Testing Web Apps with Spring Framework 3.2

Sam Brannen

Swiftmind

Rossen Stoyanchev

VMware

Sam Brannen

@sam_brannen

- Spring and Java Consultant @ Swiftmind
- Developing Java for over 14 years
- Spring Framework Core Committer
- Spring Trainer
- Lead author of *Spring in a Nutshell*
- Presenter on Spring, Java, and testing

Rossen Stoyanchev

@rstoya05

- Staff Engineer, VMware
- Spring Framework Commiter
- Focus on Web development
- Spring MVC, Spring Web Flow
- Teaching and consulting

Themes

New testing features in the Spring Framework

Spring MVC Test (`spring-test-mvc`)

Agenda

- Spring TestContext Framework
- Web Application Contexts
- Context Initializers
- Context Hierarchies
- Spring MVC Test Framework
- Server-side Spring MVC Tests
- Client-side `RestTemplate` Tests
- Q&A

Show of Hands...

- JUnit / TestNG
- Spring 2.5 / 3.0 / 3.1 / 3.2
- Integration testing with Spring
- Spring TestContext Framework
- Spring MVC / Test

Spring TestContext Framework

Introduced in Spring 2.5

Revised in Spring 3.2 ...

with a focus on web apps

Unit *and* integration testing

Annotation-driven

Convention over Configuration

JUnit & TestNG

Spring & Integration Testing

- `ApplicationContext` management & caching
- Dependency injection of test instances
- Transactional test management
  - with default rollback semantics
- `JdbcTestUtils` (-`SimpleJdbcTestUtils`-)

Spring Test Annotations

- Application Contexts
  - `@ContextConfiguration`, `@DirtiesContext`
- Dependency Injection
  - `@Autowired`
- Transactions
  - `@Transactional`, `@TransactionConfiguration`, `@BeforeTransaction`
- Web
  - `@WebAppConfiguration`

Using the TestContext Framework

- Use the `SpringJUnit4ClassRunner` for **JUnit** 4.5+
- Instrument test class with `TestContextManager` for **TestNG**
- Extend one of the base classes
  - `Abstract(Transactional)[JUnit4|TestNG]SpringContextTests`

Example: @POJO Test Class

```
public class OrderServiceTests {

  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)


public class OrderServiceTests {









  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration


public class OrderServiceTests {









  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration // defaults to
// OrderServiceTests-context.xml in same package

public class OrderServiceTests {









  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration // defaults to
// OrderServiceTests-context.xml in same package

public class OrderServiceTests {

  @Autowired
  private OrderService orderService;









  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration // defaults to
// OrderServiceTests-context.xml in same package
@Transactional
public class OrderServiceTests {

  @Autowired
  private OrderService orderService;




  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration // defaults to
// OrderServiceTests-context.xml in same package
@Transactional
public class OrderServiceTests {

  @Autowired
  private OrderService orderService;

  @BeforeTransaction
  public void verifyInitialDatabaseState() { … }



  @Test
  public void testOrderService() { … }
}
```

Example: @POJO Test Class

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration // defaults to
// OrderServiceTests-context.xml in same package
@Transactional
public class OrderServiceTests {

  @Autowired
  private OrderService orderService;

