public void eventClick(EventButtonClickEvent event) {
        Item item = eventDataSource.getItem(event.getItemId());
        Date sunday = (Date) item.getProperty(
            Timeline.PropertyId.TIMESTAMP).getValue();
        SimpleDateFormat formatter =
            new SimpleDateFormat("EEE, MMM d, ''yy");
        Notification.show(formatter.format(sunday));
    }
});
```

Now try clicking on the events and see what happens!

And here is the final demo application, yours will probably look a bit different since we are using random data.

**Figure 18.25. Final Example**

Now we hope you have a basic understanding of how the Timeline works and how it can be customized. There are still a few features we left out of this tutorial like hiding unnecessary components from the timeline and adding multiple graphs to the timeline, but these are pretty self explanatory features and you probably can look them up in the JavaDoc.

---

# Chapter 19

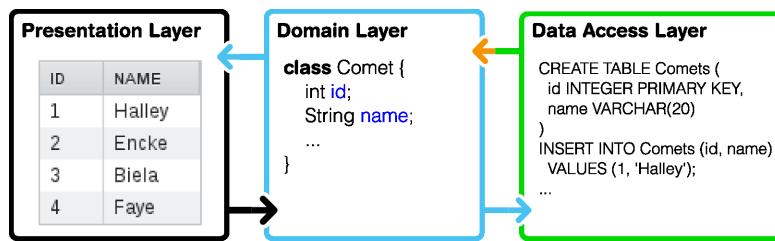
# Vaadin JPACContainer

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This chapter describes the use of the Vaadin JPACContainer add-on.

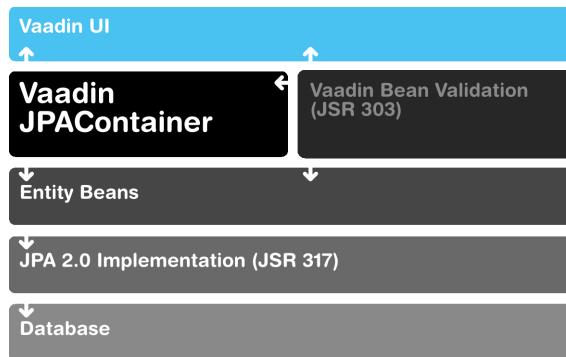
## 19.1. Overview

Vaadin JPACContainer add-on makes it possible to bind user interface components to a database easily using the Java Persistence API (JPA). It is an implementation of the `Container` interface described in Section 8.5, “Collecting Items in Containers”. It supports a typical three-layer application architecture with an intermediate *domain model* between the user interface and the data access layer.

**Figure 19.1. Three-Layer Architecture Using JPACContainer And JPA**

The role of Java Persistence API is to handle persisting the domain model in the database. The database is typically a relational database. Vaadin JPACContainer binds the user interface components to the domain model and handles database access with JPA transparently.

JPA is really just an API definition and has many alternative implementations. Vaadin JPACContainer supports especially EclipseLink, which is the reference implementation of JPA, and Hibernate. Any other compliant implementation should work just as well. The architecture of an application using JPACContainer is shown in Figure 19.2, “JPACContainer Architecture”.

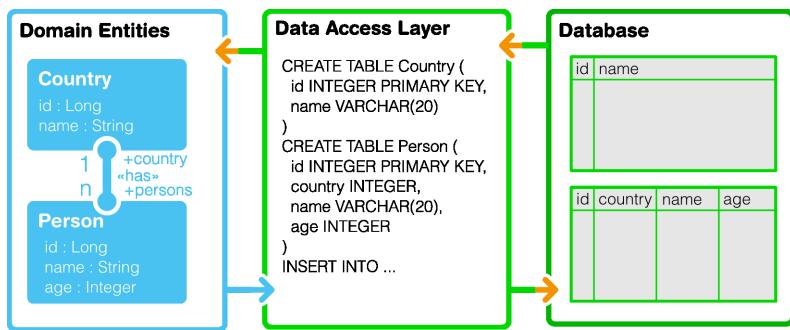
**Figure 19.2. JPACContainer Architecture**

Vaadin JPACContainer also plays together with the Vaadin support for Java Bean Validation (JSR 303).

## Java Persistence API

Java Persistence API (JPA) is an API for object-relational mapping (ORM) of Java objects to a relational database. In JPA and entity-relationship modeling in general, a Java class is considered an *entity*. Class (or entity) instances correspond with a row in a database table and member variables of a class with columns. Entities can also have relationships with other entities.

The object-relational mapping is illustrated in Figure 19.3, “Object-Relational Mapping” with two entities with a one-to-many relationship.

**Figure 19.3. Object-Relational Mapping**

The entity relationships are declared with metadata. With Vaadin JPACContainer, you provide the metadata with annotations in the entity classes. The JPA implementation uses reflection to read the annotations and defines a database model automatically from the class definitions. Definition of the domain model and the annotations are described in Section 19.3.1, “Persistence Metadata”.

The main interface in JPA is the `EntityManager`, which allows making different kinds of queries either with the Java Persistence Query Language (JPQL), native SQL, or the Criteria API in JPA 2.0. You can always use the interface directly as well, using Vaadin JPACContainer only for binding the data to the user interface.

Vaadin JPACContainer supports JPA 2.0 (JSR 317). It is available under the Apache License 2.0.

## JPACContainer Concepts

The **JPACContainer** is an implementation of the Vaadin Container interface that you can bind to user interface components such as **Table**, **ComboBox**, etc.

The data access to the persistent entities is handled with a *entity provider*, as defined in the `EntityProvider` interface. JPACContainer provides a number of different entity providers for different use cases and optimizations. The built-in providers are described in Section 19.5, “Entity Providers”.

**JPACContainer** is by default *unbuffered*, so that any entity property changes are written immediately to the database when you call `setValue()` for a property, or when a user edits a bound field. A container can be set as *buffered*, so that changes are written on calling `commit()`. Buffering can be done both at item level, such as when updating item property values, or at container level, such as when adding or deleting items. Only *batchable* containers, that is, containers with a batchable entity provider, can be buffered. Note that buffering is recommended for situations where two users could update the same entity simultaneously, and when this would be a problem. In an unbuffered container, the entity is refreshed before writing an update, so the last write wins and a conflicting simultaneous update written before it is lost. A buffered container throws an **OptimisticLockException** when two users edit the same item (an unbuffered container never throws it), thereby allowing to handle the situation with application logic.

## Documentation and Support

In addition to this chapter in the book, the installation package includes the following documentation about JPACContainer:

- API Documentation

- JPACContainer Tutorial
- JPACContainer AddressBook Demo
- JPACContainer Demo

## 19.2. Installing

Vaadin JPACContainer can be installed either as an installation package, downloaded from the Vaadin Directory, or as a Maven dependency. You can also create a new JPACContainer-enabled Vaadin project using a Maven archetype.

### 19.2.1. Downloading the Package

Vaadin JPACContainer is available for download from the Vaadin Directory. Please see Section 17.2, "Downloading Add-ons from Vaadin Directory" for basic instructions for downloading from Directory. The download page also gives the dependency declaration needed for retrieving the library with Maven.

JPACContainer is a purely server-side component, so it does not include a widget set that you would need to compile.

### 19.2.2. Installation Package Content

Once extracted to a local folder, the contents of the installation directory are as follows:

README

A readme file describing the package contents.

LICENSE

The full license text for the library.

vaadin-jpaccontainer-3.x.x.jar

The actual Vaadin JPACContainer library.

vaadin-jpaccontainer-3.x.x-sources.jar

Source JAR for the library. You can use it for example in Eclipse by associating the JavaDoc JAR with the JPACContainer JAR in the build path settings of your project.

jpaccontainer-tutorial.pdf

The tutorial in PDF format.

jpaccontainer-tutorial-html

The tutorial in HTML format.

jpaccontainer-addressbook-demo

The JPACContainer AddressBook Demo project covered in this tutorial. You can compile and package the application as a WAR with "`mvn package`" or launch it in the Jetty web browser with "`mvn jetty:run`". You can also import the demo project in Eclipse.

### 19.2.3. Downloading with Maven

The download page in Vaadin Directory gives the dependency declaration needed for retrieving the Vaadin JPACContainer library with Maven.

```
<dependency>
  <groupId>com.vaadin.addon</groupId>
  <artifactId>jpacontainer-addon</artifactId>
  <version>3.1.0</version>
</dependency>
```

Use the `LATEST` version tag to automatically download the latest stable release or use a specific version number as done above.

See Section 17.4, “Using Add-ons in a Maven Project” for detailed instructions for using a Vaadin add-on with Maven.

## Using the Maven Archetype

If you wish to create a new JPAContainer-enabled Vaadin project with Maven, you can use the `vaadin-archetype-jpacontainer` archetype. Please see Section 2.6, “Using Vaadin with Maven” for details on creating a Vaadin project with a Maven archetype.

### 19.2.4. Including Libraries in Your Project

The Vaadin JPAContainer JAR must be included in the library folder of the web application. It is located in `WEB-INF/lib` path in a web application. In a normal Eclipse web projects the path is `WebContent/WEB-INF/lib`. In Maven projects the JARs are automatically included in the folder, as long as the dependencies are defined correctly.

You will need the following JARs:

- Vaadin Framework Library
- Vaadin JPAContainer
- Java Persistence API 2.0 (`javax.persistence` package)
- JPA implementation (EclipseLink, Hibernate, ...)
- Database driver or embedded engine (H2, HSQLDB, MySQL, PostgreSQL, ...)

If you use Eclipse, the Vaadin Framework library is automatically downloaded and updated by the Vaadin Plugin for Eclipse.

To use bean validation, you need an implementation of the Bean Validation, such as Hibernate Validator.

### 19.2.5. Persistence Configuration

Persistence configuration is done in a `persistence.xml` file. In a regular Eclipse project, it should be located in `WebContent/WEB-INF/classes/META-INF`. In a Maven project, it should be in `src/main/resources/META-INF`. The configuration includes the following:

- The persistence unit
- The persistence provider
- The database driver and connection
- Logging

The `persistence.xml` file is packaged as `WEB-INF/classes/META-INF/persistence.xml` in the WAR. This is done automatically in a Maven build at the package phase.

## Persistence XML Schema

The beginning of a `persistence.xml` file defines the used schema and namespaces:

```
<?xml version="1.0" encoding="UTF-8"?>
<persistence
    xmlns="http://java.sun.com/xml/ns/persistence"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="
        http://java.sun.com/xml/ns/persistence
        http://java.sun.com/xml/ns/persistence/persistence_2_0.xsd"
    version="2.0">
```

## Defining the Persistence Unit

The root element of the persistence definition is `persistence-unit`. The name of the persistence unit is needed for creating **JPAContainer** instances from a **JPAContainerFactory**, as described in Section 19.4.1, “Creating **JPAContainer** with **JPAContainerFactory**” or when creating a JPA entity manager.

```
<persistence-unit name="addressbook">
```

Persistence provider is the JPA provider implementation used. For example, the JPAContainer AddressBook demo uses the EclipseLink JPA, which is defined as follows:

```
<provider>
    org.eclipse.persistence.jpa.PersistenceProvider
</provider>
```

The persistent classes need to be listed with a `<class>` element. Alternatively, you can allow including unlisted classes for persistence by overriding the `exclude-unlisted-classes` default as follows:

```
<exclude-unlisted-classes>false</exclude-unlisted-classes>
```

JPA provider specific parameters are given under the `properties` element.

```
<properties>
    ...
```

In the following section we give parameters for the EclipseLink JPA and H2 database used in the JPAContainer AddressBook Demo. Please refer to the documentation of the JPA provider you use for a complete reference of parameters.

## Database Connection

EclipseLink allows using JDBC for database connection. For example, if we use the the H2 database, we define its driver here as follows:

```
<property name="eclipselink.jdbc.platform"
    value="org.eclipse.persistence.platform.database.H2Platform" />
<property name="eclipselink.jdbc.driver"
    value="org.h2.Driver" />
```

Database connection is specified with a URL. For example, using an embedded H2 database stored in the home directory it would be as follows:

```
<property name="eclipselink.jdbc.url"  
         value="jdbc:h2:~/my-app-h2db" />
```

A hint: when using an embedded H2 database while developing a Vaadin application in Eclipse, you may want to add ;FILE\_LOCK=NO to the URL to avoid locking issues when redeploying.

We can just use the default user name and password for the H2 database:

```
<property name="eclipselink.jdbc.user" value="sa"/>  
<property name="eclipselink.jdbc.password" value="sa"/>
```

## Logging Configuration

JPA implementations as well as database engines like to produce logs and they should be configured in the persistence configuration. For example, if using EclipseLink JPA, you can get log that includes all SQL statements with the FINE logging level:

```
<property name="eclipselink.logging.level"  
         value="FINE" />
```

## Other Settings

The rest is some Data Definition Language settings for EclipseLink. During development, when we use generated example data, we want EclipseLink to drop tables before trying to create them. In production environments, you should use create-tables.

```
<property name="eclipselink.ddl-generation"  
         value="drop-and-create-tables" />
```

And there is no need to generate SQL files, just execute them directly to the database.

```
<property name="eclipselink.ddl-generation.output-mode"  
         value="database" />  
</properties>  
</persistence-unit>  
</persistence>
```

## 19.2.6. Troubleshooting

Below are some typical errors that you might get when using JPA. These are not specific to JPAContainer.

**javax.persistence.PersistenceException:** No Persistence provider for EntityManager  
The most typical cases for this error are that the persistence unit name is wrong in the source code or in the persistence.xml file, or that the persistence.xml is at a wrong place or has some other problem. Make sure that the persistence unit name matches and the persistence.xml is in WEB-INF/classes/META-INF folder in the deployment.

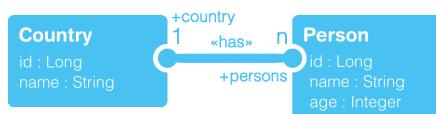
**java.lang.IllegalArgumentException:** The class is not an entity  
The class is missing from the set of persistent entities. If the persistence.xml does not have exclude-unlisted-classes defined as false, the persistent entity classes should be listed with <class> elements.

## 19.3. Defining a Domain Model

Developing a persistent application begins with defining a domain model. A domain model consists of a number of entities (classes) and relationships between them.

Figure 19.4, “A Domain Model” illustrates a simple domain model as a UML class diagram. It has two entities: **Country** and **Person**. They have a “country has persons” relationship. This is a *one-to-many relationship* with one country having many persons, each of which belongs to just one country.

**Figure 19.4. A Domain Model**



Realized in Java, the classes are as follows:

```
public class Country {
    private Long id;
    private String name;
    private Set<Person> persons;

    ... setters and getters ...
}

public class Person {
    private Long id;
    private String name;
    private Integer age;
    private Country country;

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

You should make the classes proper beans by defining a default constructor and implementing the `Serializable` interface. A default constructor is required by the JPA entity manager for instantiating entities. Having the classes serializable is not required but often useful for other reasons.

After you have a basic domain model, you need to define the entity relationship metadata by annotating the classes.

### 19.3.1. Persistence Metadata

The entity relationships are defined with metadata. The metadata can be defined in an XML metadata file or with Java annotations defined in the `javax.persistence` package. With Vaadin JPACContainer, you need to provide the metadata as annotations.

For example, if we look at the `Person` class in the JPACContainer AddressBook Demo, we define various database-related metadata for the member variables of a class:

```
@Entity
public class Person {
    @Id
    @GeneratedValue(strategy = GenerationType.AUTO)
```

```
private Long      id;  
  
private String    name;  
private Integer   age;  
  
@ManyToOne  
private Country  country;
```

The JPA implementation uses reflection to read the annotations and defines a database model automatically from the class definitions.

Let us look at some of the basic JPA metadata annotations. The annotations are defined in the javax.persistence package. Please refer to JPA reference documentation for the complete list of possible annotations.

### Annotation: @Entity

Each class that is enabled as a persistent entity must have the `@Entity` annotation.

```
@Entity  
public class Country {
```

### Annotation: @Id

Entities must have an identifier that is used as the primary key for the table. It is used for various purposes in database queries, most commonly for joining tables.

```
@Id  
@GeneratedValue(strategy = GenerationType.AUTO)  
private Long id;
```

The identifier is generated automatically in the database. The strategy for generating the identifier is defined with the `@GeneratedValue` annotation. Any generation type should work.

### Annotation: @OneToOne

The `@OneToOne` annotation describes a one-to-one relationship where each entity of one type is associated with exactly one entity of another type. For example, the postal address of a person could be given as such.

```
@OneToOne  
private Address address;
```

When using the `JPACContainer` **FieldFactory** to automatically create fields for a form, the `@OneToOne` relationship generates a nested **Form** to edit the data. See Section 19.8, “Automatic Form Generation” for more details.

### Annotation: @Embedded

Just as with the `@OneToOne` annotation, `@Embedded` describes a one-to-one relationship, but says that the referenced entity should be stored as columns in the same table as the referencing entity.

```
@Embedded  
private Address address;
```

The referenced entity class must have `@Embeddable` annotation.

The JPACContainer **FieldFactory** generates a nested **Form** for `@Embedded`, just as with `@OneToOne`.

### Annotation: `@OneToMany`

The **Country** entity in the domain model has a *one-to-many* relationship with the **Person** entity ("country has persons"). This relationship is represented with the `@OneToMany` annotation. The *mappedBy* parameter names the corresponding back-reference in the **Person** entity.

```
@OneToMany(mappedBy = "country")
private Set<Person> persons;
```

When using the JPACContainer **FieldFactory** to automatically create fields for a form, the `@OneToMany` relationship generates a **MasterDetailEditor** for editing the items. See Section 19.8, "Automatic Form Generation" for more details.

### Annotation: `@ElementCollection`

The `@ElementCollection` annotation can be used for one-to-many relationships to a collection of basic values such as **String** or **Integer**, or to entities annotated as `@Embeddable`. The referenced entities are stored in a separate table defined with a `@CollectionTable` annotation.

```
@ElementCollection
@CollectionTable(
    name="OLDPEOPLE",
    joinColumns=@JoinColumn(name="COUNTRY_ID" ))
private Set<Person> persons;
```

JPACContainer **FieldFactory** generates a **MasterDetailEditor** for the `@ElementCollection` relationship, just as with `@OneToMany`.

### Annotation: `@ManyToOne`

Many people can live in the same country. This would be represented with the `@ManyToOne` annotation in the **Person** class.

```
@ManyToOne
private Country country;
```

JPACContainer **FieldFactory** generates a **NativeSelect** for selecting an item from the collection. You can do so yourself as well in a custom field factory. Doing so you need to pay notice not to confuse the container between the referenced entity and its ID, which could even result in insertion of false entities in the database in some cases. You can handle conversion between an entity and the entity ID using the **SingleSelectConverter** as follows:

```
@Override
public <T extends Field> T createField(Class<?> dataType,
                                         Class<T> fieldType) {
    if (dataType == Country.class) {
        JPACContainer<Country> countries =
            JPACContainerFactory.make(Country.class, "mypunit");
        ComboBox cb = new ComboBox(null, countries);
        cb.setConverter(new SingleSelectConverter<Country>(cb));
        return (T) cb;
    }
}
```

```
        return super.createField(dataType, fieldType);
    }
```

The JPAContainer **FieldFactory** uses the translator internally, so using it also avoids the problem.

#### Annotation: @Transient

JPA assumes that all entity properties are persisted. Properties that should not be persisted should be marked as transient with the `@Transient` annotation.

```
@Transient
private Boolean superDepartment;
...
@Transient
public String getHierarchicalName() {
    ...
}
```

## 19.4. Basic Use of JPAContainer

Vaadin JPAContainer offers a highly flexible API that makes things easy in simple cases while allowing extensive flexibility in demanding cases. To begin with, it is a **Container**, as described in Section 8.5, “Collecting Items in Containers”.

In this section, we look how to create and use **JPAContainer** instances. We assume that you have defined a domain model with JPA annotations, as described in the previous section.

### 19.4.1. Creating JPAContainer with JPAContainerFactory

The **JPAContainerFactory** is the easy way to create **JPAContainers**. It provides a set of `make...()` factory methods for most cases that you will likely meet. Each factory method uses a different type of entity provider, which are described in Section 19.5, “Entity Providers”.

The factory methods take the class type of the entity class as the first parameter. The second parameter is either a persistence unit name (persistence context) or an **EntityManager** instance.

```
// Create a persistent person container
JPAContainer<Person> persons =
    JPAContainerFactory.make(Person.class, "book-examples");

// You can add entities to the container as well
persons.addEntity(new Person("Marie-Louise Meilleur", 117));

// Set up sorting if the natural order is not appropriate
persons.sort(new String[]{"age", "name"},
            new boolean[]{false, false});

// Bind it to a component
Table personTable = new Table("The Persistent People", persons);
personTable.setVisibleColumns(new String[]{"id", "name", "age"});
layout.addComponent(personTable);
```

It's that easy. In fact, if you run the above code multiple times, you'll be annoyed by getting a new set of persons for each run - that's how persistent the container is. The basic `make()` uses a **CachedMutableLocalEntityProvider**, which allows modifying the container and its entities, as we do above by adding new entities.

When using just the persistence unit name, the factory creates an instance of **EntityManagerFactory** for the persistence unit and uses it to build entity managers. You can also create the entity managers yourself, as described later.

The entity providers associated with the different factory methods are as follows:

**Table 19.1. JPAContainerFactory Methods**

make()	CachingMutableLocalEntityProvider
makeReadOnly()	CachingLocalEntityProvider
makeBatchable()	BatchableLocalEntityProvider
makeNonCached()	MutableLocalEntityProvider
makeNonCachedReadOnly()	LocalEntityProvider

**JPAContainerFactory** holds a cache of entity manager factories for the different persistence units, making sure that any entity manager factory is created only once, as it is a heavy operation. You can access the cache to get a new entity manager with the `createEntityManagerForPersistenceUnit()` method.

```
// Get an entity manager
EntityManager em = JPAContainerFactory.
    createEntityManagerForPersistenceUnit("book-examples");

// Do a query
em.getTransaction().begin();
em.createQuery("DELETE FROM Person p").executeUpdate();
em.persist(new Person("Jeanne Calment", 122));
em.persist(new Person("Sarah Knauss", 119));
em.persist(new Person("Lucy Hannah", 117));
em.getTransaction().commit();

...
```

Notice that if you use update the persistent data with an entity manager outside a **JPAContainer** bound to the data, you need to refresh the container as described in Section 19.4.2, “Creating and Accessing Entities”.

## Creating JPAContainer Manually

While it is normally easiest to use a **JPAContainerFactory** to create **JPAContainer** instances, you may need to create them manually. It is necessary, for example, when you need to use a custom entity provider or extend **JPAContainer**.

First, we need to create an entity manager and then the entity provider, which we bind to a **JPAContainer**.

```
// We need a factory to create entity manager
EntityManagerFactory emf =
    Persistence.createEntityManagerFactory("book-examples");

// We need an entity manager to create entity provider
EntityManager em = emf.createEntityManager();

// We need an entity provider to create a container
CachingMutableLocalEntityProvider<Person> entityProvider =
```

```
new CachingMutableLocalEntityProvider<Person>(Person.class,
                                              em);

// And there we have it
JPAContainer<Person> persons =
    new JPAContainer<Person>(Person.class);
persons.setEntityProvider(entityProvider);
```

You could save the first step by asking the entity manager from the **JPAContainerFactory**.

## 19.4.2. Creating and Accessing Entities

JPAContainer integrates with the JPA entity manager, which you would normally use to create and access entities with JPA. You can use the entity manager for any purposes you may have, and then **JPAContainer** to bind entities to user interface components such as **Table**, **Tree**, any selection components, or a **Form**.

You can add new entities to a **JPAContainer** with the `addEntity()` method. It returns the item ID of the new entity.

```
Country france = new Country("France");
Object itemId = countries.addEntity(france);
```

The item ID used by **JPAContainer** is the value of the ID property (column) defined with the `@Id` annotation. In our **Country** entity, it would have **Long** type. It is generated by the entity manager when the entity is persisted and set with the setter for the ID property.

Notice that the `addEntity()` method does *not* attach the entity instance given as the parameter. Instead, it creates a new instance. If you need to use the entity for some purpose, you need to get the actual managed entity from the container. You can get it with the item ID returned by `addEntity()`.

```
// Create a new entity and add it to a container
Country france = new Country("France");
Object itemId = countries.addEntity(france);

// Get the managed entity
france = countries.getItem(itemId).getEntity();

// Use the managed entity in entity references
persons.addEntity(new Person("Jeanne Calment", 122, france));
```

## Entity Items

The `getItem()` method is defined in the normal Vaadin Container interface. It returns an **EntityItem**, which is a wrapper over the actual entity object. You can get the entity object with `getEntity()`.

An **EntityItem** can have a number of states: persistent, modified, dirty, and deleted. The dirty and deleted states are meaningful when using *container buffering*, while the modified state is meaningful when using *item buffering*. Both levels of buffering can be used together - user input is first written to the item buffer, then to the entity instance, and finally to the database.

The `isPersistent()` method tells if the item is actually persistent, that is, fetched from a persistent storage, or if it is just a transient entity created and buffered by the container.

The `isModified()` method checks whether the **EntityItem** has changes that are not yet committed to the entity instance. It is only relevant if the item buffering is enabled with `setBuffered(true)` for the item.

The `isDirty()` method checks whether the entity object has been modified after it was fetched from the entity provider. The dirty state is possible only when buffering is enabled for the container.

The `isDeleted()` method checks whether the item has been marked for deletion with `removeItem()` in a buffered container.

## Refreshing JPAContainer

In cases where you change **JPAContainer** items outside the container, for example by through an `EntityManager`, or when they change in the database, you need to refresh the container.

The `EntityContainer` interface implemented by **JPAContainer** provides two methods to refresh a container. The `refresh()` discards all container caches and buffers and refreshes all loaded items in the container. All changes made to items provided by the container are discarded. The `refreshItem()` refreshes a single item.

### 19.4.3. Nested Properties

If you have a one-to-one or many-to-one relationship, you can define the properties of the referenced entity as *nested* in a **JPAContainer**. This way, you can access the properties directly through the container of the first entity type as if they were its properties. The interface is the same as with **BeanContainer** described in Section 8.5.4, “**BeanContainer**”. You just need to add each nested property with `addNestedContainerProperty()` using dot-separated path to the property.

```
// Have a persistent container
JPAContainer<Person> persons =
    JPAContainerFactory.make(Person.class, "book-examples");

// Add a nested property to a many-to-one property
persons.addNestedContainerProperty("country.name");

// Show the persons in a table, except the "country" column,
// which is an object - show the nested property instead
Table personTable = new Table("The Persistent People", persons);
personTable.setVisibleColumns(new String[]{"name", "age",
    "country.name"});

// Have a nicer caption for the country.name column
personTable.setColumnHeader("country.name", "Nationality");
```

The result is shown in Figure 19.5, “Nested Properties”. Notice that the `country` property in the container remains after adding the nested property, so we had to make that column invisible. Alternatively, we could have redefined the `toString()` method in the `country` object to show the name instead of an object reference.

**Figure 19.5. Nested Properties**

The Persistent People		
NAME	AGE	NATIONALITY
Jeanne Calment	122	France
Sarah Knauss	119	United States
Marie-Louise Meilleur	117	Canada
Lucy Hannah	117	United States
Tane Ikai	116	Japan

You can use the \* wildcard to add all properties in a nested item, for example, "country.\*".

#### 19.4.4. Hierarchical Container

**JPAContainer** implements the `Container.Hierarchical` interface and can be bound to hierarchical components such as a **Tree** or **TreeTable**. The feature requires that the hierarchy is represented with a *parent* property that refers to the parent item. At database level, this would be a column with IDs.

