Reactive Spring Security 5.1 Hands-On Workshop

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Chapter 1. Introduction

Target of this workshop is to learn how to make an initially unsecured (reactive) web application more and more secure step-by-step.

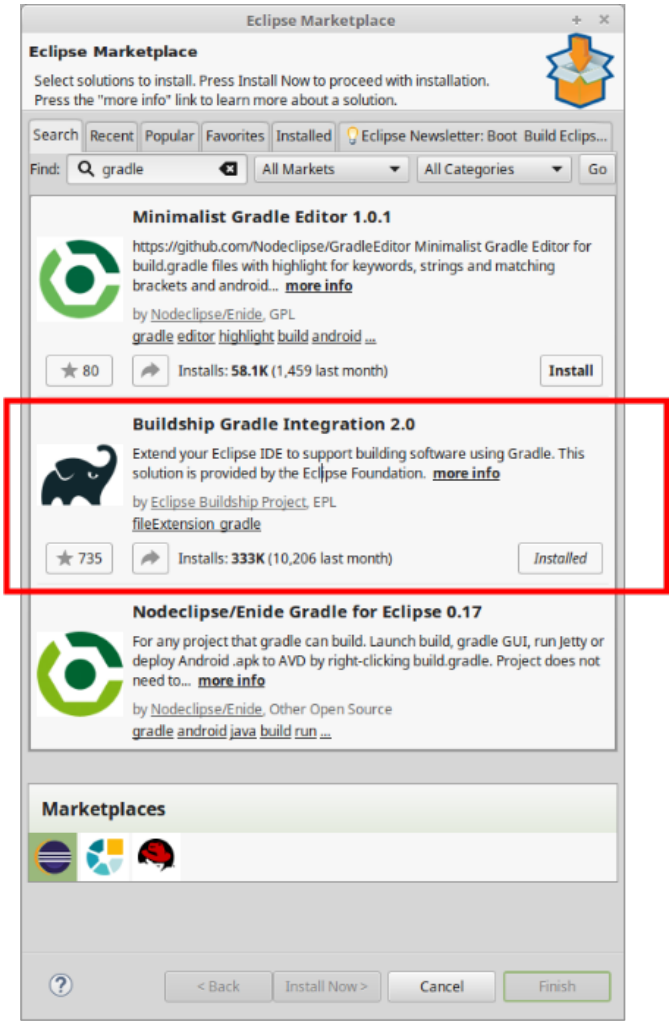
This will be done in following steps:

1. Add spring boot security starter dependency for simple auto configuration of security
2. Customize authentication configuration (provide our own user store)
3. Add authorization (access controls) to web and method layers
4. Implement automated security integration tests
5. Experiment with new OAuth2 Login Client and Resource Server of Spring Security 5.1

1.1. Requirements for this workshop

- Git
- A Java JDK (Java 8, 9 or 11 are supported and tested)
- Any Java IDE capable of building with Gradle (IntelliJ, Eclipse, VS Code, ...)
- Basic knowledge of Reactive Systems and reactive programming using Spring WebFlux & Reactor

As we are building the samples using Gradle your Java IDE should be capable use this. As IntelliJ user support for Gradle is included by default. As an Eclipse user you have to install a plugin via the marketplace



To get the workshop project you either can just clone the repository using

```
https://github.com/andifalk/reactive-spring-security-5-workshop.git
```

or

```
git@github.com:andifalk/reactive-spring-security-5-workshop.git
```

or simply download it as a zip archive.