  @BeforeTransaction
  public void verifyInitialDatabaseState() { … }

  @Before
  public void setUpTestDataWithinTransaction() { … }

  @Test
  public void testOrderService() { … }
}
```

Core Components

`TestContext`

- Tracks context for current test
- Delegates to a `ContextLoader`
- Caches the `ApplicationContext`

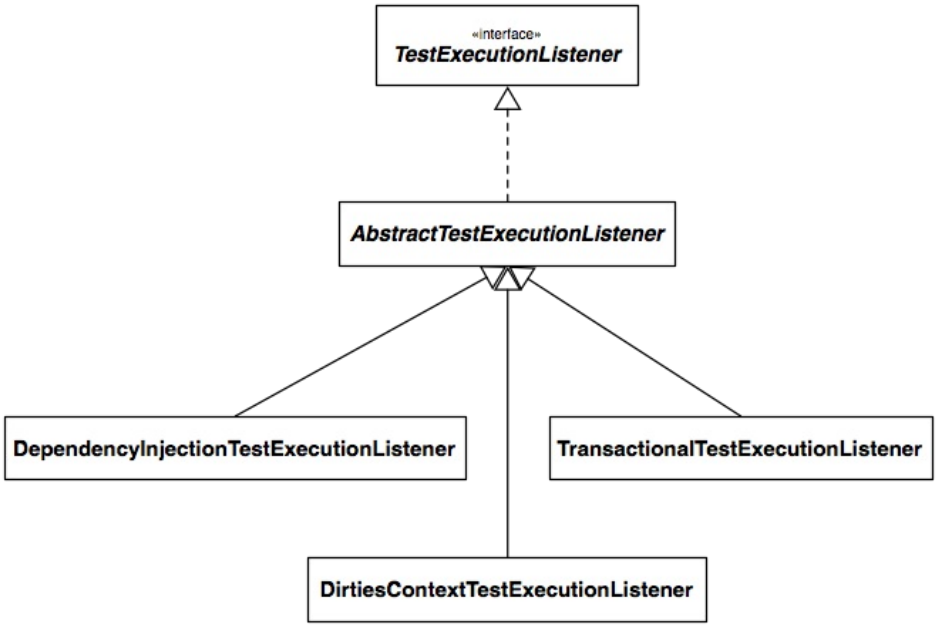
`TestContextManager`

- Manages the `TestContext`
- Signals events to listeners

`TestExecutionListener` SPI

- Reacts to test execution events
- Receives reference to current `TestContext`

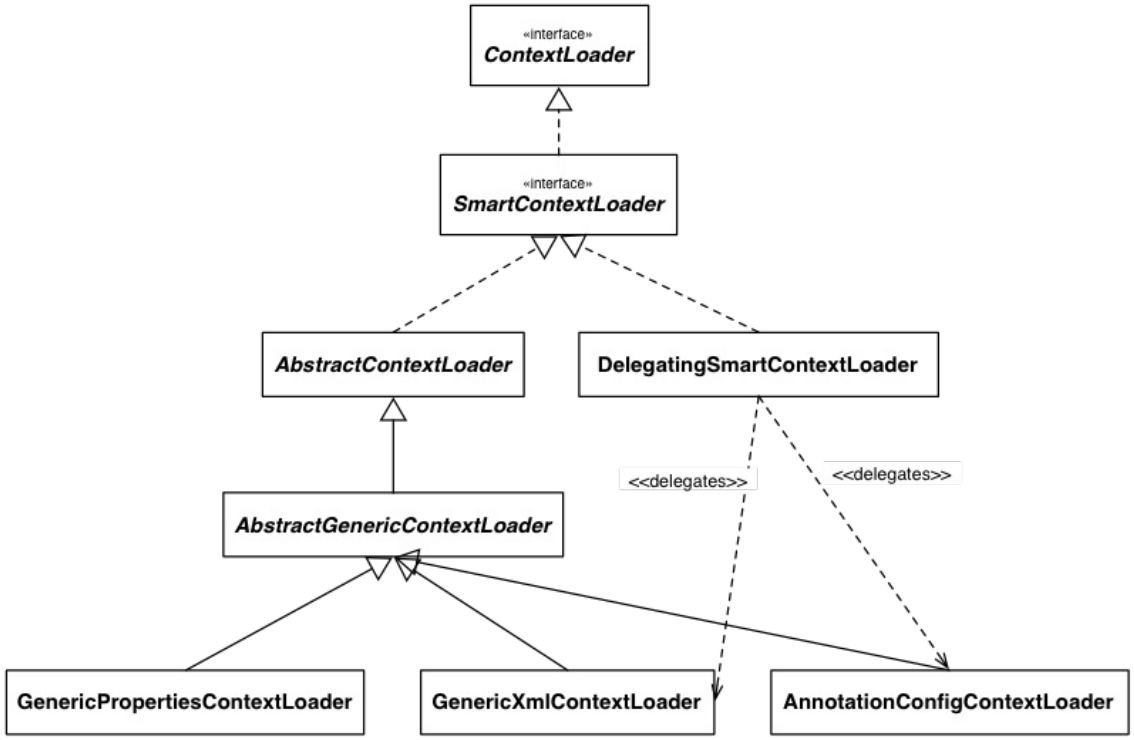
TestExecutionListener 2.5



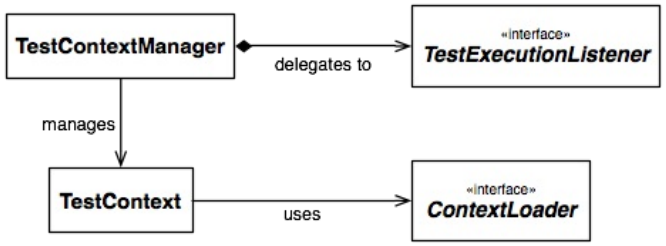
`SmartContextLoader` SPI

- Strategy for loading application contexts
- From `@Configuration` classes *or* resource locations
- Supports environment profiles and context initializers

ContextLoader 3.1



Putting it all together



What's New in 3.2

Upgraded to JUnit 4.10
and TestNG 6.5.2

`spring-test` now depends on `junit:junit-dep`

Now inferring return type of
generic factory methods

Updated Spring *mocks*

Simplified transaction manager configuration

Improved JDBC integration
testing support

Documented support for...

`@Bean` *lite* mode

and

JSR-250 lifecycle annotations

Now supporting...

WebApplicationContext

session & request scoped beans

and

ApplicationContextInitializer

Planned support for...

context hierarchies

Generic Factory Methods

- Not specific to testing
- Sometimes used for creating a proxy
- But often used for mocking Spring beans

Example: Mocking with EasyMock