The representation would be as follows:

```
@Entity
public class CelestialBody implements Serializable {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    private String name;

    @ManyToOne
    private CelestialBody parent;
    ...
}

// Create some entities
CelestialBody sun      = new CelestialBody("The Sun", null);
CelestialBody mercury  = new CelestialBody("Mercury", sun);
CelestialBody venus    = new CelestialBody("Venus", sun);
CelestialBody earth    = new CelestialBody("Earth", sun);
CelestialBody moon     = new CelestialBody("The Moon", earth);
CelestialBody mars     = new CelestialBody("Mars", sun);
...
```

You set up a **JPAContainer** to have hierarchy by calling `setParentProperty()` with the name of the property that refers to the parent. Coincidentally, it is named "parent" in the example:

```
// Create the container
JPAContainer<CelestialBody> bodies =
    JPAContainerFactory.make(CelestialBody.class, "my-unit");

// Set it up for hierarchical representation
bodies.setParentProperty("parent");

// Bind it to a hierarchical component
Tree tree = new Tree("Celestial Bodies", bodies);
```

```
tree.setItemCaptionMode(Tree.ITEM_CAPTION_MODE_PROPERTY);
tree.setItemCaptionPropertyId("name");
```

You can use the `rootItemIds()` to acquire the item IDs of the root elements with no parent.

```
// Expand the tree
for (Object rootId: bodies.rootItemIds())
    tree.expandItemsRecursively(rootId);
```

## Unsupported Hierarchical Features

Using `setParent()` in the container to define parenthood is not supported.

Also, the current implementation does not support `setChildrenAllowed()`, which controls whether the user can expand a node by clicking a toggle. The toggle is by default visible for all nodes, even if they have no children. The method is not supported because it would require storing the information outside the entities. You can override `areChildrenAllowed()` to implement the functionality using a custom logic.

```
// Customize JPAContainer to define the logic for
// displaying the node expansion indicator
JPAContainer<CelestialBody> bodies =
    new JPAContainer<CelestialBody>(CelestialBody.class) {
        @Override
        public boolean areChildrenAllowed(Object itemId) {
            // Some simple logic
            return getChildren(itemId).size() > 0;
        }
    };
bodies.setEntityProvider(
    new CachingLocalEntityProvider<CelestialBody>(
        CelestialBody.class, em));
```

## 19.5. Entity Providers

Entity providers provide access to entities persisted in a data store. They are essentially wrappers over a JPA entity manager with optimizations and other features important when binding persistent data to a user interface.

The choice and use of entity providers is largely invisible if you create your **JPAContainer** instances with the **JPAContainerFactory**, which hides such details.

JPAContainer entity providers can be customized, which is necessary for some purposes. Entity providers can be Enterprise JavaBeans (EJBs), which is useful when you use them in a Java EE application server.

### 19.5.1. Built-In Entity Providers

JPAContainer includes various kinds of built-in entity providers: caching and non-caching, read-write and read-only, and batchable.

*Caching* is useful for performance, but takes some memory for the cache and makes the provider stateful. *Batching*, that is, running updates in larger batches, can also enhance performance and be used together with caching. It is stateless, but doing updates is a bit more complex than otherwise.

Using a *read-only* container is preferable if read-write capability is not needed.

All built-in providers are *local* in the sense that they provide access to entities using a local JPA entity manager.

The **CachingMutableLocalEntityProvider** is usually recommended as the first choice for read-write access and **CachingLocalEntityProvider** for read-only access.

## LocalEntityProvider

A read-only, lazy loading entity provider that does not perform caching and reads its data directly from an entity manager.

You can create the provider with `makeNonCachedReadOnly()` method in **JPAContainerFactory**.

## MutableLocalEntityProvider

Extends **LocalEntityProvider** with write support. All changes are directly sent to the entity manager.

Transactions can be handled either internally by the provider, which is the default, or by the container. In the latter case, you can extend the class and annotate it, for example, as described in Section 19.5.1, “Built-In Entity Providers”.

The provider can notify about updates to entities through the `EntityProviderChangeNotifier` interface.

## BatchableLocalEntityProvider

A simple non-caching implementation of the `BatchableEntityProvider` interface. It extends **MutableLocalEntityProvider** and simply passes itself to the `batchUpdate()` callback method. This will work properly if the entities do not contain any references to other entities that are managed by the same container.

## CachingLocalEntityProvider

A read-only, lazy loading entity provider that caches both entities and query results for different filter/sortBy combinations. When the cache gets full, the oldest entries in the cache are removed. The maximum number of entities and entity IDs to cache for each filter/sortBy combination can be configured in the provider. The cache can also be manually flushed. When the cache grows full, the oldest items are removed.

You can create the provider with `makeReadOnly()` method in **JPAContainerFactory**.

## CachingMutableLocalEntityProvider

Just like **CachingLocalEntityProvider**, but with read-write access. For read access, caching works just like in the read-only provider. When an entity is added or updated, the cache is flushed in order to make sure the added or updated entity shows up correctly when using filters and/or sorting. When an entity is removed, only the filter/sortBy-caches that actually contain the item are flushed.

This is perhaps the most commonly entity provider that you should consider using for most tasks. You can create it with the `make()` method in **JPAContainerFactory**.

## CachingBatchableLocalEntityProvider

This provider supports making updates in *batches*. You need to implement a `BatchUpdateCallback` that does all the updates and execute the batch by calling `batchUpdate()` on the provider.

The provider is an extension of the **CachingMutableLocalEntityProvider** that implements the `BatchableEntityProvider` interface. This will work properly if the entities do not contain any references to other entities that are managed by the same container.

You can create the provider with `makeBatchable()` method in **JPAContainerFactory**.

## 19.5.2. Using JNDI Entity Providers in JEE6 Environment

JPAContainer 2.0 introduced a new set of entity providers specifically for working in a JEE6 environment. In a JEE environment, you should use an entity manager provided by the application server and, usually, JTA transactions instead of transactions provided by JPA. Entity providers in `com.vaadin.addon.jpaccontainer.provider.jndijta` package work mostly the same way as the normal providers discussed earlier, but use JNDI lookups to get reference to an `EntityManager` and to a JTA transaction.

The JNDI providers work with almost no special configuration at all. The **JPAContainerFactory** has factory methods for creating various JNDI provider types. The only thing that you commonly need to do is to expose the `EntityManager` to a JNDI address. By default, the JNDI providers look for the `EntityManager` from "java:comp/env/persistence/em". This can be done with the following snippet in `web.xml` or with similar configuration with annotations.

```
<persistence-context-ref>
    <persistence-context-ref-name>
        persistence/em
    </persistence-context-ref-name>
    <persistence-unit-name>MYPU</persistence-unit-name>
</persistence-context-ref>
```

The "MYPU" is the identifier of your persistence unit defined in your `persistence.xml` file.

If you choose to annotate your servlets (instead of using the `web.xml` file as described above), you can simply add the following annotation to your servlet.

```
@PersistenceContext(name="persistence/em", unitName="MYPU")
```

If you wish to use another address for the persistence context, you can define them with the `setJndiAddresses()` method. You can also define the location for the JTA **UserTransaction**, but that should be always accessible from "java:comp/UserTransaction" by the JEE6 specification.

## 19.5.3. Entity Providers as Enterprise Beans

Entity providers can be Enterprise JavaBeans (EJB). This may be useful if you use JPAContainer in a Java EE application server. In such case, you need to implement a custom entity provider that allows the server to inject the entity manager.

For example, if you need to use Java Transaction API (JTA) for JPA transactions, you can implement such entity provider as follows. Just extend a built-in entity provider of your choice and annotate the entity manager member as `@PersistenceContext`. Entity providers can be either stateless or stateful session beans. If you extend a caching entity provider, it has to be stateful.

```
@Stateless
@TransactionManagement
public class MyEntityProviderBean extends
    MutableLocalEntityProvider<MyEntity> {

    @PersistenceContext
    private EntityManager em;

    protected LocalEntityProviderBean() {
        super(MyEntity.class);
        setTransactionsHandledByProvider(false);
    }

    @Override
    @TransactionAttribute(TransactionAttributeType.REQUIRED)
    protected void runInTransaction(Runnable operation) {
        super.runInTransaction(operation);
    }

    @PostConstruct
    public void init() {
        setEntityManager(em);
        /*
         * The entity manager is transaction-scoped, which means
         * that the entities will be automatically detached when
         * the transaction is closed. Therefore, we do not need
         * to explicitly detach them.
         */
        setEntitiesDetached(false);
    }
}
```

If you have more than one EJB provider, you might want to create an abstract super class of the above and only define the entity type in implementations. You can implement an entity provider as a managed bean in Spring Framework the same way.

## 19.6. Filtering JPACContainer

Normally, a **JPACContainer** contains all instances of a particular entity type in the persistence context. Hence, it is equivalent to a database table or query. Just like with database queries, you often want to narrow the results down. **JPACContainer** implements the `Filterable` interface in Vaadin containers, described in Section 8.5.7, “**Filterable** Containers”. All filtering is done at the database level with queries, not in the container.

For example, let us filter all the people older than 117:

```
Filter filter = new Compare.Greater("age", 117);
persons.addContainerFilter(filter);
```

This would create a JPQL query somewhat as follows:

```
SELECT id FROM Person WHERE (AGE > 117)
```

The filtering implementation uses the JPA 2.0 Criteria API transparently. As the filtering is done at the database-level, custom filters that use the `Filterable` API do not work.

When using Hibernate, note that it does not support implicit joins. See Section 19.9.3, “Joins in Hibernate vs EclipseLink” for more details.

## 19.7. Querying with the Criteria API

When the **Filterable** API is not enough and you need to have more control, you can make queries directly with the JPA Criteria API. You may also need to customize sorting or joins, or otherwise modify the query in some way. To do so, you need to implement a **QueryModifierDelegate** that the JPACContainer entity provider calls when making a query. The easiest way to do this is to extend **DefaultQueryModifierDelegate**, which has empty implementations of all the methods so that you can only override the ones you need.

The entity provider calls specific **QueryModifierDelegate** methods at different stages while making a query. The stages are:

1. Start building a query
2. Add "ORDER BY" expression
3. Add "WHERE" expression (filter)
4. Finish building a query

Methods where you can modify the query are called before and after each stage as listed in the following table:

**Table 19.2. QueryModifierDelegate Methods**

queryWillBeBuilt()
orderByWillBeAdded()
orderByWasAdded()
filtersWillBeAdded()
filtersWereAdded()
queryHasBeenBuilt()

All the methods get two parameters. The **CriteriaBuilder** is a builder that you can use to build queries. The **CriteriaQuery** is the query being built.

You can use the `getRoots().iterator().next()` in **CriteriaQuery** to get the "root" that is queried, for example, the **PERSON** table, etc.

### 19.7.1. Filtering the Query

Let us consider a case where we modify the query for a **Person** container so that it includes only people over 116. This trivial example is identical to the one given earlier using the **Filterable** interface.

```
persons.getEntityProvider().setQueryModifierDelegate(  
    new DefaultQueryModifierDelegate () {  
        @Override  
        public void filtersWillBeAdded(  
            CriteriaBuilder criteriaBuilder,  
            CriteriaQuery<?> query,  
            List<Predicate> predicates) {  
            Root<?> fromPerson = query.getRoots().iterator().next();  
            ...  
        }  
    }  
)
```

```
// Add a "WHERE age > 116" expression
Path<Integer> age = fromPerson.<Integer>get("age");
predicates.add(criteriaBuilder.gt(age, 116));
}
});
```

## 19.7.2. Compatibility

When building queries, you should consider the capabilities of the different JPA implementations. Regarding Hibernate, see Section 19.9.3, “Joins in Hibernate vs EclipseLink”.

## 19.8. Automatic Form Generation

The JPAContainer **FieldFactory** is an implementation of the `FormFieldFactory` and `TableFieldFactory` interfaces that can generate fields based on JPA annotations in a POJO. It goes further than the **DefaultFieldFactory**, which only creates simple fields for the basic data types. This way, you can easily create forms to input entities or enable editing in tables.

The generated defaults are as follows:

Annotation	Class Mapping
<code>@ManyToOne</code>	<b>NativeSelect</b>
<code>@OneToOne</code> , <code>@Embedded</code>	<b>Nested Form</b>
<code>@OneToMany</code> , <code>@ElementCollection</code>	<b>MasterDetailEditor</b> (see below)
<code>@ManyToMany</code>	<b>Selectable Table</b>

The field factory is recursive, so that you can edit a complex object tree with one form.

### 19.8.1. Configuring the Field Factory

The **FieldFactory** is highly configurable with various configuration settings and by extending.

The `setMultiSelectType()` and `setSingleSelectType()` allow you to specify a selection component that is used instead of the default for a field with `@ManyToMany` and `@ManyToOne` annotation, respectively. The first parameter is the class type of the field, and the second parameter is the class type of a selection component. It must be a sub-class of **AbstractSelect**.

The `setVisibleProperties()` controls which properties (fields) are visible in generated forms, subforms, and tables. The first parameter is the class type for which the setting should be made, followed by the IDs of the visible properties.

The configuration should be done before binding the form to a data source as that is when the field generation is done.

Further configuration must be done by extending the many protected methods. Please see the API documentation for the complete list.

## 19.8.2. Using the Field Factory

The most basic use case for the JPAContainer **FieldFactory** is with a **Form** bound to a container item:

```
// Have a persistent container
final JPAContainer<Country> countries =
    JPAContainerFactory.make(Country.class, "book-examples");

// For selecting an item to edit
final ComboBox countrySelect =
    new ComboBox("Select a Country", countries);
countrySelect.setItemCaptionMode(Select.ITEM_CAPTION_MODE_PROPERTY);
countrySelect.setItemCaptionPropertyId("name");

// Country Editor
final Form countryForm = new Form();
countryForm.setCaption("Country Editor");
countryForm.addStyleName("bordered"); // Custom style
countryForm.setWidth("420px");
countryForm.setBuffered(true);
countryForm.setEnabled(false);

// When an item is selected from the list...
countrySelect.addValueChangeListener(new ValueChangeListener(){
    @Override
    public void valueChange(ValueChangeEvent event) {
        // Get the item to edit in the form
        Item countryItem =
            countries.getItem(event.getProperty().getValue());

        // Use a JPAContainer field factory
        // - no configuration is needed here
        final FieldFactory fieldFactory = new FieldFactory();
        countryForm.setFormFieldFactory(fieldFactory);

        // Edit the item in the form
        countryForm.setItemDataSource(countryItem);
        countryForm.setEnabled(true);

        // Handle saves on the form
        final Button save = new Button("Save");
        countryForm.getFooter().removeAllComponents();
        countryForm.getFooter().addComponent(save);
        save.addClickListener(new ClickListener() {
            @Override
            public void buttonClick(ClickEvent event) {
                try {
                    countryForm.commit();
                    countryForm.setEnabled(false);
                } catch (InvalidValueException e) {
                }
            }
        });
    }
});
countrySelect.setImmediate(true);
countrySelect.setNullSelectionAllowed(false);
```

This would create a form shown in Figure 19.6, “Using FieldFactory with One-to-Many Relationship”.

**Figure 19.6. Using FieldFactory with One-to-Many Relationship**

AGE	NAME
116	Tane Ikai
116	Kamato Hongo

If you use Hibernate, you also need to pass an **EntityManagerPerRequestHelper**, either for the constructor or with `setEntityManagerPerRequestHelper()`, as described in Section 19.9.2, “The EntityManager-Per-Request pattern”.

### 19.8.3. Master-Detail Editor

The **MasterDetailEditor** is a field component that allows editing an item property that has one-to-many relationship. The item can be a row in a table or bound to a form. It displays the referenced collection as an editable **Table** and allows adding and removing items in it.

You can use the **MasterDetailEditor** manually, or perhaps more commonly use a JPAContainer **FieldFactory** to create it automatically. As shown in the example in Figure 19.6, “Using FieldFactory with One-to-Many Relationship”, the factory creates a **MasterDetailEditor** for all properties with a `@OneToMany` or an `@ElementCollection` annotation.

## 19.9. Using JPAContainer with Hibernate

Hibernate needs special handling in some cases.

### 19.9.1. Lazy loading

In order for lazy loading to work automatically, an entity must be attached to an entity manager. Unfortunately, Hibernate can not keep entity managers for long without problems. To work around the problem, you need to use a special lazy loading delegate for Hibernate.

JPAContainer entity providers handle lazy loading in delegates defined by the `LazyLoadingDelegate` interface. The default implementation for Hibernate is defined in `HibernateLazyLoad-`

**ingDelegate**. You can instantiate one and use it in an entity provider with `setLazyLoadingDelegate()`.

The default implementation works so that whenever a lazy property is accessed through the Vaadin Property interface, the value is retrieved with a separate (JPA Criteria API) query using the currently active entity manager. The value is then manually attached to the entity instance, which is detached from the entity manager. If this default implementation is not good enough, you may need to make your own implementation.

## 19.9.2. The EntityManager-Per-Request pattern

One issue with Hibernate is that it is designed for short-lived sessions, but the lifetime of an entity manager is normally roughly that of a user session. The problem is that if an error occurs in a session or an entity manager, the manager becomes unuseable. This causes big problems with long-lived sessions that would work fine with EclipseLink.

The recommended solution is to use the *EntityManager-per-Request* pattern. It is highly recommended always when using Hibernate.

An entity manager can only be open during the request-response cycle of the Vaadin servlet, so that one is created at the beginning of the request and closed at the end.

### Storing an Entity Manager

You first need to implement an `EntityManagerProvider` that returns a stored `EntityManager` with `getEntityManager()`. The entity manager must be stored in a **ThreadLocal** variable.

```
public class LazyHibernateEntityManagerProvider
    implements EntityManagerProvider {
    private static ThreadLocal<EntityManager>
        entityManagerThreadLocal =
        new ThreadLocal<EntityManager>();

    @Override
    public EntityManager getEntityManager() {
        return entityManagerThreadLocal.get();
    }

    public static void setCurrentEntityManager(
        EntityManager em) {
        entityManagerThreadLocal.set(em);
    }
}
```

You need to create and store the per-request instance at the beginning of each request with `setCurrentEntityManager()` and clear it at the end by setting it as `null`.

### Creating Entity Managers in a Servlet Filter

You can create the entity managers for each request either by extending `VaadinServlet` and overriding the `service()` method or by implementing a servlet filter. In the following, we describe how to implement a servlet filter to do the task, but overriding the servlet could be even easier.

```
public class LazyHibernateServletFilter
    implements Filter {

    private EntityManagerFactory entityManagerFactory;
```

```
    @Override
    public void init(FilterConfig filterConfig)
        throws ServletException {
        entityManagerFactory = Persistence
            .createEntityManagerFactory("lazyhibernate");
    }

    @Override
    public void doFilter(ServletRequest servletRequest,
                         ServletResponse servletResponse,
                         FilterChain filterChain)
        throws IOException, ServletException {
        try {
            // Create and set the entity manager
            LazyHibernateEntityManagerProvider
                .setCurrentEntityManager(
                    entityManagerFactory
                        .createEntityManager());
            // Handle the request
            filterChain.doFilter(servletRequest,
                                 servletResponse);
        } finally {
            // Reset the entity manager
            LazyHibernateEntityManagerProvider
                .setCurrentEntityManager(null);
        }
    }

    @Override
    public void destroy() {
        entityManagerFactory = null;
    }
}
```

You need to define the servlet filter in the `web.xml` deployment descriptor as follows:

```
<filter>
    <filter-name>LazyHibernateServletFilter</filter-name>
    <filter-class>com.example.LazyHibernateServletFilter</filter-class>
</filter>
<filter-mapping>
    <filter-name>LazyHibernateServletFilter</filter-name>
    <url-pattern>/*</url-pattern>
</filter-mapping>
```

The `url-pattern` must match the pattern for your Vaadin servlet.

### 19.9.3. Joins in Hibernate vs EclipseLink

EclipseLink supports implicit joins, while Hibernate requires explicit joins. In SQL terms, an explicit join is a "FROM a INNER JOIN b ON a.bid = b.id" expression, while an implicit join is done in a WHERE clause, such as: "FROM a,b WHERE a.bid = b.id".

In a JPAContainer filter with EclipseLink, an implicit join would have form:

```
new Equal("skills.skill", s)
```

In Hibernate you would need to use **JoinFilter** for the explicit join:

```
new JoinFilter("skills", new Equal("skill", s))
```

---

# Chapter 20

# Mobile Applications with TouchKit

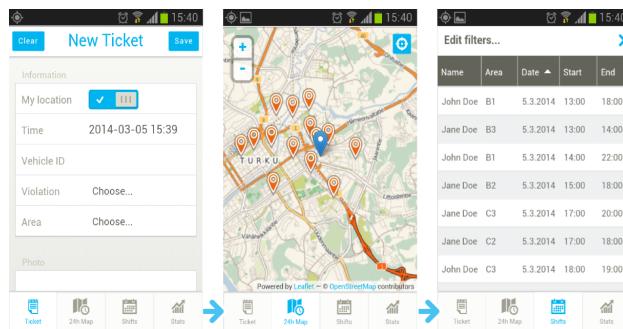
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This chapter describes how to create mobile applications using the Vaadin TouchKit.

## 20.1. Overview

Web browsing is becoming ever increasingly mobile and web applications need to satisfy users with both desktop computers and mobile devices, such as phones and tablets. While the mobile browsers can show the pages just like in regular browsers, the screen size, finger accuracy, and mobile browser features need to be considered to make the experience more pleasant. Vaadin TouchKit gives the power of Vaadin for creating mobile user interfaces that complement the regular web user interfaces of your applications. Just like the purpose of the Vaadin Framework is to make desktop-like web applications, the purpose of TouchKit is to allow creation of web applications that give the look and feel of native mobile applications.

**Figure 20.1. The Parking Demo for Vaadin TouchKit**



Creating a mobile UI is much like creating a regular Vaadin UI. You can use all the regular Vaadin components and add-ons available from Vaadin Directory, but most importantly, you can use the special TouchKit components that are optimized for mobile devices.

```
@Theme( "mobiletheme" )
@Widgetset( "com.example.myapp.MyAppWidgetSet" )
@Title("My Mobile App")
public class SimplePhoneUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        // Define a view
        class MyView extends NavigationView {
            public MyView() {
                super("Planet Details");

                CssLayout content = new CssLayout();
                setContent(content);

                VerticalComponentGroup group =
                    new VerticalComponentGroup();
                content.addComponent(group);

                group.addComponent(new TextField("Planet"));
                group.addComponent(new NumberField("Found"));
                group.addComponent(new Switch("Probed"));

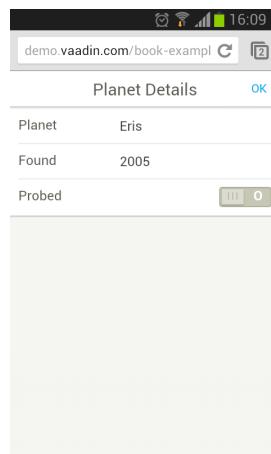
                setRightComponent(new Button("OK"));
            }
        }

        // Use it as the content root
        setContent(new MyView());
    }
}
```

```
    }  
    ...  
}
```

The above example omits the definition of the servlet class, does not have any UI logic yet, and you would normally implement some views, etc. The resulting UI is shown in Figure 20.2, “Simple TouchKit UI”.

**Figure 20.2. Simple TouchKit UI**



TouchKit supports many special mobile browser features, such as geolocation, context-specific input fields, and home screen launching. On iOS, special features such as splash screen and web app mode are supported.

In addition to developing regular server-side UIs, TouchKit allows a special *offline mode*, which is a client-side Vaadin UI that is stored in the browser cache and switched to automatically when the network connection is not available, either when starting the application or while using it. For more information, see Section 20.9, “Offline Mode”.

In this chapter, we first consider some special aspects of mobile browsing. Then, we look how to create a project that uses TouchKit. TouchKit offers a number of specialized mobile components, which are described in a dedicated section. We treat phone and tablet applications separately, and discuss testing briefly.

## TouchKit Demos

The Parking Demo showcases the most important TouchKit features for a mobile location-based business application. The app itself is for helping parking enforcement officers write parking tickets on the streets. It uses geolocation, image acquisition from the camera of the mobile device, map navigation, data visualization with Vaadin Charts, and dynamic UIs with responsive layouts. You can try it out at <http://demo.vaadin.com/parking>. See Section 20.4, “Importing the Parking Demo” for instructions for importing the project in Eclipse. The source code is available and browseable at Github.

Mobile Mail is another demo application, which shows how to implement browsing of deep category trees and make forms. You can try it out at <http://demo.vaadin.com/mobilemail>. You can browse the source code of the demo at Github.

Some of the examples given in this chapter can be seen in action at [demo.vaadin.com/touchkit-sampler](http://demo.vaadin.com/touchkit-sampler). You can browse the source code at the source repository or clone it with Git.

## Licensing

Vaadin TouchKit is a commercial product licensed under a dual-licensing scheme. The AGPL license allows open-source development, while the CVAL license needs to be purchased for closed-source use, including web deployments and internal use. Commercial licenses can be purchased from Vaadin Directory, where you can also find the license details and download Vaadin TouchKit.

## 20.2. Considerations Regarding Mobile Browsing

When developing web applications that support mobile browsing, you need to consider various issues that are different from non-mobile use. TouchKit is designed to help with these issues.

### 20.2.1. Mobile Human Interface

Mobile devices use very different human interfaces than regular computers. For example, the screen can be rotated easily to switch between portrait and landscape views. This does not just change the dimensions of the display, but also affects how to arrange components for the best user experience. In addition to TouchKit, responsive layouts help in allowing flexible layouts, as described in Section 7.9, “Responsive Themes”.

The user interface is used with a finger instead of a mouse, so there are no features such as “right-finger-button”. When using a mouse you can click double-click or right-click, but on a touch device, you are using interactions such as tap and “long tap”. Finger gestures also play a large role, such as using a vertical swipe gesture for scrolling instead of a scroll bar. Some browsers also allow using two- or multiple-finger gestures.

There is normally no physical keyboard, but an on-screen keyboard, which can change depending on the context. You also need to ensure that it does not hide the input field to which the user is trying to enter data when it pops up. This should be handled by the browser, but is among the issues that requires special testing.

### 20.2.2. Bandwidth and Performance

Mobile Internet connections are often significantly slower than with fixed lines. With a low-end mobile connection, such as 384 kbps, just loading the Vaadin client-side engine can take several seconds. This can be helped by compiling a widget set that includes only the widgets for the used components, as described in Section 20.10, “Building an Optimized Widget Set”, by compiling the theme into the widget set, and so forth.

Even with mobile broadband, the latency can be significant factor, especially with highly interactive rich applications. The latency is usually almost unnoticeable in fixed lines, typically less than 100 ms, while mobile Edge connections typically have latency around 500 ms, and sometimes much higher during hiccups. You may need to limit the use of the immediate mode, text change events, and polling. The latency compensation in some components, such as **NavigationManager**, allows view change animations to occur while the server request to display the result is being made.

Further, the choice of components affects performance. TouchKit components are designed to be light-weight. Of the other Vaadin components, some are more light-weight than others. Especially, most other layout components have a more deeper DOM structure and are slower to render than the light-weight **CssLayout**. TouchKit also includes special styling for **CssLayout**.

### 20.2.3. Mobile Features

Phones and tablets have many integrated features that are often available in the browser interface as well. Location-awareness is one of the most recent features. And of course, you can also make phone calls.

### 20.2.4. Compatibility

The mobile browsing field is currently evolving at a quick pace and the special conventions introduced by leading manufacturers may, in the next few years, stabilize as new web standards. The browser support in TouchKit originally concentrated on WebKit, which appears to be emerging as the leading mobile browser core. In addition to Apple's products, also the default browser in Android uses WebKit as the layout engine. Yet they have differences, as the Android's JavaScript engine, which is highly relevant for Vaadin, is the Google Chrome's V8 engine. As of TouchKit 4, Internet Explorer on Windows Phone is also supported.

For the list of devices supported by the latest TouchKit version, see the TouchKit product page at the Vaadin site.

Vaadin TouchKit aims to follow the quickly evolving APIs of these major platforms, with the assumption that other browsers will follow their lead in standardization. Other platforms will be supported if they rise in popularity.

#### Back Button

Some mobile devices, especially Android and Windows Phone devices, have a dedicated back button, while iOS devices in particular do not. TouchKit does not provide any particular support for the button, but as it is a regular browser back button, you can handle it with URI fragments, as described in Section 11.11, “Managing URI Fragments”. For iOS, the browser back button is hidden if the user adds the application to the home screen, in which case you need to implement application-specific logic for the back-navigation.

## 20.3. Installing Vaadin TouchKit

You can download and install TouchKit from Vaadin Directory at [vaadin.com/addon/vaadin-touchkit](http://vaadin.com/addon/vaadin-touchkit) as an installation package, or get it with Maven or Ivy. If your project is not compatible with the AGPL license, you can purchase CVAL licenses from Vaadin Directory or subscribe to the Pro Tools package at [vaadin.com/pro](http://vaadin.com/pro).