After that you can import the workshop project into your IDE

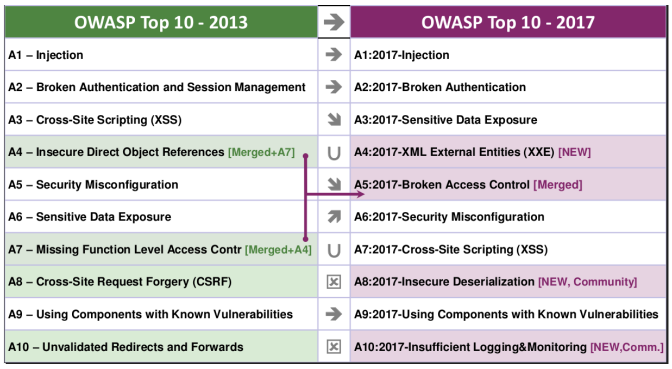
- IntelliJ: "New project from existing sources..."
- Eclipse: "Import/Gradle/Existing gradle project"
- Visual Studio Code: Just open the corresponding project directory

Chapter 2. Common Web Security Risks

In this workshop you will strive various parts of securing a web application that fit into the OWASP Top 10 2017 list.

We will look at:

- A2: Broken Authentication
- A3: Sensitive Data Exposure
- A5: Broken Access Control
- A6: Security Misconfiguration
- A10: Insufficient Logging & Monitoring



OWASP Top 10 - 2013		OWASP Top 10 - 2017
A1 – Injection	→	A1:2017-Injection
A2 – Broken Authentication and Session Management	→	A2:2017-Broken Authentication
A3 – Cross-Site Scripting (XSS)	↘	A3:2017-Sensitive Data Exposure
A4 – Insecure Direct Object References [Merged+A7]	U	A4:2017-XML External Entities (XXE) [NEW]
A5 – Security Misconfiguration	↘	A5:2017-Broken Access Control [Merged]
A6 – Sensitive Data Exposure	↗	A6:2017-Security Misconfiguration
A7 – Missing Function Level Access Contr [Merged+A4]	U	A7:2017-Cross-Site Scripting (XSS)
A8 – Cross-Site Request Forgery (CSRF)	☒	A8:2017-Insecure Deserialization [NEW, Community]
A9 – Using Components with Known Vulnerabilities	→	A9:2017-Using Components with Known Vulnerabilities
A10 – Unvalidated Redirects and Forwards	☒	A10:2017-Insufficient Logging&Monitoring [NEW,Comm.]

The Open Web Application Security Project has plenty of further free resources available.

As a developer you may also have a look into the OWASP ProActive Controls document which describes how to develop your applications using good security patterns. To help getting all security requirements right for your project and how to test these the Application Security Verification Standard can help you here.

You will find more sources of information about security referenced in the appendix section.

Chapter 3. The workshop application

In this workshop you will be provided a finished but completely unsecured reactive web application. This library server application provides a RESTful service for administering books and users.

The RESTful service for books is build using the Spring WebFlux annotation model and the RESTful service for users is build using the Spring WebFlux router model.

The application contains a complete documentation for the RESTful API build with spring rest docs which you can find in the directory *build/asciidoc/html5* after performing a full gradle build.

The domain model of this application is quite simple and just consists of *Book* and *User*. The packages of the application are organized as follows:

- **api**: Contains the complete RESTful service
- **business**: All the service classes (quite simple for workshop, usually containing business logic)
- **dataaccess**: All domain models and repositories
- **config**: All spring configuration classes

To call the provided REST API you can use curl or httpie. For details on how to call the REST API please consult the REST API documentation which also provides sample requests for *curl* and *httpie*.

There are three target user roles for this application:

- **Standard users**: A standard user can borrow and return his currently borrowed books
- **Curators**: A curator user can add or delete books
- **Administrators**: An administrator user can add or remove users

The application is build using

- Spring 5 WebFlux on Netty
- Spring Data MongoDB with reactive driver
- In-memory Mongodb to have an easier setup for the workshop

The following subsections give a very condensed introduction to the basics of Reactive Systems, the Project Reactor and Spring WebFlux.
This might help to better understand the sample application for beginners of Reactive.