```
<beans ...>

    <!-- OrderService is autowired with OrderRepository -->
    <context:component-scan base-package="com.example"/>

    <bean id="orderRepository" class="org.easymock.EasyMock"
        factory-method="createMock"
        c:_="com.example.repository.OrderRepository" />

</beans>
```

EasyMock.createMock() Signature

```
public static <T> T createMock(Class<T> toMock) {...}
```

Generic Factory Methods - Improved

- Generic return types are now inferred
  - `public static <T> T mock(Class<T> clazz)`
  - `public static <T> T proxy(T obj)`
- Autowiring *by type* now works
- And custom solutions are now chiefly unnecessary:
  - `MockitoFactoryBean`
  - `EasyMockFactoryBean`
  - Springockito

Spring Environment Mocks

- introduced `MockEnvironment` in 3.2
- complements `MockPropertySource` from 3.1

New Spring HTTP Mocks

- Client:
  - `MockClientHttpRequest`
  - `MockClientHttpResponse`
- Server:
  - `MockHttpInputMessage`
  - `MockHttpOutputMessage`

Enhanced Servlet API Mocks

- `MockServletContext`
- `MockHttpSession`
- `MockFilterChain`
- `MockRequestDispatcher`
- …

Transaction Manager Config

- support for single, *unqualified* transaction manager
- support for `TransactionManagementConfigurer`
- `@TransactionConfiguration` is now rarely necessary

JDBC Testing Support

- deprecated `SimpleJdbcTestUtils` in favor of `JdbcTestUtils`
- introduced `countRowsInTableWhere()` and `dropTables()` in `JdbcTestUtils`
- introduced `jdbcTemplate`, `countRowsInTableWhere()`, and `dropTables()` in
  - `AbstractTransactionalJUnit4SpringContextTests`
  - `AbstractTransactionalTestNGSpringContextTests`

Documentation

- support for `@Bean` *lite mode* and annotated classes
- support for JSR-250 lifecycle annotations

Web Testing Support in the TestContext Framework

New Web Testing Features

First-class `WebApplicationContext` support

`Request` and `Session` scoped beans

Loading a `WebApplicationContext`

How do you tell the TestContext framework to load a `WebApplicationContext`?

Just annotate your test class with ...

`@WebAppConfiguration`

- Denotes that the `ApplicationContext` should be a `WebApplicationContext`
- Configures the resource path for the web app
  - used in the `MockServletContext`
- Defaults to `"src/main/webapp"`
- Paths are file-system folders, relative to the project root
  - not classpath resources
- The `classpath:` prefix is also supported

Example: @WebAppConfiguration

```
// defaults to "file:src/main/webapp"
@WebAppConfiguration

// detects "WacTests-context.xml" in same package
// or static nested @Configuration class
@ContextConfiguration

public class WacTests {
    //...
}
```

Example: @WebAppConfiguration

```
// file system resource
@WebAppConfiguration("webapp")