Add-on installation is described in detail in Chapter 17, *Using Vaadin Add-ons*. The add-on includes a widget set, so you need to compile the widget set for your project.

### 20.3.1. Installing as Ivy Dependency

If you use the add-on in an Eclipse project created with the Vaadin Plugin for Eclipse, you can define an Ivy dependency to automatically download the library. Include the following declaration inside the dependencies section in the `ivy.xml`:

```
<dependency org="com.vaadin.addon"
           name="vaadin-touchkit-agpl"
           rev="latest.release"
           conf="default->default" />
```

You can use `latest.release` revision tag to always use the latest release or specify a version by its version number. IvyDE should resolve the dependency immediately as you save the file. See Section 17.3, “Installing Add-ons in Eclipse with Ivy” for further details.

### 20.3.2. Defining the Maven Dependency

You can install Vaadin TouchKit in a Maven project by adding it as a dependency, as described below, or by using the Maven archetype, as described in Section 20.5.1, “Using the Maven Archetype”.

To use TouchKit in a Vaadin project, you need to include the following dependency in the POM. The `artifactId` should be `vaadin-touchkit-agpl` or `vaadin-touchkit-cval`, depending on which license suits your project requirements.

```
<dependency>
    <groupId>com.vaadin.addon</groupId>
    <artifactId>vaadin-touchkit-agpl</artifactId>
    <version>LATEST</version>
</dependency>
```

You can use the `LATEST` version as shown above or a specific version by its version number.

You also need to define the repository for the Vaadin add-ons under the `<repositories>` element:

```
<repository>
    <id>vaadin-addons</id>
    <url>http://maven.vaadin.com/vaadin-addons</url>
</repository>
```

Finally, you need to enable the widget set compilation in the POM, as described in Section 17.4.3, “Enabling Widget Set Compilation”, and compile it.

### 20.3.3. Installing the Zip Package

Vaadin TouchKit is distributed as a Zip package that contains the TouchKit JAR, a JavaDoc JAR, license texts, and other documentation. You can download the Zip package from Vaadin Directory. A different package is provided for each of the two licenses, and Directory asks for your choice.

The TouchKit JAR in the package should be put in the `WEB-INF/lib` folder of the web application.

Please see the `README.html` for more information about the package contents.

## 20.4. Importing the Parking Demo

The Parking Demo, illustrated in Figure 20.1, “The Parking Demo for Vaadin TouchKit” in the overview, showcases most of the functionality in Vaadin TouchKit. You can try out the demo online with a TouchKit-compatible browser at [demo.vaadin.com/parking](http://demo.vaadin.com/parking).

You can browse the sources on-line or, more conveniently, import the project in Eclipse (or other IDE). As the project is Maven-based, Eclipse users need to install the m2e plugin to be able to import Maven projects, as well as EGit to be able to import Git repositories. Once they are installed, you should be able to import Parking Demo as follows.

1. Select **File → Import**

2. Select **Maven** **Check out Maven Project from SCM**, and click **Next**.
3. You may need to install the EGit SCM connector if you have not done so previously. If Git is not available in the SCM list, click **m2e marketplace**, select the EGit connector, and click **Finish**. You need to restart Eclipse and redo the earlier steps above.

Instead of using m2e EGit connector, you can also check out the project with another Git tool and then import it in Eclipse as a Maven project.
4. In **SCM URL**, select **git** and enter the repository URL `https://github.com/vaadin/parking-demo`.
5. Click **Finish**.
6. Compile the widget set either by clicking **Compile Widgetset** in the Eclipse toolbar or by running the `vaadin:compile` goal with Maven.
7. Deploy the application to a server. See Section 2.5.4, “Setting Up and Starting the Web Server” for instructions for deploying in Eclipse.
8. Open the URL `http://localhost:8080/parking` with a mobile device or a WebKit-compatible browser, such as Safari or Chrome, to run the Parking Demo.

## 20.5. Creating a New TouchKit Project

The easiest ways to create a new TouchKit application project are to either use the Maven archetype or create the project as a regular Vaadin project with the Vaadin Plugin for Eclipse and then modify it for TouchKit.

### 20.5.1. Using the Maven Archetype

You can create a new TouchKit application project using the Maven `vaadin-archetype-touchkit` archetype. Creating Vaadin projects with Maven is described in more detail in Section 2.6, “Using Vaadin with Maven”.

For example, to create a project from the command-line, you could do:

```
$ mvn archetype:generate \
-DarchetypeGroupId=com.vaadin \
-DarchetypeArtifactId=vaadin-archetype-touchkit \
-DarchetypeVersion=4.0.0 \
-DgroupId=example.com -DartifactId=myproject \
-Dversion=0.1.0 \
-DapplicationName=My -Dpackaging=war
```

The `ApplicationName` parameter for the archetype is used as a prefix for the various stub class names. For example, the above “My” name results in classes such as **MyTouchKitUI**.

The generated project has the following source files:

`MyTouchKitUI.java`

The mobile UI for the TouchKit application. See Section 20.6.4, “The UI” for the basics of a TouchKit UI. The example UI uses **TabBarView** as the content. The first tab features a **MenuView** (see below), a navigation view stub defined in the project.

**MyFallbackUI.java**

A fallback UI for browsers unsupported by TouchKit, such as regular desktop browsers. See Section 20.8.1, “Providing a Fallback UI” for more information about fallback UIs.

**MyServlet.java**

The servlet class for the UI, defined using the `@WebServlet` annotation in Servlet API 3.0. The generated servlet customizes TouchKit to define the **MyUIProvider**, which sets the fallback UI. See Section 20.6.1, “The Servlet Class” for more details about defining a custom servlet to customize TouchKit.

**MyUIProvider.java**

Creates either the **MyTouchKitUI** for supported mobile browsers or **MyFallbackUI** for unsupported browsers. See Section 20.8.1, “Providing a Fallback UI” for more information about fallback UIs.

**MenuView.java**

Presents a stub for a menu view. The menu is made of **NavigationButtons** laid out in a **VerticalComponentGroup**. Clicking a button navigates to another view; in the stub to a **FormView** (see below).

**FormView.java**

Presents a stub for a data input form.

**gwt/AppWidgetSet.gwt.xml**

Widget set descriptor for the project. When compiled, it is automatically updated to include possible other add-on widget sets in the project.

**gwt/client/MyOfflineDataService.java**

A data service stub for storing data in the offline mode. See Section 20.9, “Offline Mode”.

**gwt/client/MyPersistToServerRpc.java**

Client-to-Server RPC stub to persist offline data to the server-side.

If you import the project to Eclipse or other IDE, you at least need to compile the widget set to be able to deploy the project. You can do that with Maven integration in the IDE, or from command-line with:

```
$ mvn vaadin:compile
```

See Section 2.6, “Using Vaadin with Maven”. At least in Eclipse, you should now be able to import and deploy the project to a development server. You can also compile the project and launch it in a Jetty web server (port 8080) from command-line as follows:

```
$ mvn package  
$ mvn jetty:run
```

Note that a project generated by the archetype defines the servlet with the `@WebServlet` annotation defined in Servlet API 3.0. The application server must support Servlet 3.0. For example, if you use Tomcat, you need at least Tomcat 7.

## 20.5.2. Starting from a New Eclipse Project

You can create a new TouchKit project from a regular Vaadin project created with the Vaadin Plugin for Eclipse (see Section 2.5, “Creating and Running a Project with Eclipse”).

After creating the project, you need to do the following tasks:

1. Install the TouchKit library in the project by including it in the `ivy.xml`, as described in Section 20.3.1, “Installing as Ivy Dependency”, and compile the widget set.
2. Extend `TouchkitServlet` instead of `VaadinServlet` in the servlet class, as described in Section 20.6.1, “The Servlet Class”. It is recommended that you extract the static inner class created by the wizard to a regular class, as you most probably need to do additional configuration in it.

```
@WebServlet(value = "/*",
             asyncSupported = true)
@VaadinServletConfiguration(
    productionMode = false,
    ui = MyMobileUI.class)
public class MyProjectServlet extends TouchkitServlet {  
}
```

3. If you intend to define a fallback UI later, as described in Section 20.8.1, “Providing a Fallback UI”, you may want to copy the original UI class stub to use it as a fallback UI class.
4. To get started quickly, disable the use of custom theme by using `@Theme( "touchkit" )` in the UI class. To create a custom mobile theme later, see Section 20.6.6, “Mobile Theme”.

```
@Theme( "touchkit" )
public class MyMobileUI extends UI {
```

5. Build the mobile UI preferring TouchKit components instead of the core Vaadin components, as described in Section 20.6.4, “The UI”.

We cover these and various other tasks in more detail in Section 20.6, “Elements of a TouchKit Application”.

## 20.6. Elements of a TouchKit Application

At minimum, a TouchKit application requires a UI class, which is defined in a deployment descriptor, as usual for Vaadin applications. You usually define a servlet class, where you can also do some TouchKit-specific configuration. You may also need to have a custom theme. These and other tasks are described in the following subsections.

### 20.6.1. The Servlet Class

When using a Servlet 3.0 compatible application server, you usually define the UI and make basic configuration with a servlet class with the `@WebServlet` annotation. Vaadin Plugin for Eclipse creates the servlet class as a static inner class of the UI class, while the Maven archetype creates it as a separate class, which is usually the preferred way.

The servlet class must define the UI class as usual. Additionally, you can configure the following TouchKit features in the servlet class:

- Customize bookmark or home screen icon
- Customize splash screen image

- Customize status bar in iOS
- Use special web app mode in iOS
- Provide a fallback UI (Section 20.8.1, “Providing a Fallback UI”)
- Enable offline mode

A custom servlet should normally extend the **TouchKitServlet**. You should place your code in `servletInitialized()` and call the super method in the beginning.

```
public class MyServlet extends TouchKitServlet {  
    @Override  
    protected void servletInitialized() throws ServletException {  
        super.servletInitialized();  
  
        ... customization ...  
    }  
}
```

If you need to rather extend some other servlet, possibly in another add-on, it should be trivial to reimplement the functionality of **TouchKitServlet**, which is just to manage the TouchKit settings object.

If using `web.xml` deployment descriptor instead of the `@WebServlet`, you only need to implement custom servlet class if you need to do any of the above configuration, which you typically need to do.

## 20.6.2. Defining Servlet and UI with `web.xml` Deployment Descriptor

If using an old style `web.xml` deployment descriptor, you need to define the special **TouchKitServlet** class instead of the regular **VaadinServlet** in the `web.xml` deployment descriptor. Often you need to make some configuration or add special logic in a custom servlet, as described in the previous section, in which case you need to define your servlet in the deployment descriptor.

```
<servlet>  
    <servlet-name>Vaadin UI Servlet</servlet-name>  
    <servlet-class>  
        com.vaadin.addon.touchkit.server.TouchKitServlet  
    </servlet-class>  
    <init-param>  
        <description>Vaadin UI class to start</description>  
        <param-name>ui</param-name>  
        <param-value>com.example.myapp.MyMobileUI</param-value>  
    </init-param>  
</servlet>
```

## 20.6.3. TouchKit Settings

TouchKit has a number of settings that you can customize for your needs. The **TouchKitSettings** configuration object is managed by **TouchKitServlet**, so if you make any modifications to it, you need to implement a custom servlet, as described earlier.

```
public class MyServlet extends TouchKitServlet {  
    @Override  
    protected void servletInitialized() throws ServletException {  
        super.servletInitialized();
```

```
TouchKitSettings s = getTouchKitSettings();
...
}
```

The settings include special settings for iOS devices, which are contained in a separate **IosWebAppSettings** object, available from the TouchKit settings with `getIosWebAppSettings()`.

## Application Icons

The location bar, bookmarks, and other places can display an icon for the web application. You can set the icon, or more exactly icons, in an **ApplicationIcons** object, which manages icons for different resolutions. The most properly sized icon for the context is used. iOS devices prefer icons with 57x57, 72x72, and 144x144 pixels, and Android devices 36x36, 48x48, 72x72, and 96x96 pixels.

You can add an icon to the application icons collection with `addApplicationIcon()`. You can acquire the base URL for your application from the servlet context, as shown in the following example.

```
TouchKitSettings s = getTouchKitSettings();
String contextPath = getServletConfig()
    .getServletContext().getContextPath();
s.getApplicationIcons().addApplicationIcon(
    contextPath + "VAADIN/themes/mytheme/icon.png");
```

The basic method just takes the icon name, while the other one lets you define its size. It also has a *preComposed* parameter, which when true, instructs Safari from adding effects to the icon in iOS.

## Viewport Settings

The **ViewPortSettings** object, which you can get from the TouchKit settings with `getViewPortSettings()`, manages settings related to the display, most importantly the scaling limitations.

```
TouchKitSettings s = getTouchKitSettings();
ViewPortSettings vp = s.getViewPortSettings();
vp.setViewPortUserScalable(true);
...
```

See the Safari Development Library at the Apple developer's site for more details regarding the functionality in the iOS browser.

## Startup Image for iOS

iOS browser supports a startup (splash) image that is shown while the application is loading. You can set it in the **IosWebAppSettings** object with `setStartupImage()`. You can acquire the base URL for your application from the servlet context, as shown in the following example.

```
TouchKitSettings s = getTouchKitSettings();
String contextPath = getServletConfig().getServletContext()
    .getContextPath();
s.getIosWebAppSettings().setStartupImage(
    contextPath + "VAADIN/themes/mytheme/startup.png");
```

## Web App Capability for iOS

iOS supports a special web app mode for bookmarks added and started from the home screen. With the mode enabled, the client may, among other things, hide the browser's own UI to give more space for the web application. The mode is enabled by a header that tells the browser whether the application is designed to be used as a web application rather than a web page.

```
TouchKitSettings s = getTouchKitSettings();
s.getIosWebAppSettings().setWebAppCapable(true);
```

See the Safari Development Library at the Apple developer's site for more details regarding the functionality in the iOS browser.

## Cache Manifest

The **ApplicationCacheSettings** object manages the cache manifest, which is used to configure how the browser caches the page and other resources for the web app. See Section 20.9, “Offline Mode” for more details about its use.

### 20.6.4. The UI

Mobile UIs extend the **UI** class as usual and construct the user interface from components.

```
@Theme("mobiletheme")
@Widgetset("com.example.myapp.MyAppWidgetSet")
@Title("My Simple App")
public class SimplePhoneUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        // Create the content root layout for the UI
        TabBarView mainView = new TabBarView();
        setContent(mainView);

        ...
    }
}
```

As TouchKit comes with a custom widget set, you need to use a combining widget set for your project, defined with the `@Widgetset` annotation for the UI. The combining widget set descriptor is automatically generated by the Vaadin Plugin for Eclipse and in Maven when you install or define the TouchKit add-on.

Most commonly, you will use a combination of the major three TouchKit components as the basis of the UI: **TabBarView**, **NavigationView**, or **NavigationManager**.

If a offline UI is provided, it needs to be enabled in the initialization of the UI, as described in Section 20.9, “Offline Mode”. This code is included in the project stub created by the Maven archetype.

### 20.6.5. Mobile Widget Set

TouchKit includes a widget set and therefore requires compiling a project widget set that includes it, as described in Chapter 17, *Using Vaadin Add-ons*. The project widget set descriptor is automatically generated during the compilation process, whether you use Maven or the Eclipse plugin.

Note that if you have a TouchKit UI in the same project as a non-TouchKit UI, you probably do not want to compile the TouchKit widget set into its widget set. As the automatic generation of the descriptor includes all the widget sets that it finds from the class path, the result can be unwanted, and you need to edit the widget set descriptor manually.

## 20.6.6. Mobile Theme

You can use both Sass and CSS themes for TouchKit applications, although they are defined a bit differently from regular Vaadin themes. To optimize how a theme is loaded, you can build it into a GWT client bundle.

### Defining a Regular Theme

Using plain CSS is often the easiest way to define a simple theme for a mobile application, as using Sass would not yield all the same benefits as in a regular Vaadin application. TouchKit includes its own base theme in its widget set, so you do not need to @import it explicitly.

A CSS theme is defined in a file located at VAADIN/themes/mymobiletheme/styles.css. As importing the base does not need to (and should not) be done, it could simply be as follows:

```
.stylishlabel {  
    color: red;  
    font-style: italic;  
}
```

You need to set the theme with the @Theme( "mymobiletheme" ) annotation for your UI class, as usual.

You can also use Sass by creating a styles.scss and then compiling it to CSS with the Vaadin theme compiler. However, as above, you should not include a base theme. The rules do not need to be wrapped in a selector with the theme name, as is recommended for regular Vaadin themes.

### Responsive Mobile Themes

The Responsive add-on is especially useful for mobile themes, as it makes it easy to adapt a layout for phones and tablets and for changing the screen orientation. With the add-on, changing the UI layout according to screen orientation is handled entirely on the client-side by the add-on, using special CSS selectors in the theme. See Section 7.9, “Responsive Themes” for details about the add-on.

The Parking Demo uses the add-on. From its source code, which is available at Github, you can learn how the conditional selectors are used in the CSS defined in a GWT client bundle.

For example, the CSS for the **Stats** tab in the Parking demo defines a responsive selector as follows, to allow fitting two charts side-by-side if there is enough room horizontally:

```
.stats .statschart {  
    margin-bottom: 30px;  
    float: left;  
    width: 100%;  
}  
  
.v-ui[width-range~="801px-"] .stats .statschart {  
    width: 48% !important;
```

```
    margin: 0 1%;  
}
```

Normally, if there's 800 pixels or less space horizontally, each chart takes 100% of the screen width, causing the second one to wrap to the next line in the containing **CssLayout**. If there is more space, the two charts are shown in 48% width, so that both can fit in the same line. This follows the flexible wrapping pattern described in the section called "Flexible Wrapping".

## Defining a Theme in a GWT Client Bundle

Using a GWT theme instead of a regular Vaadin theme offers several performance benefits on mobile devices by reducing the number of resources loaded separately. All the resources, such as images and stylesheets, can be loaded with the widget set. Images can be handled as sprites tiled in bundle images.

The GWT CSS classes have their own special format, a bit similar to Sass themes. See GWT Developer's Guide for detailed information about client bundles and how to define image, CSS, and other resources.

To use a GWT client bundle in a TouchKit application, you need to define a *theme loader* that extends the TouchKit **ThemeLoader** and implements the `load()` method to inject the bundle. The theme loader and the client bundle are a client-side classes that are compiled into the widget set, and must therefore be defined under the `client` directory.

For example, in the Parking Demo we have as follows:

```
public class ParkingThemeLoader extends ThemeLoader {  
    @Override  
    public final void load() {  
        // First load the default TouchKit theme...  
        super.load();  
  
        // ... and add Parking Demo CSS from its own bundle  
        ParkingBundle.INSTANCE.fontsCss().ensureInjected();  
        ParkingBundle.INSTANCE.css().ensureInjected();  
        ParkingBundle.INSTANCE.ticketsCss().ensureInjected();  
        ParkingBundle.INSTANCE.statsCss().ensureInjected();  
        ParkingBundle.INSTANCE.shiftsCss().ensureInjected();  
        ParkingBundle.INSTANCE.mapCss().ensureInjected();  
    }  
}
```

You can call `super.load()` to load the default TouchKit theme, but you can omit the call if you do not want to use it. In such case, your GWT theme should import the Vaadin base theme explicitly.

The theme loader must be defined in the `.gwt.xml` widget set descriptor as follows:

```
<replace-with  
    class="com.vaadin.demo.parking.widgetset.client.theme.ParkingThemeLoader">  
  
    <when-type-is  
        class="com.vaadin.addon.touchkit.gwt.client.ThemeLoader" />  
</replace-with>
```

See the Parking Demo sources for a complete example of defining a GWT theme.

## 20.6.7. Using Font Icons

You can use font icons, as described in Section 7.7, “Font Icons”, also with most TouchKit components.

**Figure 20.3. Font Icons in TabBarView**



For example, as is done in the UI stub of a TouchKit project created from the Maven archetype:

```
// Have a tab bar with multiple tab views
TabBarView tabBarView = new TabBarView();

// Have a tab
... create view1 ...
Tab tab1 = tabBarView.addTab(view1);

// Use the "book" icon for the tab
tab1.setIcon(FontAwesome.BOOK);
```

## 20.7. Mobile User Interface Components

TouchKit introduces a number of components special to mobile user interfaces to give better user interaction and to utilize the special features in mobile devices.

### **NavigationView**

A view with a navigation bar (**NavigationBar** for navigating back and forth in a **NavigationManager**.

### **Toolbar**

A horizontal layout especially for buttons. A sub-component of **TabBarView** or **NavigationView**.

### **NavigationManager**

A component container that enables slide animations between the components while the server request is being made for the purpose of latency compensation. The components are typically **NavigationView**s or **SwipeView**s.

### **NavigationButton**

A special button for initiating view change in a **NavigationManager** on the client-side, for the purpose of latency compensation.

### **Popover**

A floating pop-up frame that can be positioned relative to a component.

### **SwipeView**

A view for navigating back and forth in a **NavigationManager** using horizontal swipe gestures.

### **Switch**

A sliding on/off toggle for boolean values.

**VerticalComponentGroup**

A vertical layout for grouping components.

**HorizontalButtonGroup**

A horizontal layout for grouping especially buttons.

**TabBarView**

A tabbed view with a content area on the top and a **Toolbar** for navigating between sub-views on the bottom.

**EmailField, NumberField, and UrlField**

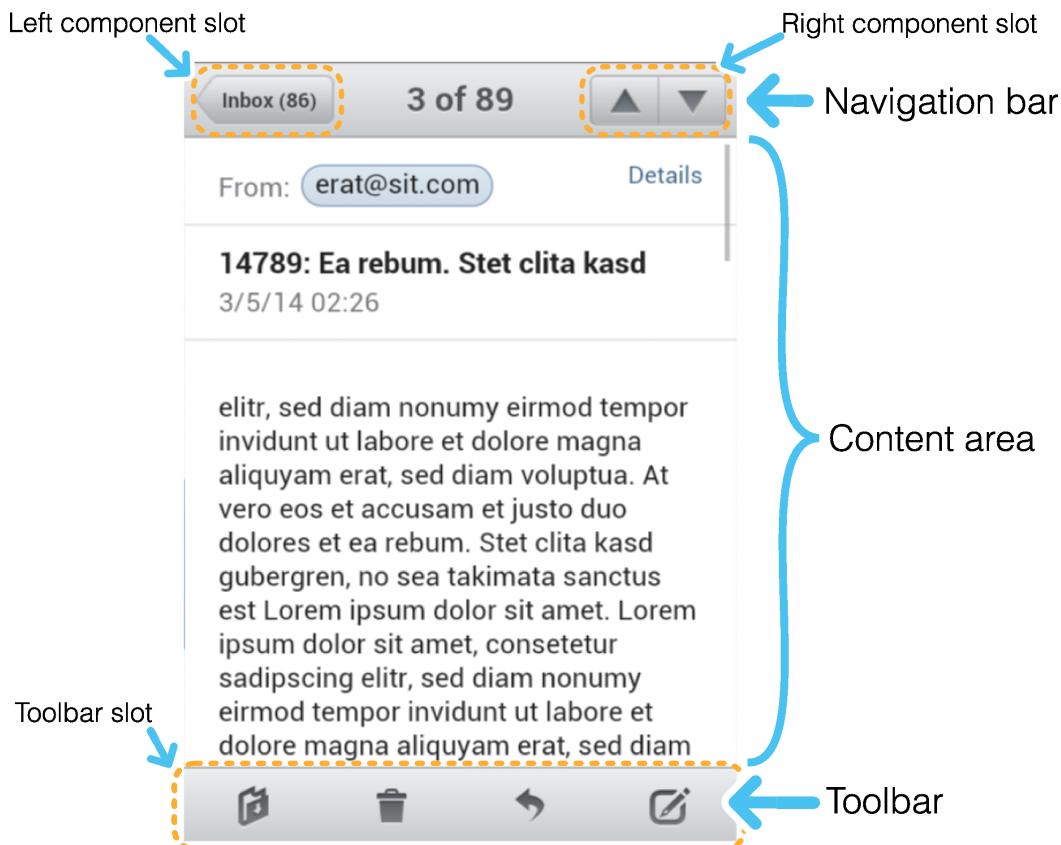
Text fields for inputting specifically email addresses, numbers, and URLs, respectively, with a specific virtual keyboard.

The components are detailed in the following subsections.

### 20.7.1. NavigationView

The **NavigationView** is a layout component that consists of a navigation bar and a content area. The content area is scrollable, so there is no need to use an inner panel component. In addition, there can be an optional toolbar component at the bottom of the view. A **NavigationView** is often used inside a **NavigationManager** to get view change animations.

**Figure 20.4. Layout of the NavigationView**



**NavigationView** has a full size by default. The content area is expanding, so that it takes all the space left over from the navigation bar and toolbar.

## Navigation Bar

The navigation bar at the top of **NavigationView** is a separate **NavigationBar** component. It has two component slots, with one on the left and one on the right. The caption is displayed in the middle. The **NavigationBar** component can be used independently as well.

When the **NavigationBar** is used for navigation and you set the previous component with `setPreviousComponent()`, the left slot is automatically filled with a **Back** button. This is done automatically if you use the **NavigationView** inside a **NavigationManager**.

You can get access to the navigation bar component with `getNavigationBar()` to use its manipulator methods directly, but **NavigationView** also offers some shorthand methods: `setLeftComponent()`, `setRightComponent()`, and a setter and a getter for the caption.

## Toolbar

A slot for an optional toolbar is located at the bottom of the **NavigationView**. The toolbar can be any component, but a **Toolbar** component made for this purpose is included in TouchKit. It is described in Section 20.7.2, “**Toolbar**”. You could also use a **HorizontalLayout** or **CssLayout**.

You usually fill the tool bar with **Button** components with an icon and no textual caption. You set the toolbar with `setToolbar()`.

## Styling with CSS

```
.v-touchkit-navview { }
.v-touchkit-navview-wrapper {}
.v-touchkit-navview-toolbar {}
.v-touchkit-navview .v-touchkit-navview-notoolbar {}
```

The root element has the `v-touchkit-navview` class. The content area is wrapped inside a `v-touchkit-navview-wrapper` element. If the view has a toolbar, the toolbar slot has the `v-touchkit-navview-toolbar` style, but if not, the top-level element has the `v-touchkit-navview-notoolbar` style.

### 20.7.2. Toolbar

The **Toolbar** is a horizontal layout component intended for containing **Button** components. The toolbar has by default 100% horizontal width and a fixed height. The components are spread evenly in the horizontal direction. **Toolbar** is used in a **TabBarView**, as described in Section 20.7.10.

For a description of the inherited features, please refer to Section 6.3, “**VerticalLayout** and **HorizontalLayout**”.

## Styling with CSS

```
.v-touchkit-toolbar { }
```

The component has an overall `v-touchkit-toolbar` style.

### 20.7.3. NavigationManager

The **NavigationManager** is a visual effect component that gives sliding animation when switching between views. You can register three components: the currently displayed component, the

previous one on the left, and the next component on the right. You can set these components with `setCurrentComponent()`, `setPreviousComponent()`, and `setNextComponent()`, respectively.

The **NavigationManager** component is illustrated in Figure 20.5, “**NavigationManager** with Three **NavigationView**s”.

**Figure 20.5. NavigationManager with Three NavigationViews**



The navigation manager is important for responsiveness, because the previous and next components are cached and the slide animation started before server is contacted to load the new next or previous views.

You give the initial view as a parameter for the constructor. Typically, you use a navigation manager as the UI content or inside a **TabBarView**.

```
public class MyUI extends UI {
    @Override
    protected void init(VaadinRequest request) {
        NavigationManager manager =
            new NavigationManager(new MainView());
        setContent(manager);
    }
}
```

## Changing Views

Switching between the views (components) is normally done with predefined navigation targets to enhance responsiveness. Clicking a **NavigationButton** or a button in a navigation bar starts navigation automatically without a server roundtrip. Swipe gestures are supported with the **SwipeView** component.

Navigation can also be done programmatically with the `navigateTo()` method. If breadcrumbs are enabled, the current view is also pushed to the breadcrumb stack. To navigate back, you can call `navigateBack()`, which is also called implicitly if a **Back** button is clicked in a **NavigationView**. Also, if navigation is done to the "previous" component, `navigateBack()` is done implicitly.