3.1. Reactive Systems & Streams

> Reactive Systems are Responsive, Resilient, Elastic and Message Driven (Asynchronous).
>
> — https://www.reactivemanifesto.org

- **Responsiveness** means the system responds in a timely manner and is the cornerstone of usability
- **Resilience** means the system stays responsive in the face of failure
- **Elasticity** means that the throughput of a system scales up or down automatically to meet varying demand as resource is proportionally added or removed
- **Message Driven** systems rely on asynchronous message-passing to establish a boundary between components that ensures loose coupling

> Reactive Streams is an initiative to provide a standard for asynchronous stream processing with non-blocking back pressure..
>
> — http://www.reactive-streams.org/

- **Back-Pressure**: When one component is struggling to keep-up, the system as a whole needs to respond in a sensible way. Back-pressure is an important feedback mechanism that allows systems to gracefully respond to load rather than collapse under it.

3.1.1. Project Reactor

The project Reactor is a Reactive library for building non-blocking applications on the JVM based on the Reactive Streams Specification and can help to build Reactive Systems.

Reactor is a fully non-blocking foundation and offers backpressure-ready network engines for HTTP (including Websockets), TCP and UDP.

Reactor introduces composable reactive types that implement Publisher but also provide a rich vocabulary of operators, most notably *Flux* and *Mono*.

A *Mono<T>* is a specialized *Publisher<T>* that emits at most one item and then optionally terminates with an onComplete signal or an onError signal.

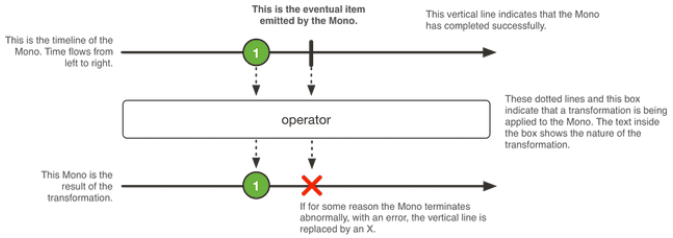


Figure 1. Mono, an Asynchronous 0-1 Result (source: projectreactor.io)

A *Flux<T>* is a standard *Publisher<T>* representing an asynchronous sequence of 0 to N emitted items, optionally terminated by either a completion signal or an error.

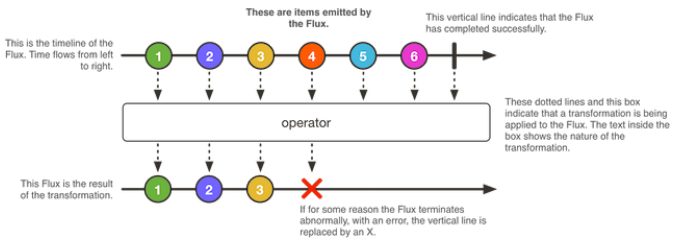


Figure 2. Flux, an Asynchronous Sequence of 0-N Items (source: projectreactor.io)

3.1.2. Spring WebFlux

Spring WebFlux was added in Spring Framework 5.0. It is fully non-blocking, supports Reactive Streams back pressure, and runs on servers such as Netty, Undertow, and Servlet 3.1+ containers.

Spring Webflux depends on Reactor and uses it internally to compose asynchronous logic and to provide Reactive Streams support.
It provides two programming models:

- Annotated Controllers: This is uses the same annotations as in the Spring MVC part
- Functional Endpoints: This provides a lambda-based, lightweight, functional programming model

Chapter 4. Workshop Organization

This interactive hands-on workshop is organized into several step with one step building upon each other. There is a separate project for each step:

- **reactive-playground**: This project provides a playground to try reactive streams with project reactor
- **00-library-server**: This contains the initial unsecured application
- **01-library-server**: This has just added the spring boot starter dependencies for spring security
- **02-library-server**: This adds a persistent user store for authentication
- **03-library-server**: This adds custom authentication and authorization rules
- **04-library-server**: This adds automatic integration tests for authorization
- **05-oauth2**: This adds an OAuth2/OIDC login client and resource server for interacting with an identity service for login

Chapter 5. Workshop Steps

To start the workshop please begin by adapting the *00-library-server* application.