// classpath resource
@ContextConfiguration("/spring/test-servlet-config.xml")

public class WacTests {
    //...
}
```

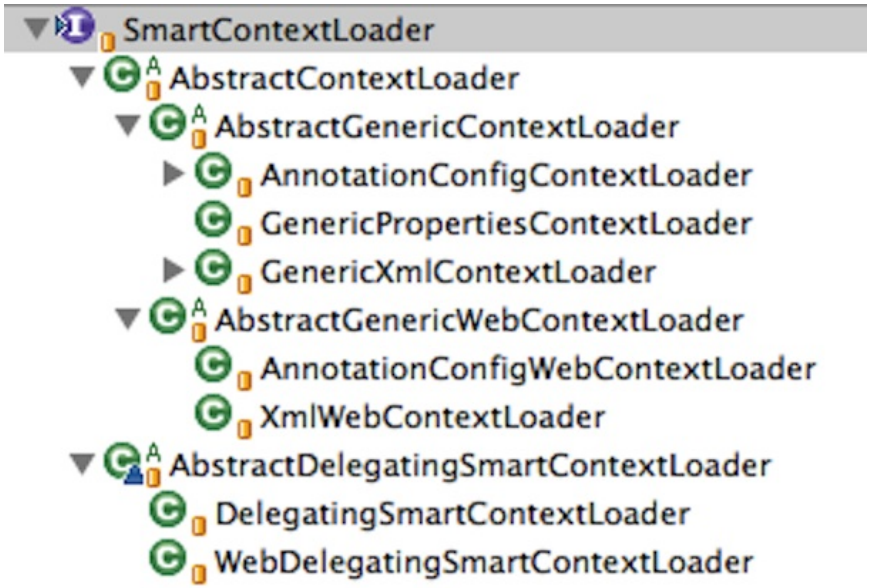
Example: @WebAppConfiguration

```
// classpath resource
@WebAppConfiguration("classpath:test-web-resources")

// file system resource
@ContextConfiguration("file:src/main/webapp/WEB-INF/servlet-config.xml")