When navigation occurs, the current component is moved as the previous or next component, according to the direction of the navigation.

## Handling View Changes

While you can put any components in the manager, some special features are enabled when using the **NavigationView**. When a view becomes visible, the `onBecomingVisible()` method in the view is called. You can override it, just remember to call the superclass method.

```
@Override  
protected void onBecomingVisible() {  
    super.onBecomingVisible();  
  
    ...  
}
```

Otherwise, you can handle navigation changes in the manager with a **NavigationListener**. The `direction` property tells whether the navigation was done forward or backward in the breadcrumb stack, that is, whether navigation was done with `navigateTo()` or `navigateBack`. The current component, accessible with `getCurrentComponent()`, refers to the navigation target component.

```
manager.addNavigationListener(new NavigationListener() {  
    @Override  
    public void navigate(NavigationEvent event) {  
        if (event.getDirection() ==  
            NavigationEvent.Direction.BACK) {  
            // Do something  
            Notification.show("You came back to " +  
                manager.getCurrentComponent().getCaption());  
        }  
    }  
});
```

## Tracking Breadcrumbs

**NavigationManager** also handles *breadcrumb* tracking. The `navigateTo()` pushes the current view on the top of the breadcrumb stack and `navigateBack()` can be called to return to the previous breadcrumb level.

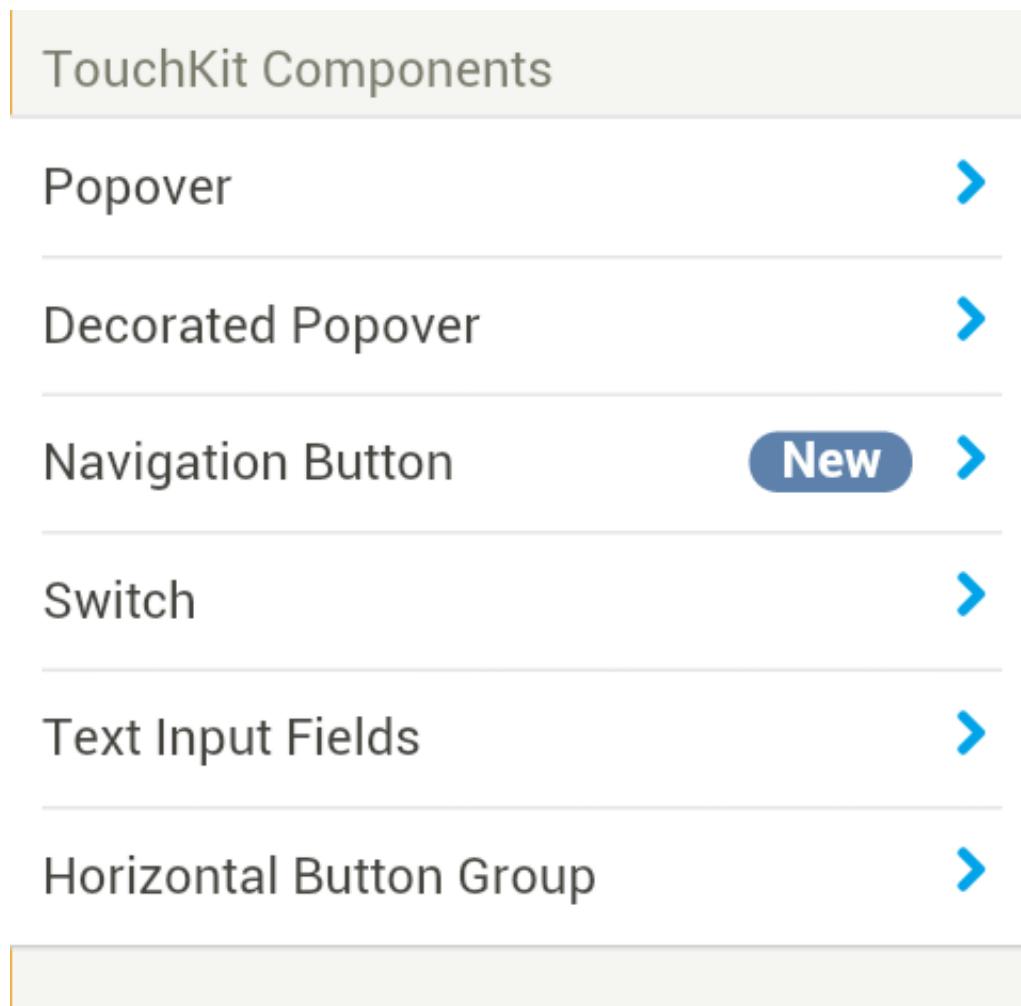
Notice that calling `navigateTo()` with the "previous" component is equivalent to calling `navigateBack()`.

### 20.7.4. NavigationButton

The **NavigationButton** is a special version of the regular **Button** component, designed for navigation inside a **NavigationManager** (see Section 20.7.3, “**NavigationManager**”). Clicking a navigation button will automatically navigate to the defined target view. The view change animation does not need to make a server request first, but starts immediately after clicking the button. If you leave the target view empty, an empty placeholder view is shown in the animation. The view is filled after it gets the content from the server.

A navigation button does not have a particular border by default, because multiple navigation buttons are typically used inside a **VerticalComponentGroup** to create menus, as illustrated in Figure 20.6, “**NavigationButtons** Inside a Vertical Component Group”.

**Figure 20.6. NavigationButtons Inside a Vertical Component Group**



A navigation button has a caption and can have a description and an icon. If not given explicitly, the caption is taken from the caption of the navigation view if it is initialized before the button. The icon is positioned left of the caption, and the description is aligned on the right side of the button.

You can give the target view either in the constructor or with `setTargetView()`, or create it later by handling the button click.

```
// Button caption comes from the view caption  
box.addComponent(new NavigationButton(new PopoverView()));  
  
// Give button caption explicitly  
box.addComponent(new NavigationButton("Decorated Popover",  
    new DecoratedPopoverView()));
```

If the target view is not created or initialized before the button is clicked, it does not yet have a caption during the animation. The default is to use the button caption as a temporary target view caption, but you can set it explicitly with `setTargetViewCaption()`. The temporary caption is shown during the slide animation and until the content for the view has been received from the server. It is then replaced with the proper caption of the view, and you normally want to have it the same. The temporary caption is also used as the caption of button if it is not given explicitly.

```
final NavigationButton navButton = new NavigationButton();
navButton.setTargetViewCaption("Text Input Fields");
navButton.addClickListener(
    new NavigationButtonClickListener() {

        @Override
        public void buttonClick(NavigationButtonClickEvent event) {
            navButton.getNavigationManager()
                .navigateTo(new FieldView());
        }
    });
box.addComponent(navButton);
```

Creating views dynamically this way is recommended to reduce the memory footprint.

Notice that the automatic navigation will only work if the button is inside a **NavigationManager** (in a view managed by it). If you just want to use the button as a visual element, you can use it like a regular **Button** and handle the click events with a **ClickListener**.

## Styling with CSS

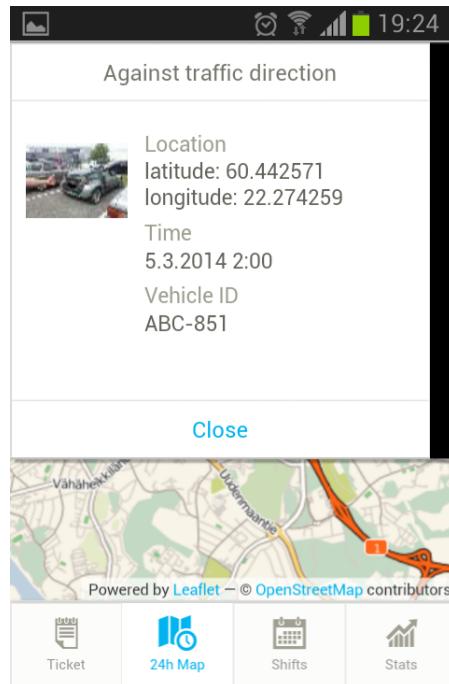
```
.v-touchkit-navbutton { }
.v-touchkit-navbutton-desc { }
.v-icon { }
```

The component has an overall `v-touchkit-navbutton` style. If the component description is set with `setDescription()`, it is shown in a separate `<span>` element with the `v-touchkit-navbutton-desc` style. The description has an alternative `emphasis` style, as well as a stronger capsule-like `pill` style with rounded corners, which you can enable with `addStyleName()`.

The default style of the navigation button is designed for placing the buttons inside a **Vertical-ComponentGroup**. It has a different style when it is in a **HorizontalButtonGroup** and when in the left or right slot of the **NavigationBar**.

### 20.7.5. Popover

**Popover** is much like a regular Vaadin sub-window, useful for quickly displaying some options or a small form related to an action. Unlike regular sub-windows, it does not support dragging or resizing by the user. As sub-windows usually require a rather large screen size, the **Popover** is most useful for tablet devices. When used on smaller devices, such as phones, the **Popover** automatically fills the entire screen.

**Figure 20.7. Popover in a Phone**

It is customary to use a **NavigationView** to have border decorations and caption. In the following, we subclass **Popover** to create the content.

```
class DetailsPopover extends Popover {
    public DetailsPopover() {
        setWidth("350px");
        setHeight("65%");

        // Have some details to display
        VerticalLayout layout = new VerticalLayout();
        ...

        NavigationView c = new NavigationView(layout);
        c.setCaption("Details");
        setContent(c);
    }
}
```

A **Popover** can be opened relative to a component by calling `showRelativeTo()`. In the following example, we open the popover when a table item is clicked.

```
Table table = new Table("Planets", planetData());
table.addItemClickListener(new ItemClickListener() {
    @Override
    public void itemClick(ItemChangeEvent event) {
        DetailsPopover popover = new DetailsPopover();

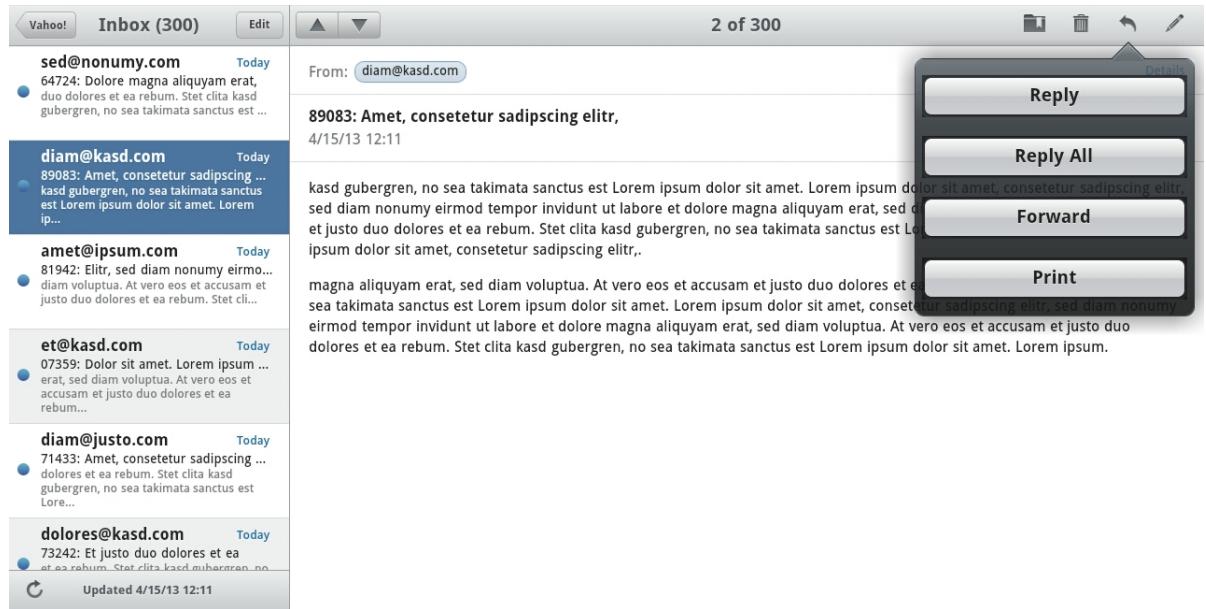
        // Show it relative to the navigation bar of
        // the current NavigationView.
        popover.showRelativeTo(view.getNavigationBar());
    }
});
```

```
}
```

You can also add the **Popover** to the UI with `addWindow()`.

A popover is shown in a tablet device as illustrated Figure 20.8, “**Popover in a Tablet Device**”. In this example, we have a **CssLayout** with some buttons as the popover content.

**Figure 20.8. Popover in a Tablet Device**



## Closing a Popover

When `closable` is enabled in a **Popover**, as it is by default, it can be closed by clicking anywhere outside the popup area. This may not be enough if the popover fills the entire screen, in which case the user gets stuck. The popover can be closed programmatically by calling `close()`. You can, for example, add a `MouseEvents.ClickListener` to the popover to allow closing it by clicking anywhere inside it.

If the popover has editable fields, you may want to have a close button in the navigation bar of the **NavigationView**. In the following example, we add a close button to the right slot of the navigation bar (you need to include the icon in your theme).

```
class DetailsPopover extends Popover
    implements Button.ClickListener {
    public DetailsPopover(Table table, Object itemId) {
        setWidth("350px");
        setHeight("65%");
        Layout layout = new FormLayout();
        ... create the content ...

        // Decorate with navigation view
        NavigationView content = new NavigationView(layout);
        content.setCaption("Details");
        setContent(content);

        // Have a close button
    }
}
```

```
        Button close = new Button(null, this);
        close.setIcon(new ThemeResource("close64.png"));
        content.setRightComponent(close);
    }

    public void buttonClick(ClickEvent event) {
        close();
    }
}
```

## Styling with CSS

```
.v-touchkit-popover .v-touchkit-fullscreen { }
.v-touchkit-popover .v-touchkit-relative { }
.v-touchkit-popover .v-touchkit-plain { }
```

The component has an overall `v-touchkit-popover` style. If full-screen, it also has the `v-touchkit-fullscreen` style, if positioned relatively it has `v-touchkit-relative`, and if not, the `v-touchkit-plain` style.

### 20.7.6. SwipeView

The **SwipeView** is a wrapper that allows navigating between views by swiping them horizontally left or right. The component works together with a **NavigationManager** (see Section 20.7.6, “**SwipeView**”) to change between the views when swiped, and to animate the change. A **SwipeView** should be an immediate child of the **NavigationManager**, but can contain a **NavigationView** to provide button navigation as well.

Let us have a selection of photographs to browse. We extend **NavigationManager** that creates the slide effect and create actual image views dynamically. In the constructor, we create the two first ones.

```
class SlideShow extends NavigationManager
    implements NavigationListener {
    String imageNames[] = {"Mercury.jpg", "Venus.jpg",
        "Earth.jpg", "Mars.jpg", "Jupiter.jpg",
        "Saturn.jpg", "Uranus.jpg", "Neptune.jpg"};
    int pos = 0;

    public SlideShow() {
        // Set up the initial views
        navigateTo(createView(pos));
        setNextComponent(createView(pos+1));

        addNavigationListener(this);
    }
}
```

The individual views have a **SwipeView** and the top.

```
SwipeView createView(int pos) {
    SwipeView view = new SwipeView();
    view.setSizeFull();

    // Use an inner layout to center the image
    VerticalLayout layout = new VerticalLayout();
    layout.setSizeFull();

    Image image = new Image(null, new ThemeResource(
```

```
    "planets/" + imageNames[pos]));
layout.addComponent(image);
layout.setComponentAlignment(image,
    Alignment.MIDDLE_CENTER);

view.setContent(layout);
return view;
}
```

When the view is swiped to either direction, we need to set the next image in that direction dynamically in the **NavigationManager**.

```
@Override
public void navigate(NavigationEvent event) {
    switch (event.getDirection()) {
        case FORWARD:
            if (++pos < imageNames.length-1)
                setNextComponent(createView(pos+1));
            break;
        case BACK:
            if (--pos > 0)
                setPreviousComponent(createView(pos-1));
    }
}
```

## 20.7.7. Switch

The **Switch** component is a two-state selector that can be toggled either by tapping or sliding and looks like the switch button in Apple iOS. It extends **CheckBox** and has therefore **Boolean** value type. The caption is managed by the containing layout.

```
VerticalComponentGroup group =
    new VerticalComponentGroup();
Switch myswitch = new Switch("To be or not to be?");
myswitch.setValue(true);
group.addComponent(myswitch);
```

As with other field components, you can handle value changes with a **ValueChangeListener**. Use `setImmediate(true)` to get them immediately when toggled.

The result is shown in Figure 20.9, “**Switch**”.

**Figure 20.9. Switch**



## Styling with CSS

```
.v-touchkit-switch { }
.v-touchkit-switch-slider { }
```

The component has an overall `v-touchkit-switch` style. The slider element has `v-touchkit-switch-slider` style.

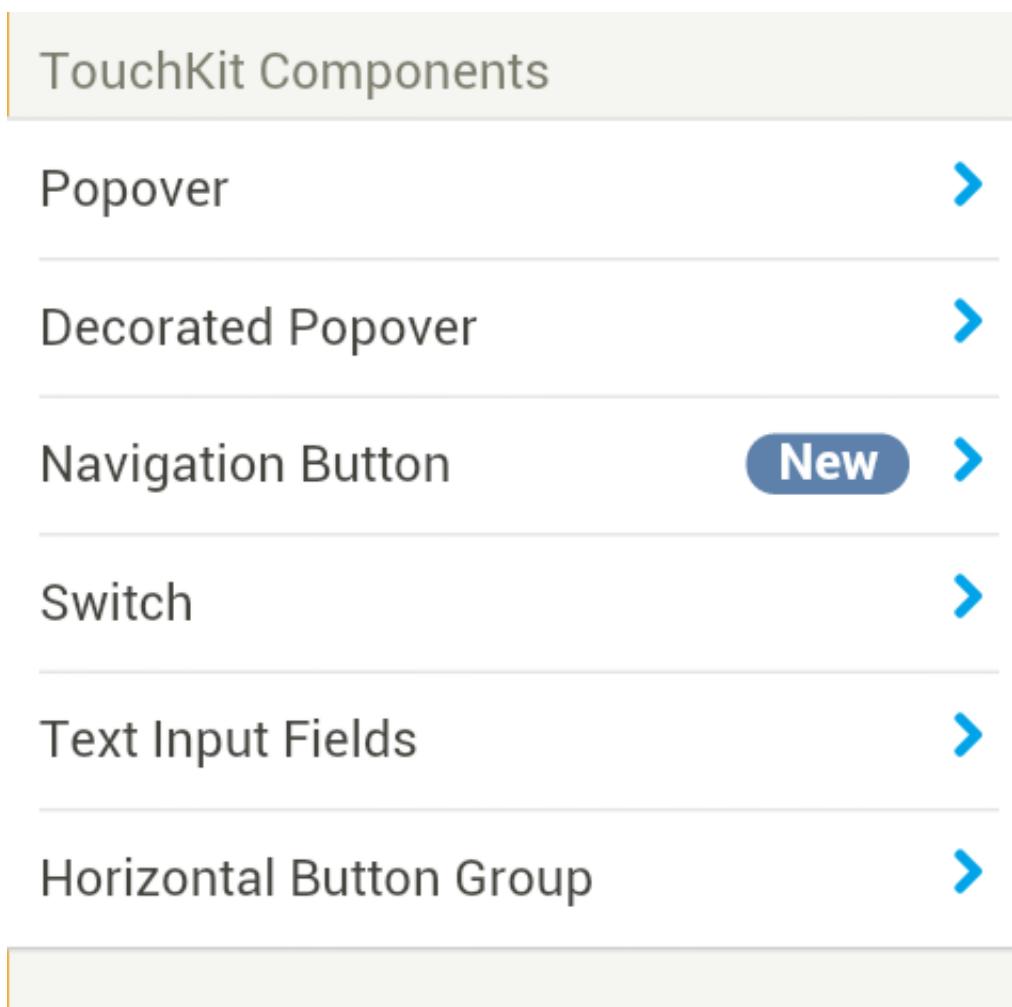
## 20.7.8. VerticalComponentGroup

The **VerticalComponentGroup** is a layout component for grouping components in a vertical stack with a border. Component captions are placed left of the components, and the components are aligned right. The component group is typically used for forms or with **NavigationButton** to create navigation menus.

```
VerticalComponentGroup group =  
    new VerticalComponentGroup("TouchKit Components");  
group.setWidth("100%");  
  
// Navigation to sub-views  
group.addComponent(new NavigationButton(  
    new PopoverView()));  
group.addComponent(new NavigationButton(  
    new DecoratedPopoverView()));  
  
layout.addComponent(box);
```

The result is shown in Figure 20.10, “VerticalComponentGroup”.

**Figure 20.10. VerticalComponentGroup**



## Styling with CSS

```
.v-touchkit-verticalcomponentgroup { }
```

The component has an overall `v-touchkit-verticalcomponentgroup` style. If the component has a caption, the `v-touchkit-has-caption` style is added.

### 20.7.9. HorizontalButtonGroup

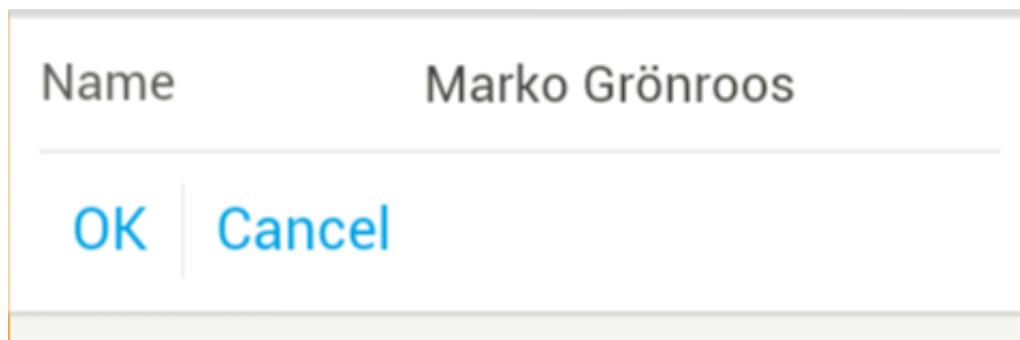
The **HorizontalButtonGroup** is intended for grouping buttons inside the slots of a **VerticalComponentGroup** with a special button group style.

```
VerticalComponentGroup vertical =
    new VerticalComponentGroup();
vertical.addComponent(new TextField("Name"));

HorizontalButtonGroup buttons =
    new HorizontalButtonGroup();
buttons.addComponent(new Button("OK"));
buttons.addComponent(new Button("Cancel"));
vertical.addComponent(buttons);
```

The result is shown in Figure 20.11, “**HorizontalButtonGroup**”

**Figure 20.11. HorizontalButtonGroup**



You can also make single buttons prettier by wrapping them in the component. Also the **Upload** component has a button, and you can give it the `v-button` style to make it look like a button would in the group, as is done in Section 20.8.4, “Uploading Content”.

Despite the name, and the fact that the button group is intended for buttons, you can, in fact, put any components inside it. Whether the result is meaningful, depends on the component.

## Styling with CSS

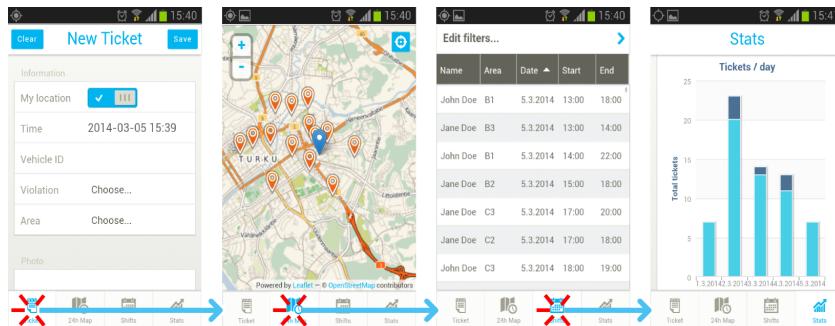
```
.v-touchkit-horizontalbuttongroup { }
```

The component has an overall `v-touchkit-horizontalbuttongroup` style. As noted above, the TouchKit style sheet includes special rules for components that have the `v-button` style inside the group.

## 20.7.10. TabBarView

The **TabBarView** is a layout component that consist of a tab bar at the bottom of the screen and a content area. Each tab has a content component which is displayed when the tab is selected.

**Figure 20.12. TabBar with Four NavigationViews**



**TabBarView** implements `ComponentContainer`, but uses its own specialized API for manipulating tabs. To add a new tab, you need to call `addTab()` with the content component. It creates the tab and returns a **Tab** object for managing it. You should set at least the caption and icon for a tab.

```
TabBarView bar = new TabBarView();

// Create some Vaadin component to use as content
Label content = new Label("Really simple content");

// Create a tab for it
Tab tab = bar.addTab(label);

// Set tab name and/or icon
tab.setCaption("tab name");
tab.setIcon(new ThemeResource(...));
```

A tab can be removed with `removeTab()`. Note that the `ComponentContainer` methods `addComponent()` and `removeComponent()` will throw an **UnsupportedOperationException** if used.

### Changing Tab Selection

Current tab selection can be accessed with `getSelectedTab()` and set with `setSelectedTab()`. Changing tab selection either by the user or programmatically causes a `SelectedTabChangeEvent`, which you can handle with a `SelectedTabChangeListener`.

```
Tab selectedTab = bar.getSelectedTab();
bar.setSelectedTab(selectedTab);
```

### Styling with CSS

```
.v-touchkit-tabbar {}
.v-touchkit-tabbar-wrapper {}
.v-touchkit-tabbar-toolbar {}
```

The component has overall `v-touchkit-tabbar` style. Content area is wrapped inside a `v-touchkit-tabbar-wrapper` element. Tab bar control area itself has the `v-touchkit-tabbar-toolbar` style.

### 20.7.11. EmailField

The **EmailField** is just like the regular **TextField**, except that it has automatic capitalization and correction turned off. Mobile devices also recognize the field as an email field and can offer a virtual keyboard for the purpose, so that it includes the at (@) and period (.) characters, and possibly a shorthand for .com.

**Figure 20.13. EmailField while editing**



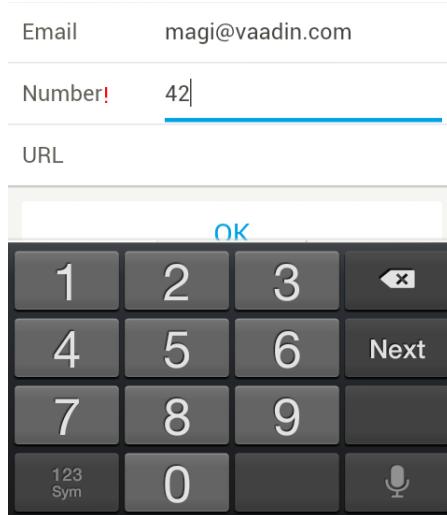
### Styling with CSS

```
.v-textfield {}  
.v-textfield.v-textfield-error {}
```

The **EmailField** has an overall `v-textfield` style, just like a regular **TextField** component would. It will get also the `v-textfield-error` if there is a component error, for example, from failed validation.

### 20.7.12. NumberField

The **NumberField** is just like the regular **TextField**, except that it is marked as a numeric input field for mobile devices, so that they will show a numeric virtual keyboard rather than the default alphanumeric.

**Figure 20.14. NumberField while editing**

## Styling with CSS

```
.v-textfield {}  
.v-textfield.v-numberfield-error {}
```

The **NumberField** has an overall `v-textfield` style, just like a regular **TextField** component would. It will get also the `v-numberfield-error` if there is a component error, for example, from failed validation.

## 20.7.13. UrlField

The **UrlField** is just like the regular **TextField**, except that it is marked as a URL input field for mobile devices, so that they will show a URL input virtual keyboard rather than the default alphanumeric. It has convenience methods `getUrl()` and `setUrl(URL url)` for converting input value from and to `java.net.URL`.

## Styling with CSS

```
.v-textfield {}  
.v-textfield.v-textfield-error {}
```

The **UrlField** has an overall `v-textfield` style, just like a regular **TextField** component would.