If you are not able to keep up with completing a particular step you always can just start over with the existing application of next step.

For example if you could not manage to complete the tutorial based on *01-library-server* just continue using *02-library-server*.

5.1. Step 1: Auto Configuration

In the first step we start quite easy by just adding the spring boot starter dependency for spring security.

We just need to add the following two dependencies to the *build.gradle* file of the initial application (*00-library-server*).

build.gradle

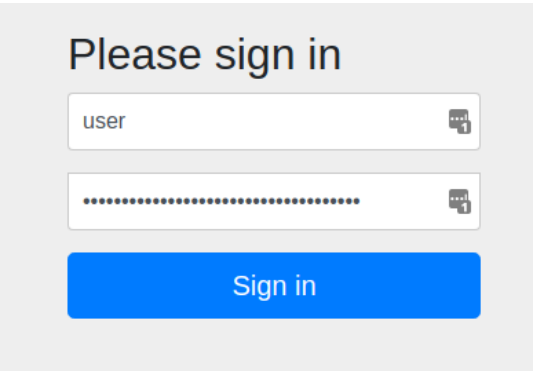
```
dependencies {
    ...
    compile('org.springframework.boot:spring-boot-starter-security') ①
    ...
    testCompile('org.springframework.security:spring-security-test') ②
}
```

① The spring boot starter for spring security

② Adds testing support for spring security

Please start the application by running the class *LibraryServerApplication*.

5.1.1. Login



If you browse to localhost:8080/books then you will notice that a login form appears in the browser window.

But wait - what are the credentials for a user to log in?

With spring security autoconfigured by spring boot the credentials are as follows:

- Username=user
- Password=<Look into the console log!>

console log

```
INFO 18465 --- [  restartedMain] ctiveUserDetailsServiceAutoConfiguration :

Using default security password: ded10c78-0b2f-4ae8-89fe-c267f9a29e1d
```

As you can see, if Spring Security is on the classpath, then the web application is secured by default. Spring boot auto-configured basic authentication and form based authentication for all web endpoints.

This also applies to all actuator endpoints like /actuator/health. All monitoring web endpoints can now only be accessed with an authenticated user. See Actuator Security for details.

5.1.2. Common Security Problems

Additionally spring security improved the security of the web application automatically for:

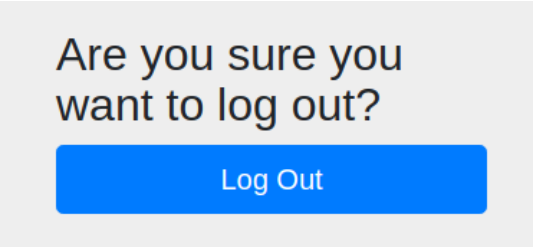
- Session Fixation: Session Fixation is an attack that permits an attacker to hijack a valid user session.
  If you want to learn more about this please read the Session Fixation page at OWASP
- Cross Site Request Forgery (CSRF): Cross-Site Request Forgery (CSRF) is an attack that forces an end user to execute unwanted actions on a web application in which they're currently authenticated.
  If you want to know what CSRF really is and how to mitigate this attack please consult CSRF attack description at OWASP
- Default Security Headers: This automatically adds all recommended security response headers to all http responses. You can find more information about this topic in the OWASP Secure Headers Project

default security response headers

```
Cache-Control: no-cache, no-store, max-age=0, must-revalidate
Expires: 0
Pragma: no-cache
Referrer-Policy: no-referrer
X-Content-Type-Options: nosniff
X-Frame-Options: DENY
X-XSS-Protection: 1 ; mode=block
```

5.1.3. Logout

Spring security 5 also added a bit more user friendly logout functionality out of the box. If you direct your browser to localhost:8080/logout you will see the following dialog on the screen.