public class WacTests {
    //...
}
```

Web Context Loaders

- New `AbstractGenericWebContextLoader`
- And two concrete subclasses:
  - `XmlWebContextLoader`
  - `AnnotationConfigWebContextLoader`
- Plus a `WebDelegatingSmartContextLoader`

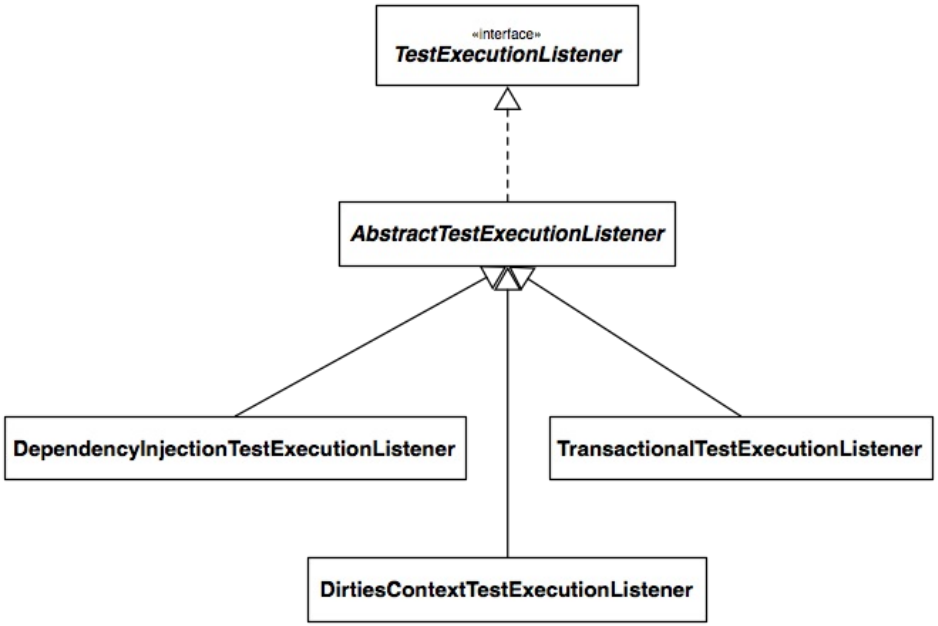
SmartContextLoader 3.2



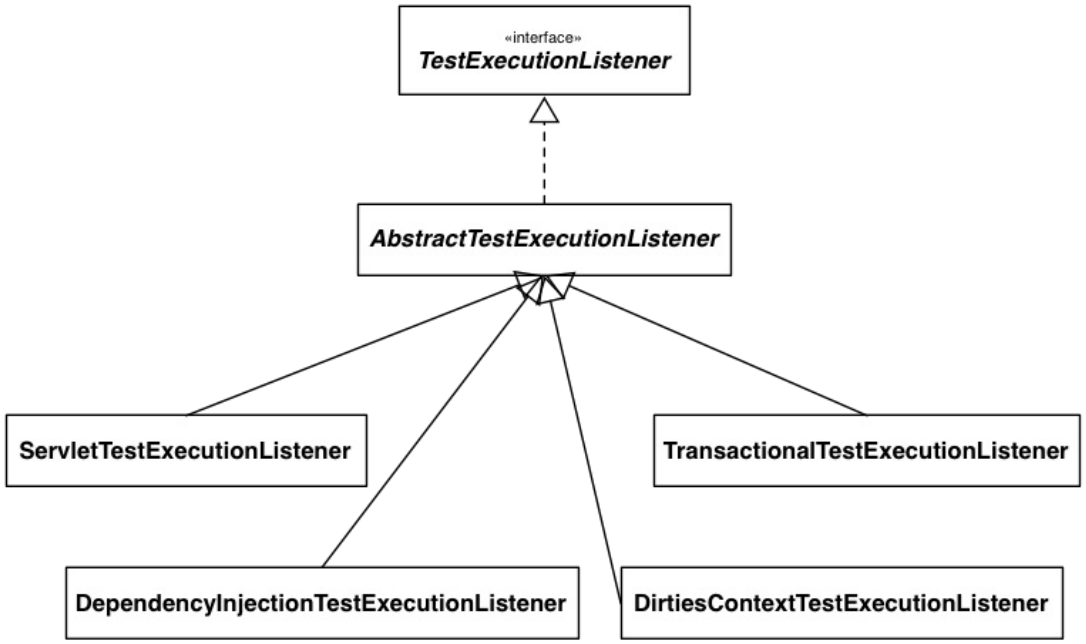
`ServletTestExecutionListener`

- Sets up default thread-local state via `RequestContextHolder` before each test method
- Creates:
  - `MockHttpServletRequest`
  - `MockHttpServletResponse`
  - `ServletWebRequest`
- Ensures that the `MockHttpServletResponse` and `ServletWebRequest` can be injected into the test instance
- Cleans up thread-local state after each test method

TestExecutionListener 2.5



TestExecutionListener 3.2



Example: Injecting Mocks

```
@WebAppConfiguration
@ContextConfiguration
public class WacTests {

    @Autowired WebApplicationContext wac; // cached

    @Autowired MockServletContext servletContext; // cached

    @Autowired MockHttpSession session;

    @Autowired MockHttpServletRequest request;

    @Autowired MockHttpServletResponse response;

    @Autowired ServletWebRequest webRequest;

    //...
}
```

Web Application Context Caching

`WebMergedContextConfiguration`

- Extension of `MergedContextConfiguration`
- Supports the base resource path from `@WebAppConfiguration`
  - which is now part of the *context cache key*

Request and Session Scoped Beans

Web Scopes

- **request**: lifecycle tied to the current `HttpServletRequest`
- **session**: lifecycle tied to the current `HttpSession`

Example: Request-scoped Bean Config

```
<beans ...>

    <bean id="userService" class="com.example.SimpleUserService"
        c:loginAction-ref="loginAction" />

    <bean id="loginAction" class="com.example.LoginAction"
            c:username="#{request.getParameter('user')}"
            c:password="#{request.getParameter('pswd')}"
            scope="request">
        <aop:scoped-proxy />
    </bean>

</beans>
```

Example: Request-scoped Bean Test

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration
@WebAppConfiguration
public class RequestScopedBeanTests {

    @Autowired UserService userService;
    @Autowired MockHttpServletRequest request;

    @Test
    public void requestScope() {

        request.setParameter("user", "enigma");
        request.setParameter("pswd", "$pr!ng");

        LoginResults results = userService.loginUser();

        // assert results
    }
}
```