## 20.8. Advanced Mobile Features

### 20.8.1. Providing a Fallback UI

You may need to use the same URL and hence the same servlet for both the mobile TouchKit UI and for regular browsers. In this case, you need to recognize the mobile browsers compatible with Vaadin TouchKit and provide a fallback UI for any other browsers. The fallback UI can be a regular Vaadin UI, a "Sorry!" message, or a redirection to an alternate user interface.

You can handle the fallback logic in a custom **UIProvider** that creates the UIs in the servlet. As TouchKit supports only WebKit and Windows Phone browsers, you can do the recognition by

checking if the `user-agent` string contains the sub-strings "webkit" or "windows phone" as follows:

```
public class MyUIProvider extends UIProvider {
    @Override
    public Class<? extends UI>
        getUIClass(UIClassSelectionEvent event) {
        String ua = event.getRequest()
            .getHeader("user-agent").toLowerCase();
        if (ua.toLowerCase().contains("webkit")
            || ua.toLowerCase().contains("windows phone 8")
            || ua.toLowerCase().contains("windows phone 9")) {
            return MyUI.class;
        } else {
            return MyFallbackUI.class;
        }
    }
}
```

The custom UI provider has to be added in a custom servlet class, which you need to define in the `web.xml`, as described in Section 20.6.3, “TouchKit Settings”. For example, as follows:

```
public class MyServlet extends TouchKitServlet {
    private MyUIProvider uiProvider = new MyUIProvider();

    @Override
    protected void servletInitialized() throws ServletException {
        super.servletInitialized();

        getService().addSessionInitListener(
            new SessionInitListener() {
                @Override
                public void sessionInit(SessionInitEvent event)
                    throws ServiceException {
                    event.getSession().addUIProvider(uiProvider);
                }
            });
        ...
    }
}
```

See the Parking Demo for a working example.

## 20.8.2. Geolocation

The geolocation feature in TouchKit allows receiving the geographical location from the mobile device. The browser will ask the user to confirm that the web site is allowed to get the location information. Tapping **Share Location** gives the permission. The browser will give the position acquired by GPS, cellular positioning, or Wi-Fi positioning, as enabled in the device.

Geolocation is requested by calling the static `detect()` method in **Geolocator**. You need to provide a **PositionCallback** handler that is called when the device has an answer for your request. If the geolocation request succeeds, `onSuccess()` is called. Otherwise, for example, if the user did not allow sharing of his location, `onFailure()` is called. The geolocation data is provided in a **Position** object.

```
Geolocator.detect(new PositionCallback() {
    public void onSuccess(Position position) {
        double latitude = position.getLatitude();
        double longitude = position.getLongitude();
        double accuracy = position.getAccuracy();

        ...
    }

    public void onFailure(int errorCode) {
        ...
    }
});
```

The position is given as degrees with fractions in the WGS84 coordinate system used by GPS. The longitude is positive to East and negative to West of the prime meridian of WGS84. The accuracy is given in meters. In addition to the above data, the following are also provided:

- Altitude
- Altitude accuracy
- Heading
- Speed

If any of the position data is unavailable, its value will be zero.

The `onFailure()` is called if the positioning fails for some reason. The `errorCode` explains the reason. Error 1 is returned if the permission was denied, 2 if the position is unavailable, 3 on positioning timeout, and 0 on an unknown error.

Notice that geolocation can take significant time, depending on the location method used by the device. With Wi-Fi and cellular positioning, the time is usually less than 30 seconds. With unassisted GPS, it can reach 15 minutes on a fresh device and even longer if the reception is bad. However, once a location fix has been made, updates to the location will be faster. If you are making navigation software, you need to update the position data fairly frequently by calling the `detect()` method in **Geolocator** multiple times.

## Displaying Position on a Map

Geographical positions are often visualized with a map. There are countless ways to do that, for example, in the Parking Demo we use the V-Leaflet add-on component.

Notice that the geolocation gives the position in the WGS84 coordinate system used by GPS. The same system is conveniently used by many Internet map services, but is not in any way universal. Further, in some countries, map data is legally required to have erroneous coordinates.

The **MapView** in the Parking Demo is a TouchKit navigation view that uses the **LMap** component from the add-on to display the map:

```
public class MapView extends CssLayout
    implements PositionCallback, LeafletClickListener {
    private LMap map;
    private final LMarker you = new LMarker();
    ...
```

Position is requested from the device when a button is clicked:

```
locatebutton = new Button("", new ClickListener() {
    @Override
    public void buttonClick(final ClickEvent event) {
        Geolocator.detect(MapView.this);
    }
});
locatebutton.addStyleName("locatebutton");
locatebutton.setWidth(30, Unit.PIXELS);
locatebutton.setHeight(30, Unit.PIXELS);
locatebutton.setDisableOnClick(true);
addComponent(locatebutton);
```

When TouchKit gets the position, we center the map as follows:

```
@Override
public void onSuccess(final Position position) {
    ParkingUI app = ParkingUI.getApp();
    app.setCurrentLatitude(position.getLatitude());
    app.setCurrentLongitude(position.getLongitude());

    setCenter();

    // Enable centering on current position manually
    locatebutton.setEnabled(true);
}

private void setCenter() {
    if (map != null)
        map.setCenter(you.getPoint());
}
```

### 20.8.3. Storing Data in the Local Storage

The **LocalStorage** UI extension allows storing data in the HTML5 local storage from the server-side application. The storage is a singleton, which you can get with `LocalStorage.get()`.

```
final LocalStorage storage = LocalStorage.get();
```

#### Storing Data

You can store data in the local storage as key-value pairs with the `put()` method. Both the key and value must be strings. Storing the data requires a client round-trip, so the success or failure of the store operation can be handled with an optional `LocalStorageCallback`.

```
// Editor for the value to be stored
final TextField valueEditor = new TextField("Value");
valueEditor.setNullRepresentation("");
layout.addComponent(valueEditor);

Button store = new Button("Store", new ClickListener() {
    @Override
    public void buttonClick(ClickEvent event) {
        storage.put("value", valueEditor.getValue(),
            new LocalStorageCallback() {
                @Override
                public void onSuccess(String value) {
                    Notification.show("Stored");
                }
            });
    }
});
```

```
        }

        @Override
        public void onFailure(FailureEvent error) {
            Notification.show("Storing Failed");
        }
    );
}
})));
layout.addComponent(store);
```

## Retrieving Data from the Storage

You can retrieve data from the local storage with the `get()` method. It takes the key and a `LocalStorageCallback` to receive the retrieved value, or a failure. Retrieving the value to the server-side requires a client round-trip and another server request is made to send the value with the callback.

```
storage.get("value", new LocalStorageCallback() {
    @Override
    public void onSuccess(String value) {
        valueEditor.setValue(value);
        Notification.show("Value Retrieved");
    }

    @Override
    public void onFailure(FailureEvent error) {
        Notification.show("Failed because: " +
            error.getMessage());
    }
});
```

### 20.8.4. Uploading Content

Uploading content from a mobile device works just like with regular Vaadin applications using the **Upload** component.

In an offline UI or client-side code in general, you need to handle uploading differently, using a special upload widget or handler.

#### Server-Side Upload Component

In a server-side UI, you can use the regular **Upload** component described in Section 5.24, “**Upload**”. When choosing a file, the device will ask to select the file from files, gallery, camera, or other possible sources, depending on the device. The only difference to normal use is that the upload component must be in *immediate* mode.

Uploading is supported by most mobile operating systems, such as iOS, Android, and Windows RT devices, but not in some, such as WP8.

The following example shows how to implement simple upload to an in-memory storage.

```
// Display the image - only a placeholder first
final Image image = new Image();
image.setWidth("100%");
image.setVisible(false);
layout.addComponent(image);
```

```
// Implement both receiver that saves upload in a file and
// listener for successful upload
class ImageUploader implements Receiver, SucceededListener,
    ProgressListener {
    final static int maxLength = 10000000;
    ByteArrayOutputStream fos = null;
    String filename;
    Upload upload;

    public ImageUploader(Upload upload) {
        this.upload = upload;
    }

    public OutputStream receiveUpload(String filename,
                                    String mimeType) {
        this.filename = filename;
        fos = new ByteArrayOutputStream(maxLength + 1);
        return fos; // Return the output stream to write to
    }

    @Override
    public void updateProgress(long readBytes,
                               long contentLength) {
        if (readBytes > maxLength) {
            Notification.show("Too big content");
            upload.interruptUpload();
        }
    }

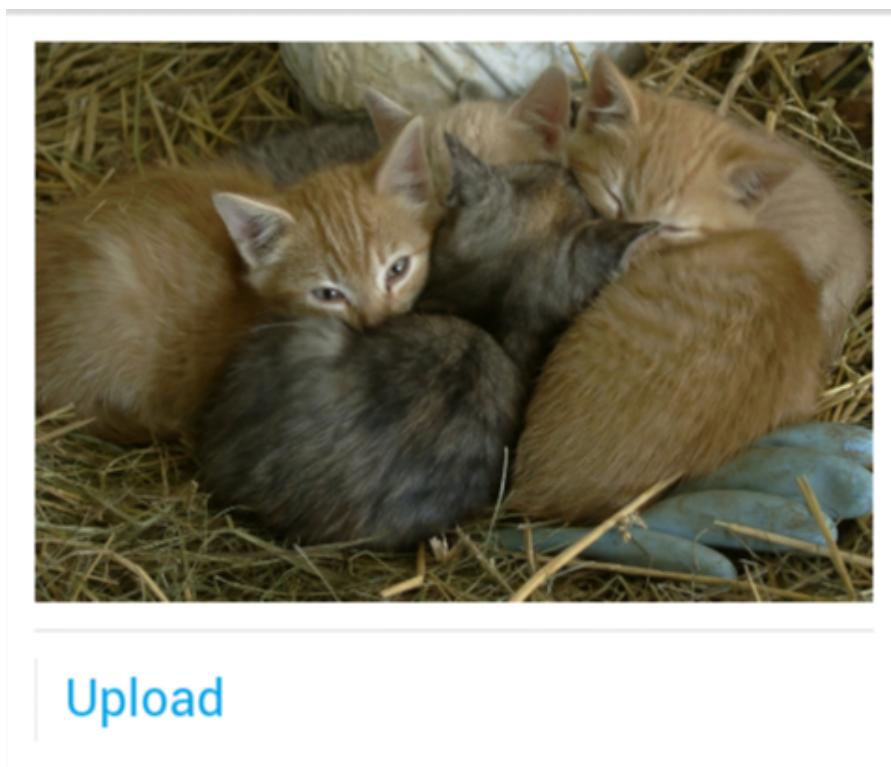
    public void uploadSucceeded(SucceededEvent event) {
        // Show the uploaded file in the image viewer
        image.setSource(new StreamResource(new StreamSource() {
            @Override
            public InputStream getStream() {
                byte[] bytes = fos.toByteArray();
                return new ByteArrayInputStream(bytes);
            }
        }, filename));

        image.setVisible(true);
    }
};

Upload upload = new Upload();
ImageUploader uploader = new ImageUploader(upload);
upload.setReceiver(uploader);
upload.addSucceededListener(uploader);
upload.setImmediate(true); // Only button

// Wrap it in a button group to give better style
HorizontalButtonGroup group = new HorizontalButtonGroup();
group.addComponent(upload);
layout.addComponent(group);
```

The result is shown in Figure 20.15, “Mobile Upload” (©2001 Marko Grönroos).

**Figure 20.15. Mobile Upload**

## Upload on the Client-Side

When making a client-side widget that handles file upload, such as for offline mode, you can use the **GWT FileUpload** component. In such case, you need to communicate the image data to the server with an RPC call.

On a mobile device, the perhaps most common upload task is to capture images with the integrated camera. To display them in the client-side UI correctly, you want make sure that they have reasonable size and correct orientation, without making a server round-trip to do the corrections. To send them to the server, you want to avoid using too much bandwidth. The **ImageUpload** widget included in the `lib-gwt-imageupload` add-on, available from Vaadin Directory, allows launching the camera application in the device and capturing an image. It further allows defining an image manipulation pipeline with transformations to reduce the image size if necessary, correct the orientation according to EXIF data, and so forth. The corrected image is loaded to a memory buffer, which you can display in another widget, send to the server, or store in the local store.

In the following, we allow capturing an image with the camera, normalize the image and reduce its size, and reduce the size further for displaying it in a thumbnail. Notice that the image data is encoded as a URL, which can be used as such in CSS, for example.

```
final ImageUpload fileUpload = new ImageUpload();

// Have a separate button to initiate the upload
final VButton takePhotoButton = new VButton();
takePhotoButton.addClickHandler(new ClickHandler() {
    @Override
    public void onClick(ClickEvent event) {
        fileUpload.click();
```

```
        }

    // Capture images from the camera, instead of allowing to
    // choose from gallery or other sources.
    fileUpload.setCapture(true);

    // Normalize the orientation and make size suitable for
    // sending to server
    EXIFOrientationNormalizer normalizer =
        new EXIFOrientationNormalizer();
    normalizer.setMaxWidth(1024);
    normalizer.setMaxHeight(1024);
    fileUpload.addImageManipulator(normalizer);
    fileUpload.addImageLoadedHandler(new ImageLoadedHandler() {
        @Override
        public void onImageLoaded(ImageLoadedEvent event) {
            // Store the image data as encoded URL
            setImage(event.getImageData().getDataURL());
        }
    });

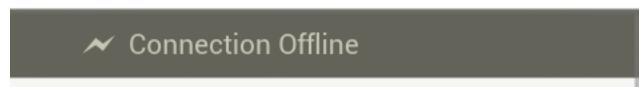
    // Reduce the size further for displaying a thumbnail
    ImageTransformer thumbGenerator = new ImageTransformer();
    thumbGenerator.setImageDataSource(fileUpload);
    thumbGenerator.setMaxWidth(75);
    thumbGenerator.setMaxHeight(75);
    thumbGenerator.addImageLoadedHandler(new ImageLoadedHandler() {
        @Override
        public void onImageLoaded(ImageLoadedEvent event) {
            // Store the thumbnail image data as encoded URL
            setThumbnail(event.getImageData().getDataURL());
        }
    });
});
```

See the Parking Demo for more details about the usage of the add-on.

## 20.9. Offline Mode

While regular Vaadin TouchKit applications are server-side applications, TouchKit allows a special *offline mode*, which is a client-side Vaadin UI that is switched to automatically when the network connection is not available. The offline UI is included in the widget set of the regular server-side UI and stored in the browser cache. By providing a special cache manifest, the browser caches the page so strongly that it persists even after browser restart, effectively making it an offline application.

**Figure 20.16. Offline Mode in the Parking Demo**



During offline operation, the offline UI can store data in the HTML5 local storage of the mobile browser and then passed to the server-side application when the connection is again available.

The offline mode is enabled in the project stub created by the Maven archetype (see Section 20.5.1, “Using the Maven Archetype”), with stubs for the offline data storage and server RPC classes.

See the Parking demo and its source code for complete examples of the offline mode.

### 20.9.1. Enabling the Cache Manifest

HTML5 supports a *cache manifest*, which makes offline web applications possible. It controls how different resources are cached. The manifest is generated by TouchKit, but you need to enable it in the TouchKit settings. To do so, you need to define a custom servlet, as described in Section 20.6.1, “The Servlet Class”, and call `setCacheManifestEnabled(true)` for the cache settings, as follows:

```
TouchKitSettings s = getTouchKitSettings();
...
s.getApplicationCacheSettings()
    .setCacheManifestEnabled(true);
```

You also need to define a MIME type for the manifest in the `web.xml` deployment descriptor as follows:

```
<mime-mapping>
  <extension>manifest</extension>
  <mime-type>text/cache-manifest</mime-type>
</mime-mapping>
```

### 20.9.2. Enabling Offline Mode

To enable the offline mode, you need to add the **OfflineMode** extension to the UI.

```
OfflineMode offlineMode = new OfflineMode();
offlineMode.extend(this);

// Maintain the session when the browser app closes
offlineMode.setPersistentSessionCookie(true);

// Define the timeout in secs to wait when a server
// request is sent before falling back to offline mode
offlineMode.setOfflineModeTimeout(15);
```

The above code is included in the project stub created by the Maven archetype (see Section 20.5.1, “Using the Maven Archetype”).

You can extend the **OfflineMode** extension to transfer data conveniently from the offline UI to the server-side, as described in Section 20.9.4, “Sending Data to Server”.

### 20.9.3. The Offline User Interface

An offline mode is built like any other client-side module, as described in Chapter 13, *Client-Side Vaadin Development*. You can use any GWT, Vaadin, add-on, and also TouchKit widgets in the offline user interface.

Most typically, a client-side application builds a simplified UI for data browsing and entry. It stores the data in the HTML5 local storage. It watches if the server connection is restored, and if it is, it sends any collected data to the server and suggests to return to the online mode.

The Parking Demo provides an example implementation of an offline mode user interface. The Ticket view is implemented as a fat client-side widget, where the server-side view only communicates the state to the widget.

#### 20.9.4. Sending Data to Server

Once the connection is available, the offline UI can send any collected data to the server-side. You can send the data from the offline UI, for example, by making a server RPC call to a server-side UI extension, as described in Section 16.6, “RPC Calls Between Client- and Server-Side”.

#### 20.9.5. The Offline Theme

Normally, client-side modules have their own stylesheets in the `public` folder that is compiled into the client-side target, as described in Section 16.8, “Styling a Widget” and Section 13.3.1, “Specifying a Stylesheet”. However, you may want to have the offline mode have the same visual style as the online mode. To use the same theme as the server-side application, you need to define the theme path in the widget set definition file as follows.

```
<set-configuration-property  
    name='touchkit.manifestlinker.additionalCacheRoot'  
    value='src/main/webapp/VAADIN/themes/mytheme:../../../../VAADIN/themes/mytheme  
/>
```

You need to follow a CSS style structure required by the Vaadin theme in your offline application. If you use any Vaadin widgets, as described in Section 15.3, “Vaadin Widgets”, they will use the Vaadin theme.

### 20.10. Building an Optimized Widget Set

Mobile networks are generally somewhat slower than DSL Internet connections. When starting a Vaadin application, the widget set is the biggest resource that needs to be loaded in the browser. As most of the Vaadin components are not used by most applications, especially mobile ones, it is beneficial to create an optimized version of the widget set.

Vaadin supports lazy loading of individual widget implementations when they are needed. The **TouchKitWidgetSet** used in TouchKit applications optimizes the widgetset to only download the most essential widgets first and then load other widget implementation lazily. This is a good compromise for most TouchKit applications. Nevertheless, because of the high latency of most mobile networks, loading the widget set in small pieces might not be the best solution for every case. With custom optimization, you can create a monolithic widget set stripped off all unnecessary widgets. Together with proper GZip compression, it should be quite light-weight for mobile browsers.

However, if the application has big components which are rarely used or not on the initial views, it may be best to load those widgets eagerly or lazily.

You can find a working example of widget set optimization in the `ParkingWidgetset.gwt.xml` and `WidgetLoaderFactory.java` in the Parking Demo sources.

#### 20.10.1. Generating the Widget Map

You can fine-tune a widget set by using a custom **WidgetMapGenerator** implementation. The generator class should extend **TouchKitBundleLoaderFactory** and override its `getConnect-`

orsForWidgetset() method. The method returns the connector classes of the widgets used in the widget set.

The list of used connectors (and their widgets) can be built manually if you know what components you use in your application. You can also, for example, use a debugger to dig into the **CommunicationManager** class in Vaadin, which opens all the views of the running application. It contains a set of all components that have been used so far.

In Parking Demo, we first build a list of the connector class names in the constructor as follows:

```
public class WidgetLoaderFactory
    extends TouchKitBundleLoaderFactory {
    private final ArrayList<String> usedConnectors;

    public WidgetLoaderFactory() {
        usedConnectors = new ArrayList<String>();
        usedConnectors.add(ButtonConnector.class.getName());
        usedConnectors.add(ChartConnector.class.getName());
        usedConnectors.add(CssLayoutConnector.class.getName());
        ...
    }
```

Then we use the list it in the getConnectorsForWidgetset() to create the proper list of class type definitions by filtering them from all class type definitions. **JClassType** is used for type definition.

```
@Override
protected Collection<JClassType> getConnectorsForWidgetset(
    TreeLogger logger, TypeOracle typeOracle)
    throws UnableToCompleteException {
    // The usedConnectors list should contain all the
    // connectors that we need in the app, so we
    // can leave all others away.

    // Get all connectors in the unoptimized widget set
    Collection<JClassType> connectorsForWidgetset = super
        .getConnectorsForWidgetset(logger, typeOracle);

    // Filter the connectors using the used list
    ArrayList<JClassType> arrayList =
        new ArrayList<JClassType>();
    for (JClassType jClassType : connectorsForWidgetset) {
        String qualifiedSourceName =
            jClassType.getQualifiedSourceName();
        if (usedConnectors.contains(qualifiedSourceName)) {
            arrayList.add(jClassType);
        }
    }
    return arrayList;
}
```

## 20.10.2. Defining the Widget Loading Style

The `getLoadStyle()` method should return the widget loading style, which should be *EAGER* to get a monolithic widgetset.

```
@Override
protected LoadStyle getLoadStyle(JClassType connectorType) {
```

```
        return LoadStyle.EAGER;
    }
}
```

### 20.10.3. Applying the Custom Widget Map Generator

It needs to be defined in the `.gwt.xml` widget set definition file as follows:

```
<generate-with class="com.myprj.WidgetLoaderFactory">
    <when-type-assignable class="com.vaadin.client.metadata.ConnectorBundleLoader" />
</generate-with>
```

### 20.10.4. Deployment

Note that you need to enable GZip compression for your deployment if you wish to optimize the startup time and minimize the amount of transferred data. The best method for doing that highly depends on your hosting setup, so we do not cover it here.

## 20.11. Testing and Debugging on Mobile Devices

Testing places special challenges for mobile devices. The mobile browsers may not have much debugging features and you may not be able to install third-party debugging add-ons, such as the Chrome Developer Tools.

### 20.11.1. Debugging

The debug window, as described in Section 11.3, “Debug Mode and Window”, works on mobile browsers as well, even if it is a bit harder to use.

The lack of in-browser analysis tools can be helped with simple client-side coding. For example, you can dump the HTML content of the page with the `innerHTML` property in the HTML DOM. To do so, you need to execute a JavaScript call from the server-side and handle its response with a call-back method, as described in Section 11.14.2, “Handling JavaScript Function Callbacks”.

### Desktop Debugging

TouchKit supports especially WebKit-based browsers, which are used in iOS and Android devices. You can therefore reach a decent compatibility by using a desktop browser based on WebKit, such as Google Chrome. Features such as geolocation are also supported by desktop browsers. If you make your phone/tablet-detection and orientation detection using screen size, you can easily emulate the modes by resizing the browser. Also, the browsers have special development settings to emulate some features in touch devices.

### Remote Debugging

Both Safari and Chrome support remote debugging, which allows you to debug the supported mobile browsers remotely from a desktop browser.



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# Chapter 21

# Vaadin TestBench

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This chapter describes the installation and use of the Vaadin TestBench.

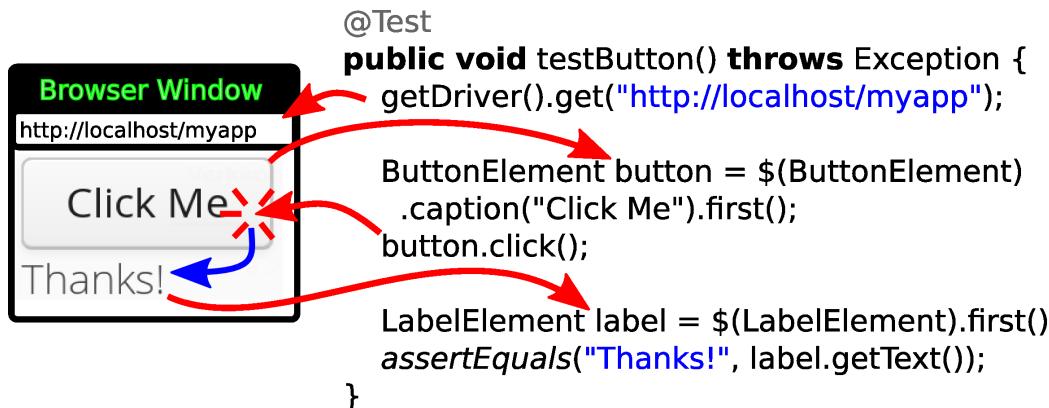
## 21.1. Overview

Testing is one of the cornerstones of modern software development. Extending throughout the development process, testing is the thread that binds the product to the requirements. In agile and other iterative development processes, with ever shorter release cycles and continuous integration, the automation of integration, regression, endurance, and acceptance testing is para-

mount. Further, UI automation may be needed for integration purposes, such as for assistive technologies. The special nature of web applications creates many unique requirements for both testing and UI automation.

Vaadin TestBench allows controlling the browser from Java code, as illustrated in Figure 21.1, “Controlling the Browser with Testbench”. It can open a new browser window to start the application, interact with the UI components, for example, by clicking them, and then get the HTML element values.

**Figure 21.1. Controlling the Browser with Testbench**



Before going further into feature details, you may want to try out Vaadin TestBench yourself. You just need to create a new Vaadin project either with the Eclipse plugin or the Maven archetype. Both create a simple application stub that includes TestBench test cases for testing the UI. You also need to install an evaluation license. For instructions, jump to Section 21.2, “Quick Start” and, after trying it out, come back.

## Vaadin TestBench in Software Development

Vaadin TestBench can work as the centerpiece of the software development process, for testing the application at all modular levels and in all the phases of the development cycle:

- Automated acceptance tests
- Unit tests
- End-to-end integration tests
- Regression tests

Let us look at each of these topics separately.

Any methodological software development, agile or not, is preceded by specification of requirements, which define what the software should actually do. *Acceptance tests* ensure that the product conforms to the requirements. In agile development, their automation allows continuous tracking of progress towards iteration goals, as well as detecting regressions. The importance of requirements is emphasized in *test-driven development* (TDD), where tests are written before actual code. In Section 21.15, “Behaviour-Driven Development”, we show how to use Vaadin TestBench for *behaviour-driven development* (BDD), a form of TDD that concentrates on the formal behavioural specification of requirements.

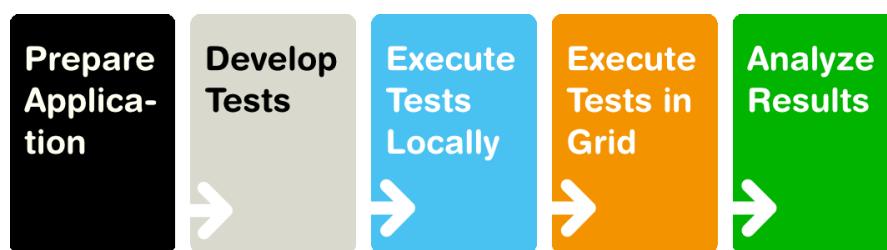
*Unit testing* is applied to the smallest scale of software components; in Vaadin applications these are typically individual UI components or view classes. You may also want to generate many different kinds of inputs for the application and check that they produce the desired outputs. For complex composites, such as views, you can use the Page Object Pattern described in Section 21.9.2, “The Page Object Pattern”. The pattern simplifies and modularizes testing by separating low-level details from the more abstract UI logic. In addition to serving the purpose of unit tests, it creates an abstraction layer for higher-level tests, such as acceptance and end-to-end tests.

*Integration tests* ensure that software units work together at different levels of modularization. At the broadest level, *end-to-end tests* extend through the entire application lifecycle from start to finish, going through many or all user stories. The aim is not just to verify the functional requirements for user interaction, but also that data integrity is maintained. For example, in a messaging application, a user would log in, both send and receive messages, and finally log out. Such test workflows could include configuration, registration, interaction between users, administrative tasks, deletion of user accounts, and so forth.

In *regression testing*, you want to ensure that only intended changes occur in the behaviour after modifying the code. There are two lines of defence against such regressions. The primary source of regression tests are the acceptance, unit, and integration tests that validate that the displayed values in the UI’s HTML representation are logically correct. Yet, they are not sufficient for detecting visual regressions, for example, because of invalid UI rendering or theme problems. Comparing screenshots to reference images forms a more sensitive layer to detect regressions, at the expense of losing robustness for changes in layout and theming. The costs of the tradeoff can be minimized by careful application of screenshot comparison only at critical points and by making the analysis of such regressions as easy as possible. As described in Section 21.10, “Taking and Comparing Screenshots”, Vaadin TestBench automatically highlights differences in screenshots and allows masking irrelevant areas from image comparison.