This concludes the first step.

You find the completed code in project *01-library-server*.

Now let's proceed to next step and start with customizing the authentication part.

5.2. Step 2: Customize Authentication

Now it is time to start customizing the auto-configuration.

The spring boot auto-configuration will back-off a bit in this step and will back-off completely in next step.

Before we start let's look into some internal details how spring security works for the reactive web stack.

5.2.1. WebFilter

Like the *javax.servlet.Filter* in the blocking servlet-based web stack there is a comparable functionality in the reactive world: The *WebFilter*.

WebFilter

```
public interface WebFilter {

    /**
     * Process the Web request and (optionally) delegate to the next
     * {@code WebFilter} through the given {@link WebFilterChain}.
     * @param exchange the current server exchange
     * @param chain provides a way to delegate to the next filter
     * @return {@code Mono<Void>} to indicate when request processing is complete
     */
    Mono<Void> filter(ServerWebExchange exchange, WebFilterChain chain);

}
```

By using the *WebFilter* you can add functionality that called around each request and response.

Table 1. Spring Security WebFilter

Filter	Description
AuthenticationWebFilter	Performs authentication of a particular request
AuthorizationWebFilter	Determines if an authenticated user has access to a specific object
CorsWebFilter	Handles CORS preflight requests and intercepts
CsrfWebFilter	Applies CSRF protection using a synchronizer token pattern.

To see how such a *WebFilter* works we will implement a simple *LoggingWebFilter*:

LoggingWebFilter

```
package com.example.library.server.filter;

import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import org.springframework.stereotype.Component;
import org.springframework.web.server.ServerWebExchange;
import org.springframework.web.server.WebFilter;
import org.springframework.web.server.WebFilterChain;
import reactor.core.publisher.Mono;

@Component
public class LoggingWebFilter implements WebFilter {

    private static Logger LOGGER = LoggerFactory.getLogger(LoggingWebFilter.class);

    @Override
    public Mono<Void> filter(ServerWebExchange exchange, WebFilterChain chain) {
        LOGGER.info("Request {} called", exchange.getRequest().getPath().value());
        return chain.filter(exchange);
    }
}
```

5.2.2. WebFilterChainProxy

In step 1 we just used the auto configuration of Spring Boot. This configured default security settings as follows:

Default security configuration (with Spring Boot)

```
@Configuration
class WebFluxSecurityConfiguration {
   ...

   /**
     * The default {@link ServerHttpSecurity} configuration.
     * @param http
     * @return
     */
    private SecurityWebFilterChain springSecurityFilterChain(ServerHttpSecurity http)
{
        http
            .authorizeExchange()
                .anyExchange().authenticated();

        if (isOAuth2Present && OAuth2ClasspathGuard.shouldConfigure(this.context)) {
            OAuth2ClasspathGuard.configure(this.context, http);
        } else {
            http
                .httpBasic().and()
                .formLogin();
        }

        SecurityWebFilterChain result = http.build();
        return result;
    }

    ...
}
```

As you can see this uses a *SecurityWebFilterChain* as central component.

SecurityWebFilterChain

```
/**
 * Defines a filter chain which is capable of being matched against a {@link
ServerWebExchange} in order to decide
 * whether it applies to that request.
 *
 * @author Rob Winch
 * @since 5.0
 */
public interface SecurityWebFilterChain {

    /**
     * Determines if this {@link SecurityWebFilterChain} matches the provided {@link
ServerWebExchange}
     * @param exchange the {@link ServerWebExchange}
     * @return true if it matches, else false
     */
    Mono<Boolean> matches(ServerWebExchange exchange);

    /**
     * The {@link WebFilter} to use
     * @return
     */
    Flux<WebFilter> getWebFilters();
}
```

To customize the spring security configuration you have to implement one or more of *SecurityWebFilterChain* configuration methods.