Example: Session-scoped Bean Config

```
<beans ...>

    <bean id="userService" class="com.example.SimpleUserService"
        c:userPreferences-ref="userPreferences" />

    <bean id="userPreferences" class="com.example.UserPreferences"
            c:theme="#{session.getAttribute('theme')}"
            scope="session">
        <aop:scoped-proxy />
    </bean>

</beans>
```

Example: Session-scoped Bean Test

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration
@WebAppConfiguration
public class SessionScopedBeanTests {

    @Autowired UserService userService;
    @Autowired MockHttpSession session;

    @Test
    public void sessionScope() throws Exception {

        session.setAttribute("theme", "blue");

        Results results = userService.processUserPreferences();

        // assert results
    }
}
```

Application Context Initializers

`ApplicationContextInitializer`

- Introduced in Spring 3.1
- Used for programmatic initialization of a `ConfigurableApplicationContext`
- For example:
  - to register property sources
  - to activate profiles against the `Environment`
- Configured in `web.xml` by specifying `contextInitializerClasses` via
  - `context-param` for the `ContextLoaderListener`
  - `init-param` for the `DispatcherServlet`

Using Initializers in Tests

- Configured in `@ContextConfiguration` via the `initializers` attribute
- Inheritance can be controlled via the `inheritInitializers` attribute
- An `ApplicationContextInitializer` may configure the entire context
  - XML resource locations or annotated classes are no longer required
- Initializers are now part of the *context cache key*
- Initializers are *ordered* based on Spring's `Ordered` interface or the `@Order` annotation

Example: Single Initializer

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(
    locations = "/app-config.xml",
    initializers = CustomInitializer.class)
public class ApplicationContextInitializerTests {}
```

Example: Multiple Initializers

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(
    locations = "/app-config.xml",
    initializers =
    {PropertySourceInitializer.class, ProfileInitializer.class})
public class ApplicationContextInitializerTests {}
```

Example: Merged Initializers

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(
    classes = BaseConfig.class,
    initializers = BaseInitializer.class)
public class BaseTest {}


@ContextConfiguration(
    classes = ExtendedConfig.class,
    initializers = ExtendedInitializer.class)
public class ExtendedTest extends BaseTest {}
```

Example: Overridden Initializers

```
@RunWith(SpringJUnit4ClassRunner.class)
@ContextConfiguration(
    classes = BaseConfig.class,
    initializers = BaseInitializer.class)
public class BaseTest {}


@ContextConfiguration(
    classes = ExtendedConfig.class,
    initializers = ExtendedInitializer.class,
    inheritInitializers = false)
public class ExtendedTest extends BaseTest {}
```

Example: Initializer w/o Locations or Classes

```
@ContextConfiguration(initializers = EntireAppInitializer.class)
public class InitializerWithoutConfigFilesOrClassesTest {}
```

Application Context Hierarchies

WARNING

*Support for context hierarchies has **not** yet been implemented.*

Status Quo for Tests

Currently only flat, non-hierarchical contexts are supported.

There is no easy way to create contexts
with parent-child relationships.

But hierarchies are supported in production.

So it would be nice to be able to test them. ;)

Context Hierarchy Goals

- Load a test application context with a parent context
- Support common hierarchies
  - Root WAC <-- Dispatcher WAC
  - EAR <-- Root WAC <-- Dispatcher WAC

Context Hierarchy Proposal

- Introduce `@ContextHierarchy` that contains nested `@ContextConfiguration` declarations
- Introduce a `name` attribute in `@ContextConfiguration`
  - for *merging* or *overriding* named configuration in the context hierarchy

Single Test with Context Hierarchy

```
@RunWith(SpringJUnit4ClassRunner.class)

@ContextHierarchy({
    @ContextConfiguration("parent.xml"),
    @ContextConfiguration("child.xml")
})
public class AppCtxHierarchyTests {}
```

Root WAC & Dispatcher WAC

```
@RunWith(SpringJUnit4ClassRunner.class)

@WebAppConfiguration

@ContextHierarchy({
    @ContextConfiguration(
        name="root",
        classes = WebAppConfig.class),
    @ContextConfiguration(
        name="dispatcher",
        locations="/spring/dispatcher-config.xml")
})
public class ControllerIntegrationTests {}
```