You can develop such tests along with your application code, for example with JUnit, which is a widely used Java unit testing framework. You can run the tests as many times as you want in your workstation or in a distributed grid setup.

**Figure 21.2. TestBench Workflow**



## Features

The main features of Vaadin TestBench are:

- Control a browser from Java
- Generate component selectors in debug window
- Validate UI state by assertions and screen capture comparison
- Screen capture comparison with difference highlighting

- Distributed test grid for running tests
- Integration with unit testing
- Test with browsers on mobile devices

Execution of tests can be distributed over a grid of test nodes, which speeds up testing. The grid nodes can run different operating systems and have different browsers installed. In a minimal setup, such as for developing the tests, you can use Vaadin TestBench on just a single computer.

## Based on Selenium

Vaadin TestBench is based on the Selenium web browser automation library, especially Selenium WebDriver, which allows you to control browsers straight from Java code.

Selenium is augmented with Vaadin-specific extensions, such as:

- Proper handling of Ajax-based communications of Vaadin
- A high-level, statically typed element query API for Vaadin components
- Performance testing of Vaadin applications
- Screen capture comparison
- Finding HTML elements by a Vaadin selector

## TestBench Components

The TestBench library includes WebDriver, which provides API to control a browser like a user would. This API can be used to build tests, for example, with JUnit. It also includes the grid hub and node servers, which you can use to run tests in a grid configuration.

Vaadin TestBench Library provides the central control logic for:

- Executing tests with the WebDriver
- Additional support for testing Vaadin-based applications
- Comparing screen captures with reference images
- Distributed testing with grid node and hub services

## Requirements

Requirements for developing and running tests are:

- Java JDK 1.6 or newer
- Browsers installed on test nodes as supported by Selenium WebDriver
  - Google Chrome
  - Internet Explorer
  - Mozilla Firefox (ESR version recommended)

- Opera
- Mobile browsers: Android, iPhone
- A build system, such as Ant or Maven, to automate execution of tests during build process (recommended)

Note that running tests on an Extended Support Release (ESR) version of Firefox is recommended because of the frequent release cycle of Firefox, which often cause tests to fail. Download an ESR release of Firefox from <http://www.mozilla.org/en-US/firefox/organizations/all.html>. Install it alongside your normal Firefox install (do not overwrite).

For Mac OS X, note the issue mentioned in Section 21.16.1, “Running Firefox Tests on Mac OS X”.

## Continuous Integration Compatibility

Continuous integration means automatic compilation and testing of applications frequently, typically at least daily, but ideally every time when code changes are committed to the source repository. This practice allows catching integration problems early and finding the changes that first caused them to occur.

You can make unit tests with Vaadin TestBench just like you would do any other Java unit tests, so they work seamlessly with continuous integration systems. Vaadin TestBench is tested to work with at least TeamCity and Hudson/Jenkins build management and continuous integration servers, which all have special support for the JUnit unit testing framework.

**Figure 21.3. Continuous Integration Workflow**

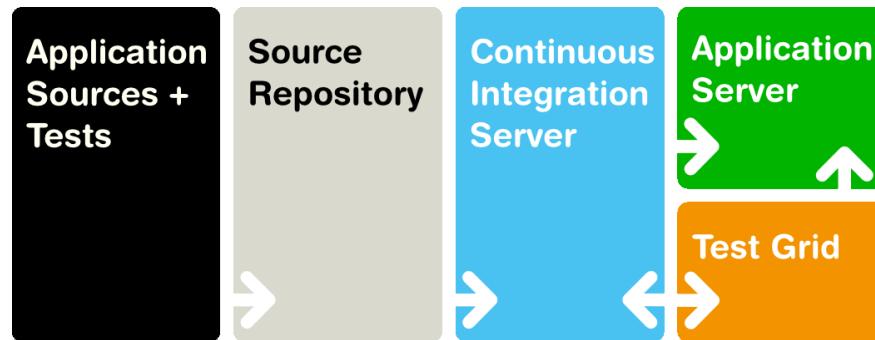


Figure 21.3, “Continuous Integration Workflow” illustrates a typical development setup. Both changes to application and test sources are checked in into a source repository, from where the CIS server checks them out, compiles, and deploys the web application to a server. Then, it runs the tests and collects the results.

## Licensing and Trial Period

You can download Vaadin TestBench from Vaadin Directory and try it out for a free 30-day trial period, after which you are required to acquire the needed licenses. You can purchase licenses from the Directory. A license for Vaadin TestBench is also included in the Vaadin Pro Account subscription.

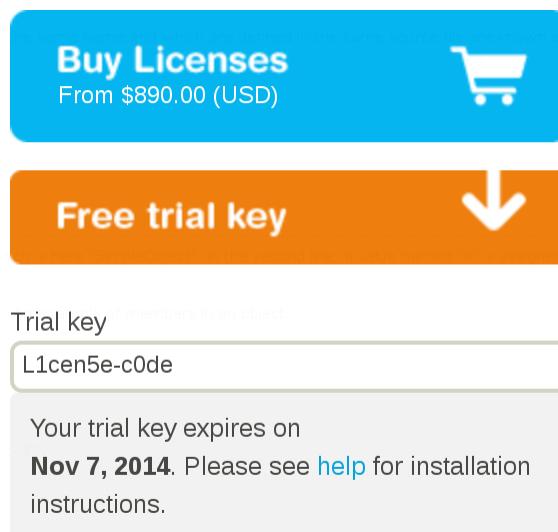
## 21.2. Quick Start

In the following, we give instructions for getting Vaadin TestBench running in minutes. You can create either a new Eclipse project or a Maven project. Both project types require installing a license key, so we cover that first.

### 21.2.1. Installing License Key

Before running tests, you need to install a license key. You can purchase Vaadin TestBench or obtain a free trial key from the Vaadin TestBench download page in Vaadin Directory. You need to register in Vaadin Directory to obtain the key.

**Figure 21.4. Obtaining License Key from Vaadin Directory**



To install the license key on a development workstation, you can copy and paste it verbatim to a `.vaadin.testbench.developer.license` file in your home directory. For example, in Linux and OS X:

```
$ echo "L1cen5e-c0de" > ~/.vaadin.testbench.developer.license
```

You can also pass the key as a system property to the Java application running the tests, usually with a `-D` option on the command-line:

```
$ java -Dvaadin.testbench.developer.license=L1cen5e-c0de ...
```

How you actually pass the parameter to your test runner depends on the actual test execution environment. Below are listed a few typical environments:

#### Eclipse IDE

To install the license key for all projects, select **Window Preferences** and navigate to the **Java Installed JREs** section. Select the JRE version that you use for the application and click **Edit**. In the **Default VM arguments**, give the `-D` expression as shown above.

For a single project, create a new JUnit launch configuration in **Run Run configurations**. Select **JUnit** and click **New launch configuration**. If you have already ran

JUnit in the project, the launch configuration already exists. Select JUnit 4 if not selected automatically. Go to **Arguments** tab and give the `-D` expression in the **VM arguments** field. Click **Run** to run the tests immediately or **Close** to just save the settings.

#### Apache Ant

If running tests with the `<junit>` task in Apache Ant, as described in Section 21.11.1, “Running Tests with Ant”, you can pass the key as follows:

```
<sysproperty key="vaadin.testbench.developer.license"
             value="L1cen5e-c0de" />
```

However, you should never store license keys in a source repository, so if the Ant script is stored in a source repository, you should pass the license key to Ant as a property that you then use in the script for the value argument of the `<sysproperty>` as follows:

```
<sysproperty key="vaadin.testbench.developer.license"
             value="${vaadin.testbench.developer.license}" />
```

When invoking Ant from the command-line, you can pass the property with a `-D` parameter to Ant.

#### Apache Maven

If running tests with Apache Maven, you can pass the license key with a `-D` parameter to Maven:

```
$ mvn -Dvaadin.testbench.developer.license=L1cen5e-c0de verify
```

#### TeamCity

In TeamCity, you can pass the license key to build runners as a system property in the build configuration. However, this only passes it to a runner. As described above, Maven passes the parameter as is to JUnit, but Ant does not do so implicitly, so you need to forward it explicitly as described earlier.

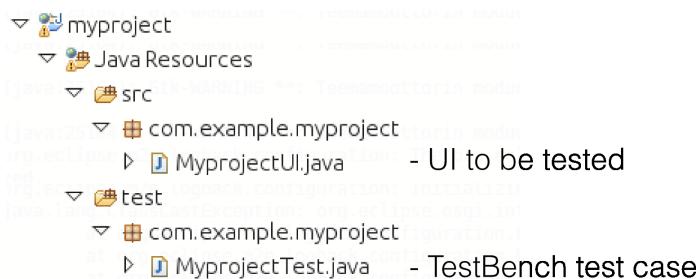
See the AGPL license key installation instructions for more details.

### 21.2.2. Quick Start with Eclipse

Once you have installed the Vaadin Plugin for Eclipse, you can use it to create a new Vaadin 7 project with the TestBench test enabled, as described in Section 2.5.1, “Creating the Project”. In the project settings, you need to have the **Create TestBench test** setting enabled.

The test case stub is created under `test` source folder, so that it will not be deployed with the application. The project and source folders are illustrated in 21.5.

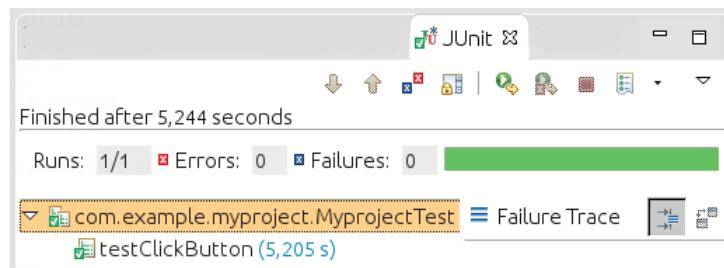
**Figure 21.5. Eclipse Project with a Test Case**



You can observe that the UI and the test case are much like in the illustration in Figure 21.1, “Controlling the Browser with Testbench”. The resulting test case stub is described in detail in Section 21.4.1, “Basic Test Case Structure”.

To run the test, open the `MyprojectTest.java` file in the editor and press **Shift+Alt+X-T**. The browser should open with the application UI and TestBench run the tests. The results are displayed in the **JUnit** view in Eclipse, as shown in Figure 21.6, “JUnit Test Results in Eclipse”.

**Figure 21.6. JUnit Test Results in Eclipse**



### 21.2.3. Quick Start with Maven

With Maven, you need to create a new Vaadin project with the `vaadin-archetype-application` archetype, as described in Section 2.6, “Using Vaadin with Maven”.

The `src` folder under the project contains both the sources for the application and the tests. The test case stub in the `src/test` folder is described in detail in Section 21.4.1, “Basic Test Case Structure”.

The license needs to be installed or given as parameter for the following command, as mentioned earlier. Build the project with the `integration-test` or a later phase in the build lifecycle. For example, from the command-line:

```
$ mvn integration-test
```

This will execute all required lifecycle phases, including compilation and packaging the application, launch Jetty web server to host the application, and run the TestBench tests. Results are reported on the console. A Maven GUI, such as the one in Eclipse, will provide more visual results.

## 21.3. Installing Vaadin TestBench

As with most Vaadin add-ons, you can install Vaadin TestBench as a Maven or Ivy dependency in your project, or from an installation package. The installation package contains some extra material, such as documentation, as well as the standalone library, which you use for testing in a grid.

The component element classes are Vaadin version specific and they are packaged in a `vaadin-testbench-api` library JAR, separately from the `vaadin-testbench-core` runtime library, which is needed for executing the tests.

Additionally, you may need to install drivers for the browsers you are using.

### 21.3.1. Test Development Setup

In a typical test development setup, you develop tests in a Java project and run them on the development workstation. You can run the same tests in a dedicated test server, such as a continuous integration system.

In a test development setup, you do not need a grid hub or nodes. However, if you develop tests for a grid, you can run the tests, the grid hub, and one node all in your development workstation. A distributed setup is described later.

#### Maven Dependency

The Maven dependency for Vaadin TestBench is as follows:

```
<dependency>
    <groupId>com.vaadin</groupId>
    <artifactId>vaadin-testbench</artifactId>
    <version>4.x.x</version>
    <scope>test</scope>
</dependency>
```

You also need to define the Vaadin add-ons repository if not already defined:

```
<repository>
    <id>vaadin-addons</id>
    <url>http://maven.vaadin.com/vaadin-addons</url>
</repository>
```

The `vaadin-archetype-application` archetype, as mentioned in Section 21.2.3, “Quick Start with Maven”, includes the declarations.

#### Ivy Dependency

The Ivy dependency, to be defined in `ivy.xml`, would be as follows:

```
<dependency org="com.vaadin" name="vaadin-testbench-api"
    rev="latest.release" conf="nodeploy->default"/>
```

The optional `nodeploy->default` configuration mapping requires a `nodeploy` configuration in the Ivy module; it is automatically created for new Vaadin projects.

A new Vaadin project created with the Vaadin Plugin for Eclipse, as described in Section 21.2.2, “Quick Start with Eclipse”, includes the dependency.

#### Code Organization

We generally recommend developing tests in a project or module separate from the web application to be tested to avoid library problems. If the tests are part of the same project, you should at least arrange the source code and dependencies so that the test classes, the TestBench library, and their dependencies would not be deployed unnecessarily with the web application.

### 21.3.2. A Distributed Testing Environment

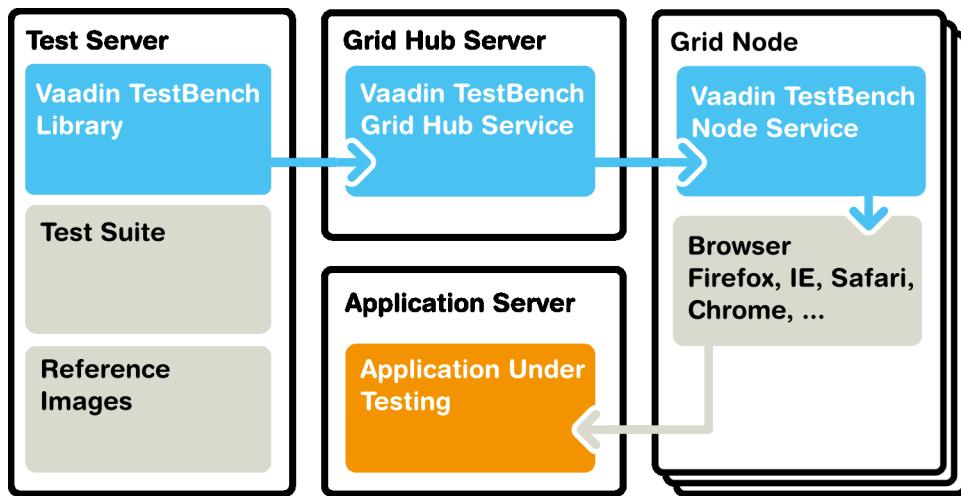
Vaadin TestBench supports distributed execution of tests in a grid. A test grid consists of the following categories of hosts:

- One or more test servers executing the tests

- A grid hub
- Grid nodes

The components of a grid setup are illustrated in Figure 21.7, “Vaadin TestBench Grid Setup”.

**Figure 21.7. Vaadin TestBench Grid Setup**



The grid hub is a service that handles communication between the JUnit test runner and the nodes. The nodes are services that perform the actual execution of test commands in the browser.

The hub requires very little resources, so you would typically run it either in the test server or on one of the nodes. You can run the tests, the hub, and one node all in one host, but in a fully distributed setup, you install the Vaadin TestBench components on separate hosts.

Controlling browsers over a distributed setup requires using a remote WebDriver. Grid development and use of the hub and nodes is described in Section 21.12, “Running Tests in a Distributed Environment”.

### 21.3.3. Installation Package Contents

The installation package contains the following:

#### documentation

The documentation folder contains release notes, a PDF excerpt of this chapter of Book of Vaadin, and the license.

#### maven

The Maven folder contains the Vaadin TestBench library JARs (you can use them in non-Maven projects as well). The folder contains a POM file, so that you can install it in your local Maven repository. Please follow the instructions in Section 21.11.2, “Running Tests with Maven”.

#### vaadin-testbench-standalone-4.x.x.jar

This is a standalone version of the Vaadin TestBench library that is mainly used for running the grid hub and node services, as described in Section 21.12, “Running Tests in a Distributed Environment”.

### 21.3.4. TestBench Demo

A TestBench demo is available at <https://github.com/vaadin/testbench-demo>. You can browse the sources at the website and clone the repository with a Git client; from command line with:

```
$ git clone https://github.com/vaadin/testbench-demo
```

The tests can be run from the command line by issuing the following command:

```
$ mvn verify
```

The source code for the application to be tested, a desktop calculator application, is given in the `src/main/java` subfolder.

The TestBench tests for the application are located under the `src/test/java` subfolder, in the `com/vaadin/testbenchexample` package subfolder. They are as follows:

`SimpleCalculatorITCase.java`

Demonstrates the basic use of WebDriver. Interacts with the buttons in the user interface by clicking them and checks the resulting value. Uses the ElementQuery API to access the elements.

`LoopingCalculatorITCase.java`

Otherwise as the simple example, but shows how to use looping to produce programmatic repetition to create a complex use case.

`ScreenshotITCase.java`

Shows how to compare screenshots, as described in Section 21.10.3, “Taking Screenshots for Comparison”. Some of the test cases include random input, so they require masked screenshot comparison to mask the random areas out.

The example is ignored by default with an `@Ignore` annotation, because the included images were taken with a specific browser on a specific platform, so if you use another environment, they will fail. If you enable the test, you will need to run the tests, copy the error images to the reference screenshot folder, and mask out the areas with the alpha channel. Please see the `example/Screenshot_Comparison_Tests.pdf` for details about how to enable the example and how to create the masked reference images.

`SelectorExamplesITCase.java`

This example shows how to find elements in different ways; by using the high-level ElementQuery API as well as low-level `By.xpath()` selectors.

`VerifyExecutionTimeITCase.java`

Shows how to time the execution of a test case and how to report it.

`AdvancedCommandsITCase.java`

Demonstrates how to test context menus (see Section 21.8.5, “Testing Context Menus”) and tooltips (see Section 21.8.2, “Testing Tooltips”). Also shows how to send keypresses to a component and how to read values of table cells.

`pageobjectexample/PageObjectExampleITCase.java`

Shows how to create maintainable tests using the *Page Object Pattern* that separates the low-level page structure from the business logic, as described in Section 21.9, “Creating Maintainable Tests”. The page object classes that handle low-level interaction with the application views are in the `pageobjects` subpackage.

bdd/CalculatorSteps.java, bdd/SimpleCalculation.java  
Shows how to develop tests following the *behaviour-driven development* (BDD) model, by using the JBehave framework. SimpleCalculation.java defines a JUnit-based user story with one scenario, which is defined in CalculatorSteps.java. The scenario reuses the page objects defined in the page object example (see above) for low-level application view access and control. The example is described in Section 21.15, “Behaviour-Driven Development”.

### 21.3.5. Installing Browser Drivers

Whether developing tests with the WebDriver in the workstation or running tests in a grid, using some browsers requires that a browser driver is installed.

1. Download the latest browser driver

- Internet Explorer (Windows only) - install IEDriverServer.exe from under the latest Selenium release:

<http://selenium-release.storage.googleapis.com/index.html>

- Chrome - install ChromeDriver (a part of the Chromium project) for your platform from under the latest release at:

<http://chromedriver.storage.googleapis.com/index.html>

2. Add the driver executable to user PATH. In a distributed testing environment, give it as a command-line parameter to the grid node service, as described in Section 21.12.4, “Starting a Grid Node”.

#### Installing ChromeDriver for Ubuntu Chromium

While you can install Google Chrome in Ubuntu, it also has its own Chromium Browser, which is based on the Google Chrome. Chromium has its own version of ChromeDriver, which requires some additional installation steps to be usable.

Install the ChromeDriver:

```
$ sudo apt-get install chromium-chromedriver
```

Add the driver executable to path, such as:

```
$ sudo ln -s /usr/lib/chromium-browser/chromedriver /usr/local/bin/chromedriver
```

The Chromium libraries need to be included in the system library path:

```
$ sudo sh -c 'echo "/usr/lib/chromium-browser/libs" > /etc/ld.so.conf.d/chrome_libs.conf'
```

```
$ sudo ldconfig
```

### 21.3.6. Test Node Configuration

If you are running the tests in a grid environment, you need to make some configuration to the test nodes to get more stable results.

Further configuration is provided in command-line parameters when starting the node services, as described in Section 21.12.4, “Starting a Grid Node”.

## Operating system settings

Make any operating system settings that might interfere with the browser and how it is opened or closed. Typical problems include crash handler dialogs.

On Windows, disable error reporting in case a browser crashes as follows:

1. Open **Control Panel System**
2. Select the **Advanced** tab
3. Select **Error reporting**
4. Check that **Disable error reporting** is selected
5. Check that **But notify me when critical errors occur** is not selected

## Settings for Screenshots

The screenshot comparison feature requires that the user interface of the browser stays constant. The exact features that interfere with testing depend on the browser and the operating system.

In general:

- Disable blinking cursor
- Use identical operating system themeing on every host
- Turn off any software that may suddenly pop up a new window
- Turn off screen saver

If using Windows and Internet Explorer, you should give also the following setting:

- Turn on **Allow active content to run in files on My Computer** under **Security settings**

## 21.4. Developing JUnit Tests

JUnit is a popular unit testing framework for Java development. Most Java IDEs, build systems, and continuous integration systems provide support for JUnit. However, while we concentrate on the development of JUnit tests in this chapter, Vaadin TestBench and the WebDriver are in no way specific to JUnit and you can use any test execution framework, or just regular Java applications, to develop TestBench tests.

You may want to keep your test classes in a separate source tree in your application project, or in an altogether separate project, so that you do not have to include them in the web application WAR. Having them in the same project may be nicer for version control purposes.

### 21.4.1. Basic Test Case Structure

A JUnit test case is defined with annotations for methods in a test case class. With TestBench, the test case class should extend the **TestBenchTestCase** class, which provides the WebDriver and ElementQuery APIs.

```
public class MyTestcase extends TestBenchTestCase {
```

The basic JUnit annotations used in TestBench testing are the following:

#### @Rule

You can define certain TestBench parameters and other JUnit rules with the @Rule annotation.

For example, to enable taking screenshots on test failures, as described in Section 21.10.2, “Taking Screenshots on Failure”, you would define:

```
@Rule  
public ScreenshotOnFailureRule screenshotOnFailureRule =  
    new ScreenshotOnFailureRule(this, true);
```

Note that if you use this rule, you must *not* call `driver.quit()` in your @After method, as the method is executed before the screenshot is taken, but the driver must be open to take it.

#### @Before

The annotated method is executed before each test (annotated with @Test). Normally, you create and set the driver here.

```
@Before  
public void setUp() throws Exception {  
    setDriver(new FirefoxDriver());  
}
```

The driver class should be one of **FirefoxDriver**, **ChromeDriver**, **InternetExplorerDriver**, **SafariDriver**, or **PhantomJSDriver**. Please check **RemoteWebDriver** from API documentation for the current list of implementations. Notice that some of the drivers require installing a browser driver, as described in Section 21.3.5, “Installing Browser Drivers”.

The driver instance is stored in the `driver` property in the test case. While you can access the property directly by the member variable, you should set it only with the setter.

#### @Test

Annotates a test method. You normally first open the page and then execute commands and make assertions on the content.

```
@Test  
public void testClickButton() throws Exception {  
    getDriver().get("http://localhost:8080/myproject");  
  
    // Click the button  
    ButtonElement button = $(ButtonElement.class).  
        caption("Click Me").first();  
    button.click();  
  
    // Check that the label text is correct  
    LabelElement label = $(LabelElement.class).first();  
    assertEquals("Thanks!", label.getText());  
}
```

Normally, you would define the URL with a variable that is common for all tests, and possibly concatenate it with a URI fragment to get to an application state.

```
@After
```

After each test is finished, you normally need to quit the driver to close the browser.

```
@After
```

```
public void tearDown() throws Exception {  
    driver.quit();  
}
```

However, if you enable grabbing screenshots on failure with the **ScreenshotOnFailureRule**, as described in Section 21.10.2, “Taking Screenshots on Failure”, the rules are executed after @After, but the driver needs to be open when the rule to take the screenshot is executed. Therefore, you should not quit the driver in that case. The rule quits the driver implicitly.

You can use any other JUnit features. Notice, however, that using TestBench requires that the driver has been created and is still open.

A complete test case could be as follows:

```
import com.vaadin.testbench.ScreenshotOnFailureRule;  
import com.vaadin.testbench.TestBenchTestCase;  
import com.vaadin.testbench.elements.ButtonElement;  
import com.vaadin.testbench.elements.LabelElement;  
  
import org.junit.Before;  
import org.junit.Rule;  
import org.junit.Test;  
import org.openqa.selenium.firefox.FirefoxDriver;  
  
import java.util.List;  
  
import static org.junit.Assert.assertEquals;  
import static org.junit.Assert.assertFalse;  
  
public class MyprojectTest extends TestBenchTestCase {  
    @Rule  
    public ScreenshotOnFailureRule screenshotOnFailureRule =  
        new ScreenshotOnFailureRule(this, true);  
  
    @Before  
    public void setUp() throws Exception {  
        setDriver(new FirefoxDriver()); // Firefox  
    }  
  
    /**  
     * Opens the URL where the application is deployed.  
     */  
    private void openTestUrl() {  
        getDriver().get("http://localhost:8080/myproject");  
    }  
  
    @Test  
    public void testClickButton() throws Exception {  
        openTestUrl();  
  
        // At first there should be no labels  
        assertFalse(${LabelElement.class}.exists());  
  
        // Click the button
```

```
        ButtonElement clickMeButton = $(ButtonElement.class).  
            caption("Click Me").first();  
        clickMeButton.click();  
  
        // There should now be one label  
        assertEquals(1, $(LabelElement.class).all().size());  
  
        // ... with the specified text  
        assertEquals("Thank you for clicking",  
            $(LabelElement.class).first().getText());  
  
        // Click the button again  
        clickMeButton.click();  
  
        // There should now be two labels  
        List<LabelElement> allLabels =  
            $(LabelElement.class).all();  
        assertEquals(2, allLabels.size());  
  
        // ... and the last label should have the correct text  
        LabelElement lastLabel = allLabels.get(1);  
        assertEquals("Thank you for clicking",  
            lastLabel.getText());  
    }  
}
```

This test case stub is created by the Vaadin project wizard in Eclipse and by the Maven archetype, as described in Section 21.2, “Quick Start”.

## 21.4.2. Running JUnit Tests in Eclipse

The Eclipse IDE integrates JUnit with nice control features, such as running the tests in the current test source file. The test results are reported visually in the JUnit view in Eclipse.

New Vaadin projects created with the Vaadin Plugin for Eclipse contain the TestBench API dependency, as described in Section 21.2, “Quick Start”, so you can run TestBench tests right away.

To configure an existing project for TestBench testing, you need to do the following:

1. Include the TestBench API dependency in the project.
  - a. If using a project created with the Vaadin Plugin for Eclipse, add the TestBench API library dependency in `ivy.xml`. It should be as follows:

```
<dependency org="com.vaadin"  
           name="vaadin-testbench-api"  
           rev="latest.release"  
           conf="nodeploy->default" />
```

The TestBench API library provides element classes for Vaadin components, so its revision number follows the earliest supported Vaadin release. For old Vaadin versions, you can try using the `latest.release` as given above.

The project should contain the `nodeploy` configuration, as created for new Vaadin projects. See Section 17.3, “Installing Add-ons in Eclipse with Ivy” for more details.