These are handled centrally by the *WebFilterChainProxy* class.

WebFilterChainProxy

```
public class WebFilterChainProxy implements WebFilter {
    private final List<SecurityWebFilterChain> filters;

    public WebFilterChainProxy(List<SecurityWebFilterChain> filters) {
        this.filters = filters;
    }

    public WebFilterChainProxy(SecurityWebFilterChain... filters) {
        this.filters = Arrays.asList(filters);
    }

    @Override
    public Mono<Void> filter(ServerWebExchange exchange, WebFilterChain chain) { ①
        return Flux.fromIterable(this.filters)
                .filterWhen( securityWebFilterChain ->
securityWebFilterChain.matches(exchange))
                .next()
                .switchIfEmpty(chain.filter(exchange).then(Mono.empty()))
                .flatMap( securityWebFilterChain ->
securityWebFilterChain.getWebFilters()
                    .collectList()
                )
                .map( filters -> new FilteringWebHandler(webHandler ->
chain.filter(webHandler), filters))
                .map( handler -> new DefaultWebFilterChain(handler) )
                .flatMap( securedChain -> securedChain.filter(exchange));
    }
}
```

① Central point for spring security to step into reactive web requests

5.2.3. Encrypting Passwords

We start by replacing the default user/password with our own persistent user storage (already present in MongoDB). To do this we add a new class *WebSecurityConfiguration* to package *com.example.library.server.config* having the following contents.

WebSecurityConfiguration class

```
package com.example.library.server.config;

import org.springframework.context.annotation.Bean;
import
org.springframework.security.config.annotation.web.reactive.EnableWebFluxSecurity;
import org.springframework.security.crypto.factory.PasswordEncoderFactories;
import org.springframework.security.crypto.password.PasswordEncoder;

@EnableWebFluxSecurity ①
public class WebSecurityConfiguration {

    @Bean
    public PasswordEncoder passwordEncoder() {
        return PasswordEncoderFactories.createDelegatingPasswordEncoder(); ②
    }

}
```

① This auto-configures the SecurityWebFilterChain

② This adds the new delegating password encoder introduced in spring security 5

The *WebSecurityConfiguration* implementation does two important things:

1. This adds the *SecurityWebFilterChain*. If you already have secured servlet based spring mvc web applications then you might know what's called the *spring security filter chain*. In spring webflux the *SecurityWebFilterChain* is the similar approach based on matching a request with one or more WebFilter.
2. Configures a *PasswordEncoder*. A password encoder is used by spring security to encrypt passwords and to check if a given password matches the encrypted one.

PasswordEncoder interface

```
package org.springframework.security.crypto.password;

public interface PasswordEncoder {

    String encode(CharSequence rawPassword); ①

    boolean matches(CharSequence rawPassword, String encodedPassword); ②
}
```

① Encrypts the given cleartext password

② Validates the given cleartext password with the encrypted one (without revealing the unencrypted one)

In spring security 5 creating an instance of the *DelegatingPasswordEncoder* is much easier by using the class *PasswordEncoderFactories*. In past years several previously used password encryption

algorithms have been broken (like *MD4* or *MD5*). By using *PasswordEncoderFactories* you always get a configured *PasswordEncoder* that uses an *PasswordEncoder* with a *state of the art* encryption algorithm like *BCrypt* at the time of creating this workshop.