Class & Context Hierarchies

```
@RunWith(SpringJUnit4ClassRunner.class)
@WebAppConfiguration
@ContextConfiguration("file:src/main/webapp/WEB-INF/applicationContext.xml")
public abstract class AbstractWebTests {}

@ContextHierarchy(@ContextConfiguration("/spring/soap-ws-config.xml")
public class SoapWebServiceTests extends AbstractWebTests {}

@ContextHierarchy(@ContextConfiguration("/spring/rest-ws-config.xml")
public class RestWebServiceTests extends AbstractWebTests {}
```

Feedback is Welcome

- SPR-5613: context hierarchy support
- SPR-9863: web context hierarchy support

Intermission... ;)

Spring MVC Test Framework

Background

Recently added to `spring-test` as of Spring 3.2 RC1

Originates from spring-test-mvc separate project on Github

Nearly identical code bases

spring-test-mvc will continue to support Spring 3.1

Differences with spring-test-mvc

Dependency on Spring 3.2, not Spring 3.1

Support for Spring 3.2 features (e.g. Servlet 3 async)

Integration with `@WebAppConfiguration`

Different packages

Easy migration from spring-test-mvc to Spring 3.2

What does it provide?

1st class support for testing Spring MVC apps

Fluent API

Server-side tests involve the `DispatcherServlet`

Client-side tests are `RestTemplate`-based

Built on `spring-test`

`TestContext` framework used for loading Spring config

`MockHttpServletRequest/Response`

`MockFilterChain`

Servlet container is not used

Extent of support

Pretty much everything should work as it does at runtime

HTTP message conversion
e.g. `@RequestBody`/`@ResponseBody`

Most rendering technologies
JSON, XML, Freemarker/Velocity, Thymeleaf, Excel, etc

Limitations

We are not in a servlet container

Foward and redirect not executed

No JSP rendering

Server-side Spring MVC Tests

Example

```
@RunWith(SpringJUnit4ClassRunner.class)
@WebAppConfiguration
@ContextConfiguration("servlet-context.xml")
public class SampleTests {









}
```

```
@RunWith(SpringJUnit4ClassRunner.class)
@WebAppConfiguration
@ContextConfiguration("servlet-context.xml")
public class SampleTests {

  @Autowired
  private WebApplicationContext wac;

  private MockMvc mvc;

  @Before
  public void setup() {
    this.mvc = webAppContextSetup(this.wac).build();
  }









}
```

```
@RunWith(SpringJUnit4ClassRunner.class)
@WebAppConfiguration
@ContextConfiguration("servlet-context.xml")
public class SampleTests {

  @Autowired
  private WebApplicationContext wac;

  private MockMvc mvc;

  @Before
  public void setup() {
    this.mvc = webAppContextSetup(this.wac).build();
  }

  @Test
  public void getFoo() throws Exception {
    this.mvc.perform(get("/foo").accept("application/json"))
        .andExpect(status().isOk())
        .andExpect(content().mimeType("application/json"))
        .andExpect(jsonPath("$.name").value("Lee"));
  }

}
```

Static Imports

`MockMvcBuilders.*`, `MockMvcRequestBuilders.*`,
`MockMvcResultMatchers.*`

Add as *"favorite packages"* in Eclipse prefs
for code completion

Or simply search `"MockMvc*"`

Set-Up Options

The goal:
`MockMvc` instance ready to perform requests

Prepare `DispatcherServlet` config

Specify root of webapp

Add servlet Filters

Option 1: `TestContext` framework

Load actual `DispatcherServlet` config

Smart caching of `WebApplicationContext` instances

Possibly inject controllers with mock services

Declaring a Mock Service For Injection

```
<bean class="org.mockito.Mockito" factory-method="mock">
    <constructor-arg value="org.example.FooService"/>
</bean>
```

Option 2: "Standalone"

Simply register one or more `@Controller` instances

Config similar to MVC Java Config

No Spring context is actually loaded

"Stub" `WebApplicationContext` used to configure `DispatcherServlet`

"Standalone" Setup Example

```
standaloneSetup(new PersonController()).build()
  .mockMvc.perform(post("/persons").param("name", "Joe"))
    .andExpect(status().isMovedTemporarily())
    .andExpect(redirectedUrl("/persons/Joe"))
    .andExpect(model().size(1))
    .andExpect(model().attributeExists("name"));
```

`@WebAppConfiguration` vs. "Standalone"