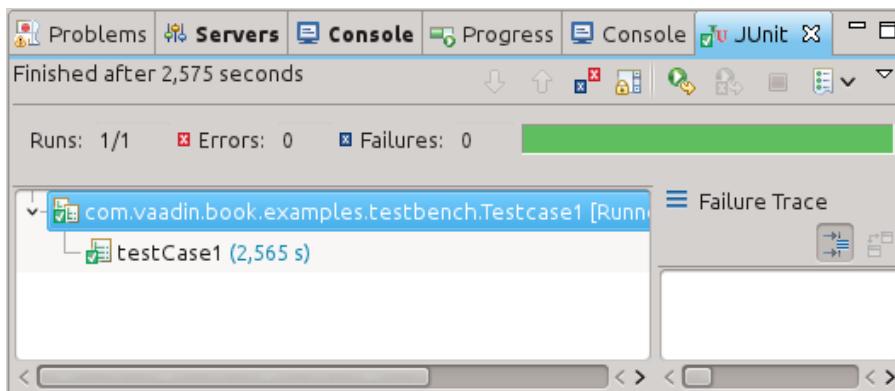
- b. Otherwise, add the `vaadin-testbench-api` and `vaadin-testbench-core` JARs from the installation package to a library folder in the project, such as `lib`. You

should not put the library in `WEB-INF/lib` as it is not used by the deployed Vaadin web application. Refresh the project by selecting it and pressing **F5**.

2. Right-click the project in Project Explorer and select **Properties**, and open the **Java Build Path** and the **Libraries** tab. Click **Add JARs**, navigate to the library folder, select the library, and click **OK**.
3. Switch to the **Order and Export** tab in the project properties. Make sure that the TestBench JAR is above the `gwt-dev.jar` (it may contain an old `httpclient` package), by selecting it and moving it with the **Up** and **Down** buttons.
4. Click **OK** to exit the project properties.
5. Right-click a test source file and select **Run As JUnit Test**.

A JUnit view should appear, and it should open the Firefox browser, launch the application, run the test, and then close the browser window. If all goes well, you have a passed test case, which is reported in the JUnit view area in Eclipse, as illustrated in Figure 21.8, “Running JUnit Tests in Eclipse”.

**Figure 21.8. Running JUnit Tests in Eclipse**



If you are using some other IDE, it might support JUnit tests as well. If not, you can run the tests using Ant or Maven.

## 21.5. Creating a Test Case

### 21.5.1. Test Setup

Test configuration is done in a method annotated with `@Before`. The method is executed before each test case.

The basic configuration tasks are:

- Set TestBench parameters
- Create the web driver
- Do any other initialization

## TestBench Parameters

TestBench parameters are defined with static methods in the **com.vaadin.testbench.Parameters** class. The parameters are mainly for screenshots and documented in Section 21.10, “Taking and Comparing Screenshots”.

### 21.5.2. Basic Test Case Structure

A typical test case does the following:

1. Open the URL
2. Navigate to desired state
  - a. Find a HTML element (**WebElement**) for interaction
  - b. Use `click()` and other commands to interact with the element
  - c. Repeat with different elements until desired state is reached
3. Find a HTML element (**WebElement**) to check
4. Get and assert the value of the HTML element
5. Get a screenshot

The **WebDriver** allows finding HTML elements in a page in various ways, for example, with XPath expressions. The access methods are defined statically in the **By** class.

These tasks are realized in the following test code:

```
@Test
public void basic() throws Exception {
    getDriver().get("http://localhost:8080/tobetested");

    // Find an element to interact upon
    ButtonElement button =
        $(ButtonElement.class).id("mybutton");

    // Click the button
    button.click();

    // Check that the label text is correct
    LabelElement label = $(LabelElement.class).first();
    assertEquals("Thanks!", label.getText());
}
```

You can also use URI fragments in the URL to open the application at a specific state. For information about URI fragments, see Section 11.11, “Managing URI Fragments”.

You should use the JUnit assertion commands. They are static methods defined in the `org.junit.Assert` class, which you can import (for example) with:

```
import static org.junit.Assert.assertEquals;
```

Please see the Selenium API documentation for a complete reference of the element search methods in the **WebDriver** and **By** classes and for the interaction commands in the **WebElement** class.

TestBench has a collection of its own commands, defined in the `TestBenchCommands` interface. You can get a command object that you can use by calling `testBench(driver)` in a test case.

While you can develop tests simply with test cases as described above, for the sake of maintainability it is often best to modularize the test code further, such as to separate testing at the levels of business logic and the page layout. See Section 21.9, “Creating Maintainable Tests” for information about using page objects for this purpose.

### 21.5.3. Creating and Closing a Web Driver

Vaadin TestBench uses Selenium WebDriver to execute tests in a browser. The **WebDriver** instance is created with the static `createDriver()` method in the **TestBench** class. It takes the driver as the parameter and returns it after registering it. The test cases must extend the **TestBenchTestCase** class, which manages the TestBench-specific features. You need to store the driver in the test case with `setDriver()`.

The basic way is to create the driver in a method annotated with the JUnit `@Before` annotation and close it in a method annotated with `@After`.

```
public class AdvancedTest extends TestBenchTestCase {
    @Before
    public void setUp() throws Exception {
        ...
        setDriver(TestBench.createDriver(new FirefoxDriver()));
    }
    ...
    @After
    public void tearDown() throws Exception {
        driver.quit();
    }
}
```

This creates the driver for each test you have in the test class, causing a new browser instance to be opened and closed. If you want to keep the browser open between the tests, you can use `@BeforeClass` and `@AfterClass` methods to create and quit the driver. In that case, the methods as well as the driver instance have to be static and you need to set the driver in a `@Before` method.

```
public class AdvancedTest extends TestBenchTestCase {
    static private WebDriver driver;

    @BeforeClass
    static public void createDriver() throws Exception {
        driver = TestBench.createDriver(new FirefoxDriver());
    }

    @Before
    public void setUp() throws Exception {
        setDriver(driver);
    }
    ...
    @AfterClass
    static public void tearDown() throws Exception {
```

```
        driver.quit();
    }
}
```

## Browser Drivers

Please see the API documentation of the `WebDriver` interface for a complete list of supported drivers, that is, classes implementing the interface.

Both the Internet Explorer and Chrome require a special driver, as was noted in Section 21.3.5, “Installing Browser Drivers”. The driver executable must be included in the operating system PATH, be given with a driver-specific system Java property:

- Chrome: `webdriver.chrome.driver`
- IE: `webdriver.ie.driver`

You can set the property in Java with `System.setProperty(prop, key)` or pass it as a command-line parameter to the Java executable with `-Dwebdriver.chrome.driver=/path/to/driver`.

If you use an ESR version of Firefox, which is recommended for test stability, you need to the binary when creating the driver as follows:

```
FirefoxBinary binary =
    new FirefoxBinary(new File("/path/to/firefox_ESR_10"));
driver = TestBench.createDriver(
    new FirefoxDriver(binary, new FirefoxProfile()));
```

## 21.6. Querying Elements

The high-level `ElementQuery` API allows querying Vaadin components in the browser according to their component class type, hierarchy, caption, and other properties. Once one or more components are found, they can be interacted upon. The query API forms an domain-specific language (DSL), embedded in the `TestBenchTestCase` class.

The basic idea of element queries match elements and return queries, which can again be queried upon, until terminated by a terminal query that returns one or more elements.

Consider the following query:

```
List<ButtonElement> buttons = $(ButtonElement.class).all();
```

The query returns a list of HTML elements of all the **Button** components in the UI. Every Vaadin component has its corresponding element class, which has methods to interact with the particular component type. We could control the buttons found by the query, for example, by clicking them as follows:

```
for (ButtonElement b: buttons)
    b.click();
```

In the following sub-sections, we look into the details of element queries.

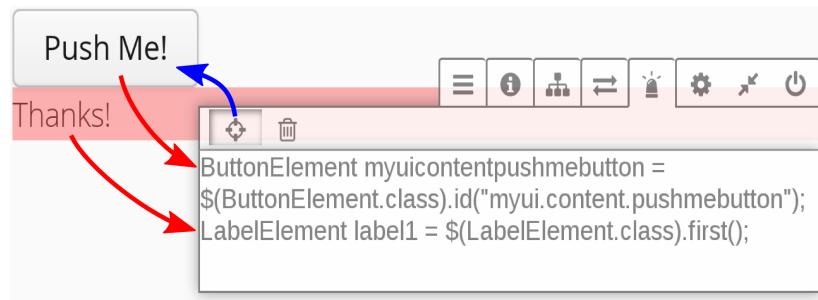
## 21.6.1. Generating Queries with Debug Window

You can use the debug window to easily generate the element query code to select a particular element in the UI. This should be especially useful when starting to use TestBench, to get the idea what the queries should be like.

First, enable the debug window with the `&debug` parameter for the application, as described in more detail in Section 11.3, “Debug Mode and Window”. You can interact with the UI in any way you like before generating the query code, but we recommend that you proceed by following the sequence in which the user would use the UI in each use case, making the queries at each step.

Switch to the TestBench tab in the debug window, and enable the pick mode by clicking the small button. Now, when you hover the mouse pointer on elements, it highlights them, and when you click one, it generates the TestBench element query to find the element. Use of the debug window is illustrated in Figure 21.9, “Using Debug Window to Generate Element Queries”.

**Figure 21.9. Using Debug Window to Generate Element Queries**



You can select and copy and paste the code from the debug window to your editor. To exit the pick mode, click the pick button again.

The debug window feature is available in Vaadin 7.2 and later.

## 21.6.2. Querying Elements by Component Type (\$)

The `$` method creates an **ElementQuery** that looks for the given element class. The method is available both in **TestBenchTestcase** and **ElementQuery**, which defines the context. The search is done recursively in the context.

```
// Find the first OK button in the UI
ButtonElement button = $(ButtonElement.class)
    .caption("OK").first();

// A nested query where the context of the latter
// component type query is the matching elements
// - matches the first Label inside the "content" layout.
LabelElement label = $(VerticalLayoutElement.class)
    .id("content").$(LabelElement.class).first();
```

## 21.6.3. Non-Recursive Component Queries (\$\$)

The `$$` method creates a non-recursive **ElementQuery**. It is a shorthand for first creating a recursive query with `$` and then calling `recursive(false)` for the query.

## 21.6.4. Element Classes

Each Vaadin component has a corresponding element class in TestBench, which contains methods for interacting with the particular component. The element classes extend **TestBenchElement**. It implements Selenium **WebElement**, so the Selenium element API can be used directly. The element classes are distributed in a Vaadin library rather than with TestBench, as they must correspond with the Vaadin version used in the application.

In addition to components, other Vaadin UI elements such as notifications (see Section 21.8.4, “Testing Notifications”) can have their corresponding element class. Add-on libraries may also define their custom element classes.

**TestBenchElement** is a TestBench command executor, so you can always use an element to create query in the sub-tree of the element. For example, in the following we first find a layout element by its ID and then do a sub-query to find the first label in it:

```
VerticalLayoutElement layout =
    $(VerticalLayoutElement.class).id("content");
LabelElement label = layout.$(LabelElement.class).first();
```

## 21.6.5. ElementQuery Objects

You can use an **ElementQuery** object to either make sub-queries to refine the query, or use a query terminator to finalize the query and get one or more matching elements.

## 21.6.6. Query Terminators

A query is finalized by a sub-query that returns an element or a collection of elements.

<code>first()</code>	Returns the first found element.
<code>get()</code>	Returns the element by index in the collection of matching elements.
<code>all()</code>	Returns a <code>List</code> of elements of the query type.
<code>id()</code>	Returns the unique element having the given ID. Element IDs must always be unique in the web page. It is therefore meaningless to make a complex query to match the ID, just matching the element class is enough.

## Web Elements

A query returns one or more elements extending Selenium **WebElement**. The particular element-specific class offers methods to manipulate the associated Vaadin component, while you can also use the lower-level general-purpose methods defined in **WebElement**.

## 21.7. Element Selectors

In addition to the high-level ElementQuery API described in the previous section, Vaadin TestBench includes the lower-level Selenium WebDriver API, with Vaadin extensions. You can find elements also by a plain XPath expression, an element ID, CSS style class, and so on. You can use such

selectors together with the element queries. Like the ElementQuery API, it can be considered a domain-specific language (DSL) that is embedded in the **TestBenchTestCase** class.

The available selectors are defined as static methods in the **com.vaadin.testbench.By** class. They create and return a **By** instance, which you can use for the `findElement()` method in **WebDriver**.

The ID, CSS class, and Vaadin selectors are described below. For others, we refer to the Selenium WebDriver API documentation.

Some selectors are not applicable to all elements, for example if an element does not have an ID or it is outside the Vaadin application. In such case, another selector is used according to a preference order. You can change the order of the preferred selectors by selecting **Options Options Locator Builders** and dragging the selectors (or locators) to a preferred order. Normally, the Vaadin selector should be at top of the list.

### 21.7.1. Finding by ID

Selecting elements by their HTML element `id` attribute is a robust way to select elements, as noted in Section 21.9.1, “Increasing Selector Robustness”. It requires that you component IDs for the UI components with `setId()`.

```
Button button = new Button("Push Me!");
button.setId("pushmebutton");
```

The button would be rendered as a HTML element: `<div id="pushmebutton" ...>...</div>`. The element would then be accessible with a low-level WebDriver call:

```
findElement(By.id("pushmebutton")).click();
```

The selector is equivalent to the statically typed element query `$(ButtonElement.class).id("pushmebutton")`.

### 21.7.2. Finding by CSS Class

An element with a particular CSS style class name can be selected with the `By.className()` method. CSS selectors are useful for elements which have no ID, nor can be found easily from the component hierarchy, but do have a particular unique CSS style. Tooltips are one example, as they are floating `div` elements under the root element of the application. Their `v-tooltip` style makes it possible to select them as follows:

```
// Verify that the tooltip contains the expected text
String tooltipText = findElement(
    By.className("v-tooltip")).getText();
```

For a complete example, see the `AdvancedCommandsITCase.java` file in the **TestBench** demo described in Section 21.3.4, “TestBench Demo”.

## 21.8. Special Testing Topics

In the following, we go through a number of TestBench features for handling special cases, such as tooltips, scrolling, notifications, context menus, and profiling responsiveness. Finally, we look into the Page Object pattern.

## 21.8.1. Waiting for Vaadin

Selenium, on which Vaadin TestBench is based, is originally intended for regular web applications that load a page that is immediately rendered by the browser. In such applications, you can test the page elements immediately after the page is loaded. In Vaadin and other AJAX applications, rendering is done by JavaScript code asynchronously, so you need to wait until the server has given its response to an AJAX request and the JavaScript code finishes rendering the UI. Selenium supports AJAX applications by having special wait methods to poll the UI until the rendering is finished. In pure Selenium, you need to use the wait methods explicitly, and know what to use and when. Vaadin TestBench works together with the client-side engine of Vaadin framework to immediately detect when the rendering is finished. Waiting is implicit, so you do not normally need to insert any wait commands yourself.

Waiting is automatically enabled, but it may be necessary to disable it in some cases. You can do that by calling `disableWaitForVaadin()` in the `TestBenchCommands` interface. You can call it in a test case as follows:

```
testBench(driver).disableWaitForVaadin();
```

When disabled, you can wait for the rendering to finish by calling `waitForVaadin()` explicitly.

```
testBench(driver).waitForVaadin();
```

You can re-enable the waiting with `enableWaitForVaadin()` in the same interface.

## 21.8.2. Testing Tooltips

Component tooltips show when you hover the mouse over a component. Showing them require special command. Handling them is also special, as the tooltips are floating overlay element, which are not part of the normal component hierarchy.

Let us assume that you have set the tooltip as follows:

```
// Create a button with a component ID
Button button = new Button("Push Me!");
button.setId("main.button");

// Set the tooltip
button.setDescription("This is a tip");
```

The tooltip of a component is displayed with the `showTooltip()` method in the `TestBenchElementCommands` interface. You should wait a little to make sure it comes up. The floating tooltip element is not under the element of the component, but you can find it by `//div[@class='v-tooltip']` XPath expression.

```
@Test
public void testTooltip() throws Exception {
    driver.get(appUrl);

    ButtonElement button =
        $(ButtonElement.class).id("main.button");

    button.showTooltip();

    WebElement ttip = findElement(By.className("v-tooltip"));
    assertEquals(ttip.getText(), "This is a tip");
}
```

### 21.8.3. Scrolling

Some Vaadin components, such as **Table** and **Panel** have a scrollbar. Normally, when you interact with an element within such a scrolling region, TestBench implicitly tries to scroll to the element to make it visible. In some cases, you may wish to scroll a scrollbar explicitly. You can accomplish that with the `scroll()` (vertical) and `scrollLeft()` (horizontal) methods in the respective element classes for the scrollable components. The scroll position is given in pixels.

```
// Scroll to a vertical position
PanelElement panel = $(PanelElement.class)
    .caption("Scrolling Panel").first();
panel.scroll(123);
```

### 21.8.4. Testing Notifications

You can find notification elements by the **NotificationElement** class in the element query API. The element class supports getting the caption with `getCaption()`, description with `getDescription()`, and notification type with `getType()`.

Let us assume that you pop the notification up as follows:

```
Button button = new Button("Pop It Up", e -> // Java 8
    Notification.show("The caption", "The description",
        Notification.Type.WARNING_MESSAGE));
```

You could then check for the notification as follows:

```
// Click the button to open the notification
ButtonElement button =
    $(ButtonElement.class).caption("Pop It Up").first();
button.click();

// Verify the notification
NotificationElement notification =
    $(NotificationElement.class).first();
assertEquals("The caption", notification.getCaption());
assertEquals("The description", notification.getDescription());
assertEquals("warning", notification.getType());
notification.close();
```

You need to close the notification box with `close()` to move forward.

### 21.8.5. Testing Context Menus

Opening context menus requires special handling. First, to open a menu, you need to "context-click" on a specific sub-element in a component that supports context menus. You can do that with a `contextClick()` action in a **Actions** object.

A context menu is displayed as a floating element, which is under a special overlays element in the HTML page, not under the component from which it pops up. You can find it from the page by its CSS class `v-contextmenu`. The menu items are represented as text, and you can find the text with an XPath expression as shown in the example below.

In the following example, we open a context menu in a **Table** component, find an item by its caption text, and click it.

```
// Get a table cell to work on
TableElement table = inExample(TableElement.class).first();
WebElement cell = table.getCell(3, 0); // A cell in the row

// Perform context click action to open the context menu
new Actions(getDriver()).contextClick(cell).perform();

// Find the opened menu
WebElement menu = findElement(By.className("v-contextmenu"));

// Find a specific menu item
WebElement menuitem = menu.findElement(
    By.xpath("//*[text() = 'Add Comment']]"));

// Select the menu item
menuitem.click();
```

## 21.8.6. Profiling Test Execution Time

It is not just that it works, but also how long it takes. Profiling test execution times consistently is not trivial, as a test environment can have different kinds of latency and interference. For example in a distributed setup, timings taken on the test server would include the latencies between the test server, the grid hub, a grid node running the browser, and the web server running the application. In such a setup, you could also expect interference between multiple test nodes, which all might make requests to a shared application server and possibly also share virtual machine resources.

Furthermore, in Vaadin applications, there are two sides which need to be profiled: the server-side, on which the application logic is executed, and the client-side, where it is rendered in the browser. Vaadin TestBench includes methods for measuring execution time both on the server-side and the client-side.

The `TestBenchCommands` interface offers the following methods for profiling test execution time:

`totalTimeSpentServicingRequests()`

Returns the total time (in milliseconds) spent servicing requests in the application on the server-side. The timer starts when you first navigate to the application and hence start a new session. The time passes only when servicing requests for the particular session. The timer is shared in the servlet session, so if you have, for example, multiple portlets in the same application (session), their execution times will be included in the same total.

Notice that if you are also interested in the client-side performance for the last request, you must call the `timeSpentRenderingLastRequest()` before calling this method. This is due to the fact that this method makes an extra server request, which will cause an empty response to be rendered.

`timeSpentServicingLastRequest()`

Returns the time (in milliseconds) spent servicing the last request in the application on the server-side. Notice that not all user interaction through the WebDriver cause server requests.

As with the total above, if you are also interested in the client-side performance for the last request, you must call the `timeSpentRenderingLastRequest()` before calling this method.

```
totalTimeSpentRendering()
```

Returns the total time (in milliseconds) spent rendering the user interface of the application on the client-side, that is, in the browser. This time only passes when the browser is rendering after interacting with it through the WebDriver. The timer is shared in the servlet session, so if you have, for example, multiple portlets in the same application (session), their execution times will be included in the same total.

```
timeSpentRenderingLastRequest()
```

Returns the time (in milliseconds) spent rendering user interface of the application after the last server request. Notice that not all user interaction through the WebDriver cause server requests.

If you also call the `timeSpentServicingLastRequest()` or `totalTimeSpentServicingRequests()`, you should do so before calling this method. The methods cause a server request, which will zero the rendering time measured by this method.

Generally, only interaction with fields in the *immediate* mode cause server requests. This includes button clicks. Some components, such as **Table**, also cause requests otherwise, such as when loading data while scrolling. Some interaction could cause multiple requests, such as when images are loaded from the server as the result of user interaction.

The following example is given in the `VerifyExecutionTimeITCase.java` file in the TestBench demo.

```
@Test
public void verifyServerExecutionTime() throws Exception {
    // Get start time on the server-side
    long currentSessionTime = testBench(getDriver())
        .totalTimeSpentServicingRequests();

    // Interact with the application
    calculateOnePlusTwo();

    // Calculate the passed processing time on the serve-side
    long timeSpentByServerForSimpleCalculation =
        testBench().totalTimeSpentServicingRequests() -
        currentSessionTime;

    // Report the timing
    System.out.println("Calculating 1+2 took about "
        + timeSpentByServerForSimpleCalculation
        + "ms in servlets service method.");

    // Fail if the processing time was critically long
    if (timeSpentByServerForSimpleCalculation > 30) {
        fail("Simple calculation shouldn't take " +
            timeSpentByServerForSimpleCalculation + "ms!");
    }

    // Do the same with rendering time
    long totalTimeSpentRendering =
        testBench().totalTimeSpentRendering();
    System.out.println("Rendering UI took "
        + totalTimeSpentRendering + "ms");
    if (totalTimeSpentRendering > 400) {
        fail("Rendering UI shouldn't take " +
            totalTimeSpentRendering + "ms!");
    }
}
```

```
// A normal assertion on the UI state
assertEquals("3.0",
    $(TextFieldElement.class).first()
    .getAttribute("value"));
}
```

## 21.9. Creating Maintainable Tests

The first important rule in developing tests is to keep them readable and maintainable. Otherwise, when the test fail, such as after refactoring the application code, the developers get impatient in trying to understand them to fix them, and easily disable them. Readability and maintainability can be improved with the Page Object Pattern described below.

The second rule is to run the tests often. It is best to use a continuous integration server to run them at least once a day, or preferably on every commit.

### 21.9.1. Increasing Selector Robustness

Robustness of tests is important for avoiding failures because of irrelevant changes in the HTML DOM tree. Different selectors have differences in their robustness and it depends on how they are used.

The ElementQuery API uses the logical widget hierarchy to find the HTML elements, instead of the exact HTML DOM structure. This makes them somewhat robust, although still vulnerable to irrelevant changes in the exact component hierarchy of the UI. Also, if you internationalize the application, selecting components by their caption is not viable.

The low-level XPath selector can be highly vulnerable to changes in the DOM path, especially if the path is given down from the body element of the page. The selector is, however, very flexible, and can be used in robust ways, for example, by selecting by HTML element and a CSS class name or an attribute value. You can likewise use a CSS selector to select specific components by CSS class in a robust way.

### Using Component IDs to Increase Robustness

To make UIs more robust for testing, you can set a unique *component ID* for specific components with `setId()`, as described in more detail in Section 21.7.1, “Finding by ID”.

Let us consider the following application, in which we set the IDs using a hierarchical notation to ensure that they are unique; in a more modular case you could consider a different strategy.

```
public class UIToBeTested extends UI {
    @Override
    protected void init(VaadinRequest request) {
        setId("myui");

        final VerticalLayout content = new VerticalLayout();
        content.setMargin(true);
        content.setId("myui.content");
        setContent(content);

        // Create a button
        Button button = new Button("Push Me!");

        // Optional: give the button a unique ID
```

```
        button.setId("myui.content.pushmebutton");

        content.addComponent(button);
    }
}
```

After preparing the application this way, you can find the element by the component ID with the `id()` query terminator.

```
// Click the button
ButtonElement button =
    $(ButtonElement.class).id("myui.content.pushmebutton");
button.click();
```

The IDs are HTML element `id` attributes and must be unique in the UI, as well as in the page in which the UI is running, in case the page has other content than the particular UI instance. In case there could be multiple UIs, you can include a UI part in the ID, as we did in the example above.

## Using CSS Class Names to Increase Robustness

As a similar method to using component IDs, you can add CSS class names to components with `addStyleName()`. This enables matching them with the `findElement(By.className())` selector, as described in Section 21.7.2, “Finding by CSS Class”. You can use the selector in element queries. Unlike IDs, CSS class names do not need to be unique, so an HTML page can have many elements with the same CSS class.

You can use CSS class names also in XPath selectors.

### 21.9.2. The Page Object Pattern

The Page Object Pattern aims to simplify and modularize testing application views. The pattern follows the design principle of separation of concerns, to handle different concerns in separate modules, while hiding information irrelevant to other tests by encapsulation.

#### Defining a Page Object

A *page object* has methods to interact with a view or a sub-view, and to retrieve values in the view. You also need a method to open the page and navigate to the proper view.

For example:

```
public class CalculatorPageObject
    extends TestBenchTestCase {
    @FindBy(id = "button_=")
    private WebElement equals;
    ...

    /**
     * Opens the URL where the calculator resides.
     */
    public void open() {
        getDriver().get(
            "http://localhost:8080/?restartApplication");
    }

    /**
```

```
* Pushes buttons on the calculator
*
* @param buttons the buttons to push: "123+2", etc.
* @return The same instance for method chaining.
*/
public CalculatorPageObject enter(String buttons) {
    for (char numberChar : buttons.toCharArray()) {
        pushButton(numberChar);
    }
    return this;
}

/**
 * Pushes the specified button.
 *
 * @param button The character of the button to push.
 */
private void pushButton(char button) {
    getDriver().findElement(
        By.id("button_" + button)).click();
}

/**
 * Pushes the equals button and returns the contents
 * of the calculator "display".
 *
 * @return The string (number) shown in the "display"
 */
public String getResult() {
    equals.click();
    return display.getText();
}

...
}
```

## Finding Member Elements By ID

If you have **WebElement** members annotated with **@FindBy**, they can be automatically filled with the HTML element matching the given component ID, as if done with `driver.findElement(By.id(fieldname))`. To do so, you need to create the page object with **PageFactory** as is done in the following test setup:

```
public class PageObjectExampleITCase {
    private CalculatorPageObject calculator;

    @Before
    public void setUp() throws Exception {
        driver = TestBench.createDriver(new FirefoxDriver());

        // Use PageFactory to automatically initialize fields
        calculator = PageFactory.initElements(driver,
            CalculatorPageObject.class);
    }
    ...
}
```

The members must be typed dynamically as **WebElement**, but you can wrap them to a typed element class with the `wrap()` method:

```
ButtonElement equals = equalsElement.wrap(ButtonElement.class);
```

## Using a Page Object

Test cases can use the page object methods at business logic level, without knowing about the exact structure of the views.

For example:

```
@Test
public void testAddCommentRowToLog() throws Exception {
    calculator.open();

    // Just do some math first
    calculator.enter("1+2");

    // Verify the result of the calculation
    assertEquals("3.0", calculator.getResult());

    ...
}
```

## The Page Object Example

You can find the complete example of the Page Object Pattern in the `src/test/java/com/vaadin/testbenchexample/pageobjectexample/` folder in the TestBench Demo. The `PageObjectExampleITCase.java` runs tests on the Calc UI (also included in the example sources), using the page objects to interact with the different parts of the UI and to check the results.

The page objects included in the `pageobjects` subfolder are as follows:

- The **CalculatorPageObject** (as outlined in the example code above) has methods to click the buttons in the calculator and the retrieve the result shown in the "display".
- The **LogPageObject** can retrieve the content of the log entries in the log table, and right-click them to open the comment sub-window.
- The **AddComment** can enter a comment string in the comment editor sub-window and submit it (click the **Add** button).

## 21.10. Taking and Comparing Screenshots

You can take and compare screenshots with reference screenshots taken earlier. If there are differences, you can fail the test case.