"Standalone" more targetted
one controller at a time, explicit config

`@WebAppConfiguration` verifies application config

No right or wrong choice, different test styles

May also mix and match

Performing Requests

Specify HTTP method and URI at a minimum

Additional builder-style methods corresponding to `MockHttpServletRequest` fields

Request Examples

```
mockMvc.perform(
  post("/hotels/{id}?n={n}", 42, "N"));

mockMvc.perform(
  fileUpload("/doc").file("a1", "ABC".getBytes("UTF-8")));
```

Specifying Parameters

Query string in the URI

```
get("/hotels?a=b")
```

Form params in the request body

```
get("/hotels").body("a=b".getBytes("ISO-8859-1"))
```

Servlet parameters

```
get("/hotels").param("a", "b")
```

Context/Servlet Path + PathInfo

If you specify full path

```
get("/app/main/hotels/{id}")
```

Then set paths accordingly

```
get("").contextPath("/app").servletPath("/main")
```

Or leave out context/servlet path

```
get("/hotels/{id}")
```

Default Request Properties

Performed requests are often similar

Same header, parameter, cookie

Specify default request when setting up `MockMvc`

Performed requests override defaults!

Default Request Example

```
webAppContextSetup(this.wac).defaultRequest(get("/")
  .accept(MediaType.APPLICATION_JSON)
  .param("locale", "en_US"));
```

Defining Expectations

Simply add one or more `.andExpect(..)`

After the call to `perform(..)`

`MockMvcResultMatchers` provides many choices

What Can Be Verified

Response status, headers, content

But also Spring MVC specific information

Flash attrs, handler, model content, etc

See lots of sample tests for examples

JSON and XML Content

JSONPath

XPath

XMLUnit

In Doubt?

Print all details

```
mvc.perform("/foo").andDo(print())
```

Or directly acccess the result

```
MvcResult r = mvc.perform("/foo").andReturn()
```

Common Expectations

Tests often have similar expectations

Same status, headers

Specify such expectations when setting up `MockMvc`

Common Expectations Example

```
webAppContextSetup(this.wac)
    .andAlwaysExpect(status.isOk())
    .alwaysExpect(content().mimeType("application/xml"))
    .alwaysDo(print())
    .build();
```

Filters

Filters may be added when setting up `MockMvc`

Executed as requests get peformed

Various possible use case

See `Spring Security` sample tests

HtmlUnit Integration

Adapts `HtmlUnit` request-response to
`MockHttpServletRequest/Response`

Enables use of `Selenium` and `Geb Spock` on top

No running server

Give it a try, feedback welcome!

Client-side `RestTemplate` Tests

Example

```
RestTemplate restTemplate = new RestTemplate();

MockRestServiceServer mockServer =
    MockRestServiceServer.createServer(restTemplate);

mockServer.expect(requestTo("/greeting"))
    .andRespond(withSuccess("Hello world", "text/plain"));


// use RestTemplate ...


mockServer.verify();
```

Static Imports

`MockRestRequestMatchers.*` and `MockRestResponseCreators.*`

Add as *"favorite packages"* in Eclipse prefs
for code completion

Or simply search `"MockRest*"`

`RestTemplate` Instrumentation

```
MockRestServiceServer.createServer(restTemplate)
```

Configures `RestTemplate` with custom `ClientHttpRequestFactory`

Can be used further to ...

Define expected requests and responses

Verify expectations

Define Expected Requests-Responses

`mockServer.expect(..).andExpect(..)`

Followed by `.andReturn(..)`

Set up any number of requests with `mockServer.expect(..)`

Each Time `RestTemplate` Is Used

Request expectations asserted

Stub response returned

Exception raised if no more expected requests

After `RestTemplate` Is Used

```
mockServer.verify(..)
```

Ensures all expected requests executed

In Closing ...

Presentation Source

https://github.com/rstoyanchev/spring-32-test-webapps

Resources for Spring MVC Test

- Spring MVC Showcase tests
- Sample client and server tests in the Spring Framework
- Reference documentation will be added in 3.2 RC2

Resources for Core Spring

- **Spring Framework**: www.springsource.org/spring-framework
- **Reference Manual**: Spring 3.2.x
- **Forums**: forum.springframework.org
- **JIRA**: jira.springsource.org

Q&A

Sam Brannen

Web: Swiftmind.com

Twitter: @sam_brannen

Rossen Stoyanchev

Web: SpringSource.com

Twitter: @rstoya05