### 21.10.1. Screenshot Parameters

The screenshot configuration parameters are defined with static methods in the `com.vaadin.testbench.Parameters` class.

`screenshotErrorDirectory` (default: null)

Defines the directory where screenshots for failed tests or comparisons are stored.

*screenshotReferenceDirectory* (default: null)  
Defines the directory where the reference images for screenshot comparison are stored.

*screenshotComparisonTolerance* (default: 0.01)  
Screen comparison is usually not done with exact pixel values, because rendering in browser often has some tiny inconsistencies. Also image compression may cause small artifacts.

*screenshotComparisonCursorDetection* (default: false)  
Some field component get a blinking cursor when they have the focus. The cursor can cause unnecessary failures depending on whether the blink happens to make the cursor visible or invisible when taking a screenshot. This parameter enables cursor detection that tries to minimize these failures.

*maxScreenshotRetries* (default: 2)  
Sometimes a screenshot comparison may fail because the screen rendering has not yet finished, or there is a blinking cursor that is different from the reference screenshot. For these reasons, Vaadin TestBench retries the screenshot comparison for a number of times defined with this parameter.

*screenshotRetryDelay* (default: 500)  
Delay in milliseconds for making a screenshot retry when a comparison fails.

For example:

```
@Before  
public void setUp() throws Exception {  
    Parameters.setScreenshotErrorDirectory(  
        "screenshots/errors");  
    Parameters.setScreenshotReferenceDirectory(  
        "screenshots/reference");  
    Parameters.setMaxScreenshotRetries(2);  
    Parameters.setScreenshotComparisonTolerance(1.0);  
    Parameters.setScreenshotRetryDelay(10);  
    Parameters.setScreenshotComparisonCursorDetection(true);  
    Parameters.setCaptureScreenshotOnFailure(true);  
}
```

## 21.10.2. Taking Screenshots on Failure

Vaadin TestBench can take screenshots automatically when a test fails. To enable the feature, you need to include the **ScreenshotOnFailureRule** JUnit rule with a member variable annotated with **@Rule** in the test case as follows:

```
@Rule  
public ScreenshotOnFailureRule screenshotOnFailureRule =  
    new ScreenshotOnFailureRule(this, true);
```

Notice that you must not call `quit()` for the driver in the `@After` method, as that would close the driver before the rule takes the screenshot.

The screenshots are written to the error directory defined with the *screenshotErrorDirectory* parameter. You can configure it in the test case setup as follows:

```
@Before  
public void setUp() throws Exception {
```

```
Parameters.setScreenshotErrorDirectory("screenshots/errors");
...
}
```

### 21.10.3. Taking Screenshots for Comparison

Vaadin TestBench allows taking screenshots of the web browser window with the `compareScreen()` command in the **TestBenchCommands** interface. The method has a number of variants.

The `compareScreen(File)` takes a **File** object pointing to the reference image. In this case, a possible error image is written to the error directory with the same file name. You can get a file object to a reference image with the static `ImageFileUtil.getReferenceScreenshotFile()` helper method.

```
assertTrue("Screenshots differ",
    testBench(driver).compareScreen(
        ImageFileUtil.getReferenceScreenshotFile(
            "myshot.png")));

```

The `compareScreen(String)` takes a base name of the screenshot. It is appended with browser identifier and the file extension.

```
assertTrue(testBench(driver).compareScreen("tooltip"));

```

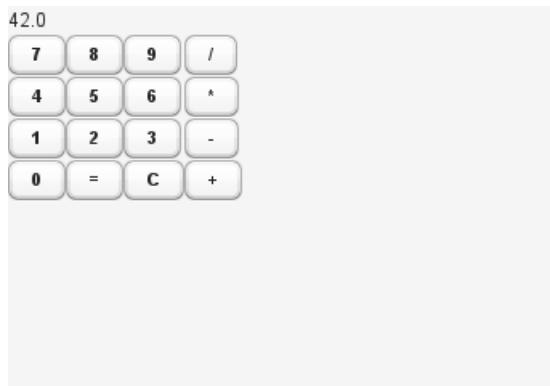
The `compareScreen(BufferedImage, String)` allows keeping the reference image in memory. An error image is written to a file with a name determined from the base name given as the second parameter.

Screenshots taken with the `compareScreen()` method are compared to a reference image stored in the reference image folder. If differences are found (or the reference image is missing), the comparison method returns `false` and stores the screenshot in the error folder. It also generates an HTML file that highlights the differing regions.

### Screenshot Comparison Error Images

Screenshots with errors are written to the error folder, which is defined with the `screenshotErrorDirectory` parameter described in Section 21.10.1, “Screenshot Parameters”.

For example, the error caused by a missing reference image could be written to `screenshots/errors/tooltip_firefox_12.0.png`. The image is shown in Figure 21.10, “A screenshot taken by a test run”.

**Figure 21.10. A screenshot taken by a test run**

Screenshots cover the visible page area in the browser. The size of the browser is therefore relevant for screenshot comparison. The browser is normally sized with a predefined default size. You can set the size of the browser window in a couple of ways. You can set the size of the browser window with, for example, `driver.manage().window().setSize(new Dimension(1024, 768));` in the `@Before` method. The size includes any browser chrome, so the actual screenshot size will be smaller. To set the actual view area, you can use `TestBenchCommands.resizeViewPortTo(1024, 768)`.

## Reference Images

Reference images are expected to be found in the reference image folder, as defined with the `screenshotReferenceDirectory` parameter described in Section 21.10.1, “Screenshot Parameters”. To create a reference image, just copy a screenshot from the `errors/` directory to the `reference/` directory.

For example:

```
$ cp screenshot/errors/tooltip_firefox_12.0.png screenshot/reference/
```

Now, when the proper reference image exists, rerunning the test outputs success:

```
$ java ...
JUnit version 4.5
.
Time: 18.222

OK (1 test)
```

## Masking Screenshots

You can make masked screenshot comparison with reference images that have non-opaque regions. Non-opaque pixels in the reference image, that is, ones with less than 1.0 value in the alpha channel, are ignored in the screenshot comparison.

Please see the `ScreenshotITCase.java` example in the TestBench Demo for an example of using masked screenshots. The `example/Screenshot_Comparison_Tests.pdf` document describes how to enable the example and how to create the screenshot masks in an image editor.

## Visualization of Differences in Screenshots with Highlighting

Vaadin TestBench supports advanced difference visualization between a captured screenshot and the reference image. A difference report is written to a HTML file that has the same name as the failed screenshot, but with .html suffix. The reports are written to the same errors/ folder as the screenshots from the failed tests.

The differences in the images are highlighted with blue rectangles. Moving the mouse pointer over a square shows the difference area as it appears in the reference image. Clicking the image switches the entire view to the reference image and back. Text "Image for this run" is displayed in the top-left corner of the screenshot to distinguish it from the reference image.

Figure 21.11, "The reference image and a highlighted error image" shows a difference report with one difference between the visualized screenshot (bottom) and the reference image (top).

**Figure 21.11. The reference image and a highlighted error image**



### 21.10.4. Practices for Handling Screenshots

Access to the screenshot reference image directory should be arranged so that a developer who can view the results can copy the valid images to the reference directory. One possibility is to store the reference images in a version control system and check-out them to the reference/ directory.

A build system or a continuous integration system can be configured to automatically collect and store the screenshots as build artifacts.

### 21.10.5. Known Compatibility Problems

#### Screenshots when running Internet Explorer 9 in Compatibility Mode

Internet Explorer prior to version 9 adds a two-pixel border around the content area. Version 9 no longer does this and as a result screenshots taken using Internet Explorer 9 running in compatibility mode (IE7/IE8) will include the two pixel border, contrary to what the older versions of Internet Explorer do.

## 21.11. Running Tests

During test development, you usually run the tests from your IDE. After that, you want to have them run by a build system, possibly under a continuous integration system. In the following, we describe how to run tests by Ant and Maven.

## 21.11.1. Running Tests with Ant

Apache Ant has built-in support for executing JUnit tests; you can use the `<junit>` task in an Ant script to execute JUnit tests. Note that in earlier versions, you need to enable the support, you need to have the JUnit library `junit.jar` and its Ant integration library `ant-junit.jar` in the Ant classpath, as described in the Ant documentation.

The following Ant script allows testing a Vaadin application created with the Vaadin Plugin for Eclipse. It assumes that the test source files are located under a `test` directory under the current directory and compiles them to the `classes` directory. The the class path is defined with the `classpath` reference ID and should contain `TestBench` and other necessary libraries.

```
<?xml version="1.0" encoding="UTF-8"?>
<project default="run-tests">
    <path id="classpath">
        <fileset dir="lib">
            <include name="vaadin-testbench-*.jar"/>
            <include name="junit-*.jar"/>
        </fileset>
    </path>

    <!-- This target compiles the JUnit tests. -->
    <target name="compile-tests">
        <mkdir dir="classes" />
        <javac srcdir="test" destdir="classes"
              debug="on" encoding="utf-8"
              includeantruntime="false">
            <classpath>
                <path refid="classpath" />
            </classpath>
        </javac>
    </target>

    <!-- This target calls JUnit -->
    <target name="run-tests" depends="compile-tests">
        <junit fork="yes">
            <classpath>
                <path refid="classpath" />
                <path element path="classes" />
            </classpath>

            <formatter type="brief" usefile="false" />

            <batchtest>
                <fileset dir="test">
                    <include name="**/*.java" />
                </fileset>
            </batchtest>
        </junit>
    </target>
</project>
```

You also need to deploy the application to test, and possibly launch a dedicated server for it.

## Retrieving TestBench with Ivy

To retrieve TestBench and its dependencies with Ivy in the Ant script, first install Ivy to your Ant installation, if necessary. In the build script, you need to enable Ivy with the namespace declaration and include a target for retrieving the libraries, as follows:

```
<project xmlns:ivy="antlib:org.apache.ivy.ant"
         default="run-tests">
    ...
    <!-- Retrieve dependencies with Ivy -->
    <target name="resolve">
        <ivy:retrieve conf="testing" type="jar,bundle"
                      pattern="lib/[artifact]-[revision].[ext]"/>
    </target>

    <!-- This target compiles the JUnit tests. -->
    <target name="compile-tests" depends="resolve">
        ...
    
```

This requires that you have a "testing" configuration in your `ivy.xml` and that the TestBench dependency are enabled in the configuration.

```
<ivy-module>
    ...
    <configurations>
        ...
        <conf name="testing" />
    </configurations>

    <dependencies>
        ...
        <!-- TestBench 4 -->
        <dependency org="com.vaadin"
                    name="vaadin-testbench-api"
                    rev="latest.release"
                    conf="nodeploy,testing -> default" />
        ...
    
```

You also need to build and deploy the application to be tested to the server and install the TestBench license key.

### 21.11.2. Running Tests with Maven

Executing JUnit tests with Vaadin TestBench under Maven requires defining it as a dependency in any POM that needs to execute TestBench tests.

A complete example of a Maven test setup is given in the TestBench demo project available at [github.com/vaadin/testbench-demo](https://github.com/vaadin/testbench-demo). See the README for further instructions.

#### Defining TestBench as a Dependency

You need to define the TestBench library as a dependency in the Maven POM of your project as follows:

```
<dependency>
    <groupId>com.vaadin</groupId>
    <artifactId>vaadin-testbench</artifactId>
```

```
<version>4.x.x</version>
</dependency>
```

For instructions on how to create a new Vaadin project with Maven, please see Section 2.6, “Using Vaadin with Maven”.

## Running the Tests

To compile and run the tests, simply execute the `test` lifecycle phase with Maven as follows:

```
$ mvn test
...
-----
T E S T S
-----
Running TestBenchExample
Tests run: 6, Failures: 1, Errors: 0, Skipped: 1, Time elapsed: 36.736 sec <<<
FAILURE!

Results :

Failed tests:
  testDemo(TestBenchExample):
    expected:<[5/17/]12> but was:<[17.6.20]12>

Tests run: 6, Failures: 1, Errors: 0, Skipped: 1
...
```

The example configuration starts Jetty to run the application that is tested.

If you have screenshot tests enabled, as mentioned in Section 21.3.4, “TestBench Demo”, you will get failures from screenshot comparison. The failed screenshots are written to the `target/testbench/errors` folder. To enable comparing them to “expected” screenshots, you need to copy the screenshots to the `src/test/resources/screenshots/reference` folder. See Section 21.10, “Taking and Comparing Screenshots” for more information regarding screenshots.

## 21.12. Running Tests in a Distributed Environment

A distributed test environment consists of a grid hub and a number of test nodes. The hub listens to calls from test runners and delegates them to the grid nodes. Different nodes can run on different operating system platforms and have different browsers installed.

A basic distributed installation was covered in Section 21.3.2, “A Distributed Testing Environment”.

### 21.12.1. Running Tests Remotely

Remote tests are just like locally executed tests, except instead of using a browser driver, you use a remote web driver that can connect to the hub. The hub delegates the connection to a grid node with the desired capabilities, that is, which browsers are installed in the node.

Instead of creating and handling the remote driver explicitly, as described in the following, you can use the **ParallelTest** framework presented in Section 21.13, “Parallel Execution of Tests”.

An example of remote execution of tests is given in the TestBench demo described in Section 21.3.4, “TestBench Demo”. See the `README.md` file for further instructions.

In the following example, we create and use a remote driver that runs tests in a Selenium cloud at [testingbot.com](https://testingbot.com). The desired capabilities of a test node are described with a **DesiredCapabilities** object.

```
public class UsingHubITCase extends TestBenchTestCase {

    private String baseUrl;
    private String clientKey = "INSERT-YOUR-CLIENT-KEY-HERE";
    private String clientSecret = "INSERT-YOUR-CLIENT-KEY-HERE";

    @Before
    public void setUp() throws Exception {
        // Create a RemoteDriver against the hub.
        // In your local setup you don't need key and secret,
        // but if you use service like testingbot.com, they
        // can be used for authentication
        URL testingbotdotcom = new URL("http://" +
            clientKey + ":" + clientSecret +
            "@hub.testingbot.com:4444/wd/hub");
        setDriver(new RemoteWebDriver(testingbotdotcom,
            DesiredCapabilities.iphone()));
        baseUrl = "http://demo.vaadin.com/Calc/";
    }

    @Test
    @Ignore("Requires testingbot.com credentials")
    public void testOnePlusTwo() throws Exception {
        // run the test just as with "local bots"
        openCalculator();
        $(ButtonElement.class).caption("1").first().click();
        $(ButtonElement.class).caption("+").first().click();
        $(ButtonElement.class).caption("2").first().click();
        $(ButtonElement.class).caption("=").first().click();
        assertEquals("3.0", $(TextFieldElement.class)
            .first().getAttribute("value"));

        // That's it. Services may provide also some other goodies
        // like the video replay of your test in testingbot.com
    }

    private void openCalculator() {
        getDriver().get(baseUrl);
    }

    @After
    public void tearDown() throws Exception {
        getDriver().quit();
    }
}
```

Please see the API documentation of the **DesiredCapabilities** class for a complete list of supported capabilities.

Running the example requires that the hub service and the nodes are running. Starting them is described in the subsequent sections. Please refer to Selenium documentation for more detailed information.

## 21.12.2. Starting the Hub

The TestBench grid hub listens to calls from test runners and delegates them to the grid nodes. The grid hub service is included in the Vaadin TestBench JAR and you can start it with the following command:

```
$ java -jar vaadin-testbench-standalone-4.x.x.jar \
    -role hub
```

You can open the control interface of the hub also with a web browser. Using the default port, just open URL `http://localhost:4444/`. Once you have started one or more grid nodes, as instructed in the next section, the "console" page displays a list of the grid nodes with their browser capabilities.

## 21.12.3. Node Service Configuration

Test nodes can be configured with command-line options, as described later, or in a configuration file in JSON format. If no configuration file is provided, a default configuration is used.

A node configuration file is specified with the `-nodeConfig` parameter to the node service, for example as follows:

```
$ java -jar vaadin-testbench-standalone-4.x.x.jar
    -role node -nodeConfig nodeConfig.json
```

See Section 21.12.4, “Starting a Grid Node” for further details on starting the node service.

## Configuration File Format

The test node configuration file follows the JSON format, which defines nested associative maps. An associative map is defined as a block enclosed in curly braces (`{ }`). A mapping is a key-value pair separated with a colon (`:`). A key is a string literal quoted with double quotes ("key"). The value can be a string literal, list, or a nested associative map. A list a comma-separated sequence enclosed within square brackets (`[ ]`).

The top-level associative map should have two associations: `capabilities` (to a list of associative maps) and `configuration` (to a nested associative map).

```
{
  "capabilities": [
    [
      {
        "browserName": "firefox",
        ...
      },
      ...
    ],
    "configuration": [
      {
        "port": 5555,
        ...
      }
    ]
}
```

A complete example is given later.

## Browser Capabilities

The browser capabilities are defined as a list of associative maps as the value of the `capabilities` key. The capabilities can also be given from command-line using the `-browser` parameter, as described in Section 21.12.4, “Starting a Grid Node”.

The keys in the map are the following:

<i>platform</i>	The operating system platform of the test node: WINDOWS, XP, VISTA, LINUX, or MAC.
<i>browserName</i>	A browser identifier, any of: android, chrome, firefox, htmlunit, internet explorer, iphone, opera, or phantomjs (as of TestBench 3.1).
<i>maxInstances</i>	The maximum number of browser instances of this type open at the same time for parallel testing.
<i>version</i>	The major version number of the browser.
<i>seleniumProtocol</i>	This should be WebDriver for WebDriver use.
<i>firefox_binary</i>	Full path and file name of the Firefox executable. This is typically needed if you have Firefox ESR installed in a location that is not in the system path.

## Server Configuration

The node service configuration is defined as a nested associative map as the value of the `configuration` key. The configuration parameters can also be given as command-line parameters to the node service, as described in Section 21.12.4, “Starting a Grid Node”.

See the following example for a typical server configuration.

## Example Configuration

```
{  
  "capabilities": [  
    {  
      "browserName": "firefox",  
      "maxInstances": 5,  
      "seleniumProtocol": "WebDriver",  
      "version": "10",  
      "firefox_binary": "/path/to/firefox10"  
    },  
    {  
      "browserName": "firefox",  
      "maxInstances": 5,  
      "version": "16",  
      "firefox_binary": "/path/to/firefox16"  
    },  
    {  
      "browserName": "chrome",  
      "maxInstances": 5,  
      "version": "42",  
      "seleniumProtocol": "WebDriver",  
      "firefox_binary": null  
    }  
  ]  
}
```

```
        "maxInstances": 5,
        "seleniumProtocol": "WebDriver"
    },
    {
        "platform": "WINDOWS",
        "browserName": "internet explorer",
        "maxInstances": 1,
        "seleniumProtocol": "WebDriver"
    }
],
"configuration":
{
    "proxy": "org.openqa.grid.selenium.proxy.DefaultRemoteProxy",
    "maxSession": 5,
    "port": 5555,
    "host": ip,
    "register": true,
    "registerCycle": 5000,
    "hubPort": 4444
}
}
```

## 21.12.4. Starting a Grid Node

A TestBench grid node listens to calls from the hub and is capable of opening a browser. The grid node service is included in the Vaadin TestBench JAR and you can start it with the following command:

```
$ java -jar \
vaadin-testbench-standalone-4.x.x.jar \
-role node \
-hub http://localhost:4444/grid/register
```

The node registers itself in the grid hub. You need to give the address of the hub either with the `-hub` parameter or in the node configuration file as described in Section 21.12.3, “Node Service Configuration”.

You can run one grid node in the same host as the hub, as is done in the example above with the localhost address.

## Browser Capabilities

The browsers installed in the node can be defined either with command-line parameters or with a configuration file in JSON format, as described in Section 21.12.3, “Node Service Configuration”.

On command-line, you can issue one or more `-browser` options to define the browser capabilities. It must be followed by a comma-separated list of property-value definitions, such as the following:

```
-browser "browserName=firefox,version=10,firefox_binary=/path/to/firefox10" \
-browser "browserName=firefox,version=16,firefox_binary=/path/to/firefox16" \
-browser "browserName=chrome,maxInstances=5" \
-browser "browserName=internet explorer,maxInstances=1,platform=WINDOWS"
```

The configuration properties are described in Section 21.12.3, “Node Service Configuration”.

## Browser Driver Parameters

If you use Chrome or Internet Explorer, their remote driver executables must be in the system path (in the PATH environment variable) or be given with a command-line parameter to the node service:

Internet Explorer

`-Dwebdriver.ie.driver=C:\path\to\IEDriverServer.exe`

Google Chrome

`-Dwebdriver.chrome.driver=/path/to/ChromeDriver`

## 21.12.5. Mobile Testing

Vaadin TestBench includes an iPhone and an Android driver, with which you can test on mobile devices. The tests can be run either in a device or in an emulator/simulator.

The actual testing is just like with any WebDriver, using either the **iPhoneDriver** or the **Android-Driver**. The Android driver assumes that the hub (`android-server`) is installed in the emulator and forwarded to port 8080 in localhost, while the iPhone driver assumes port 3001. You can also use the **RemoteWebDriver** with either the `iphone()` or the `android()` capability, and specify the hub URI explicitly.

The mobile testing setup is covered in detail in the Selenium documentation for both the iOS driver and the AndroidDriver.

## 21.13. Parallel Execution of Tests

The **ParallelTest** class provides an easy way to run tests in parallel locally, as well as remotely in a test grid.

### 21.13.1. Local Parallel Execution

To enable parallel execution of tests, usually during test development, you need to extend the **ParallelTest** instead of **TestBenchTestCase** and annotate the test case class with `@RunLocally`.

```
@RunLocally  
public class MyTest extends ParallelTest {  
    @Test  
    ...  
}
```

When you run the tests, TestBench launches multiple browser windows to run each test in parallel.

Parallel execution defaults to Firefox. You can give another browser as a parameter for the annotation, as enumerated in the **Browser** enumeration:

```
@RunLocally(Browser.CHROME)
```

For Chrome and IE, you need to have the browser driver installed, as described in Section 21.3.5, “Installing Browser Drivers”.

## 21.13.2. Multi-Browser Execution in a Grid

To run tests in multiple different browsers or remotely, you first need to set up and launch a grid hub and one or more grid nodes, as described in Section 21.12, “Running Tests in a Distributed Environment”. This enables remote execution in a test grid, although you can run the hub and a test node also in your development workstation.

To run a test case class in a grid, you simply need to annotate the test case classes with the `@RunOnHub` annotation. It takes the host address of the hub as parameter, with `localhost` as the default host. You need to define the desired browser capabilities in a method annotated with `@BrowserConfiguration`. It must return a list of `DesiredCapabilities`.

```
@RunOnHub( "hub.testgrid.mydomain.com" )
public class MyTest extends ParallelTest {
    @Test
    ...

    @BrowserConfiguration
    public List<DesiredCapabilities> getBrowserConfiguration() {
        List<DesiredCapabilities> browsers =
            new ArrayList<DesiredCapabilities>();

        // Add all the browsers you want to test
        browsers.add(BrowserUtil.firefox());
        browsers.add(BrowserUtil.chrome());
        browsers.add(BrowserUtil.ie11());

        return browsers;
    }
}
```

The actual browsers tested depends on the browser capabilities of the test node or nodes.

If you have more test classes, you can put the configuration in a common base class that extends `ParallelTest`.

## 21.14. Headless Testing

TestBench (3.1 and later) supports fully-featured headless testing with PhantomJS (<http://phantomjs.org>), a headless browser based on WebKit. It has fast native support for various web standards: JavaScript, DOM handling, CSS selector, JSON, Canvas, and SVG.

Headless testing using PhantomJS allows for around 15% faster test execution without having to start a graphical web browser, even when performing screenshot-based testing! This also makes it possible to run full-scale functional tests on the front-end directly on a build server, without the need to install any web browsers.

It is usually best to use a graphical browser to develop the test cases, as it is possible to see interactively what happens while the tests are being executed. Once the tests are working correctly in a graphical browser, you can migrate them to run on the PhantomJS headless browser.

### 21.14.1. Basic Setup for Running Headless Tests

The only set up required is to install the PhantomJS binary. Follow the instructions for your operating system at [PhantomJS download page](#), and place the binary in the system path.

The PhantomJS Driver dependency is already included in Vaadin TestBench.

## Creating a Headless WebDriver Instance

Creating an instance of the **PhantomJS Driver** is just as easy as creating an instance of **FirefoxDriver**.

```
setDriver(TestBench.createDriver(  
    new PhantomJSdriver()));
```

Some tests may fail because of the small default window size in PhantomJS. Such tests are, for example, tests containing elements that pop up and might go off-screen when the window is small. To make them work better, specify a size for the window:

```
getDriver().manage().window().setSize(  
    new Dimension(1024, 768));
```

Nothing else is needed to run tests headlessly.

### 21.14.2. Running Headless Tests in a Distributed Environment

Running PhantomJS in a distributed grid is equally easy. First, install PhantomJS in the nodes by following the instructions in Section 21.14.1, “Basic Setup for Running Headless Tests”. Then, start PhantomJS using the following command:

```
phantomjs --webdriver=8080 \  
--webdriver-selenium-grid-hub=http://127.0.0.1:4444
```

The above will start PhantomJS in the WebDriver mode and register it with a grid hub running at 127.0.0.1:4444. After this, running tests in the grid is as easy as passing `DesiredCapabilities.phantomjs()` to the `RemoteWebDriver` constructor.

```
setDriver(new RemoteWebDriver(  
    DesiredCapabilities.phantomjs()));
```

## 21.15. Behaviour-Driven Development

Behaviour-driven development (BDD) is a development methodology based on test-driven development, where development starts from writing tests for the software-to-be. BDD involves using a *ubiquitous language* to communicate between business goals - the desired behaviour - and tests to ensure that the software fulfills those goals.

The BDD process starts by collection of business requirements expressed as *user stories*, as is typical in agile methodologies. A user with a *role* requests a *feature* to gain a *benefit*.

Stories can be expressed as number of *scenarios* that describe different cases of the desired behaviour. Such a scenario can be formalized with the following three phases:

- *Given* that I have calculator open
- *When* I push calculator buttons
- *Then* the display should show the result

This kind of formalization is realized in the JBehave BDD framework for Java. The TestBench Demo includes a JBehave example, where the above scenario is written as the following test class:

```
public class CalculatorSteps extends TestBenchTestCase {
    private WebDriver driver;
    private CalculatorPageObject calculator;

    @BeforeScenario
    public void setUpWebDriver() {
        driver = TestBench.createDriver(new FirefoxDriver());
        calculator = PageFactory.initElements(driver,
            CalculatorPageObject.class);
    }

    @AfterScenario
    public void tearDownWebDriver() {
        driver.quit();
    }

    @Given("I have the calculator open")
    public void theCalculatorIsOpen() {
        calculator.open();
    }

    @When("I push $buttons")
    public void enter(String buttons) {
        calculator.enter(buttons);
    }

    @Then("the display should show $result")
    public void displayShows(String result) {
        assertEquals(result, calculator.getResult());
    }
}
```

The demo employs the page object defined for the application UI, as described in Section 21.9.2, “The Page Object Pattern”.

Such scenarios are included in one or more stories, which need to be configured in a class extending **JUnitStory** or **JUnitStories**. In the example, this is done in the **SimpleCalculation** class. It defines how story classes can be found dynamically by the class loader and how stories are reported.

For further documentation, please see JBehave website at [jbehave.org](http://jbehave.org).

## 21.16. Known Issues

This section provides information and instructions on a few features that are known to be difficult to use or need modification to work.

### 21.16.1. Running Firefox Tests on Mac OS X

Firefox needs to have focus in the main window for any focus events to be triggered. This sometimes causes problems if something interferes with the focus. For example, a **TextField** that has an input prompt relies on the JavaScript `onFocus()` event to clear the prompt when the field is focused.

The problem occurs when OS X considers the Java process of an application using TestBench (or the node service) to have a native user interface capability, as with AWT or Swing, even when they are not used. This causes the focus to switch from Firefox to the process using TestBench,

causing tests requiring focus to fail. To remedy this problem, you need to start the JVM in which the tests are running with the `-Djava.awt.headless=true` parameter to disable the user interface capability of the Java process.

Note that the same problem is present also when debugging tests with Firefox. We therefore recommend using Chrome for debugging tests, unless Firefox is necessary.



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