DelegatingPasswordEncoder class

```
package org.springframework.security.crypto.factory;

public class PasswordEncoderFactories {
    ...
    public static PasswordEncoder createDelegatingPasswordEncoder() {
        String encodingId = "bcrypt"; ①
        Map<String, PasswordEncoder> encoders = new HashMap<>();
        encoders.put(encodingId, new BCryptPasswordEncoder()); ②
        encoders.put("ldap", new LdapShaPasswordEncoder());
        encoders.put("MD4", new Md4PasswordEncoder());
        encoders.put("MD5", new MessageDigestPasswordEncoder("MD5"));
        encoders.put("noop", NoOpPasswordEncoder.getInstance());
        encoders.put("pbkdf2", new Pbkdf2PasswordEncoder());
        encoders.put("scrypt", new SCryptPasswordEncoder());
        encoders.put("SHA-1", new MessageDigestPasswordEncoder("SHA-1"));
        encoders.put("SHA-256", new MessageDigestPasswordEncoder("SHA-256"));
        encoders.put("sha256", new StandardPasswordEncoder());

        return new DelegatingPasswordEncoder(encodingId, encoders);
    }
    ...
}
```

① BCrypt is the default for encrypting passwords

② Suitable encoders for decrypting are selected based on prefix in encrypted value

To have encrypted passwords in our MongoDB store we need to tweak our existing *DataInitializer* a bit with the *PasswordEncoder* we just have configured.

DataInitializer class

```
package com.example.library.server;
...
import org.springframework.security.crypto.password.PasswordEncoder;
...

@Component
public class DataInitializer implements CommandLineRunner {

    ...
    private final PasswordEncoder passwordEncoder; ①

    @Autowired
    public DataInitializer(BookRepository bookRepository, UserRepository
userRepository,
                           IdGenerator idGenerator, PasswordEncoder passwordEncoder)
{
        ...
        this.passwordEncoder = passwordEncoder;
    }

    ...

    private void createUsers() {
        ...
        userRepository
                .save(
                        new User(
                                USER_IDENTIFIER,
                                "user@example.com",
                                passwordEncoder.encode("user"), ②
                                "Library",
                                "User",
                                Collections.singletonList(Role.USER)))
                .subscribe();
        ...
    }
    ...
}
```

① Inject *PasswordEncoder* to encrypt user passwords

② Change cleartext passwords into encrypted ones (using BCrypt as default)

5.2.4. Persistent User Storage

Now that we already have configured the encrypting part for passwords of our user storage we need to connect our own user store (the users already stored in the MongoDB) with spring security's authentication manager.

This is done in two steps:

In the first step we need to implement spring security's definition of a user called *UserDetails*.

LibraryUser class

```
package com.example.library.server.security;

import com.example.library.server.business.UserResource;
import org.springframework.security.core.GrantedAuthority;
import org.springframework.security.core.authority.AuthorityUtils;
import org.springframework.security.core.userdetails.UserDetails;

import java.util.Collection;
import java.util.stream.Collectors;

public class LibraryUser implements UserDetails { ①

    private final UserResource userResource; ②

    public LibraryUser(UserResource userResource) {
        this.userResource = userResource;
    }

    @Override
    public Collection<? extends GrantedAuthority> getAuthorities() {
        return AuthorityUtils
                .commaSeparatedStringToAuthorityList(
                        userResource.getRoles().stream()
                                .map(rn -> "ROLE_" + rn.name())
                                .collect(Collectors.joining(",")));
    }

    @Override
    public String getPassword() {
        return userResource.getPassword();
    }

    @Override
    public String getUsername() {
        return userResource.getEmail();
    }

    @Override
    public boolean isAccountNonExpired() {
        return true;
    }

    @Override
    public boolean isAccountNonLocked() {
        return true;
```

```
    }

    @Override
    public boolean isCredentialsNonExpired() {
        return true;
    }

    @Override
    public boolean isEnabled() {
        return true;
    }

    public UserResource getUserResource() {
        return userResource;
    }
}
```

① To provide our own user store we have to implement the spring security's predefined interface *UserDetails*

② The implementation for *UserDetails* is backed up by our existing *UserResource* value object

In the second step we need to implement spring security's interface *ReactiveUserDetailsService* to integrate our user store with the authentication manager.

LibraryReactiveUserDetailsService class

```
package com.example.library.server.security;

import com.example.library.server.business.UserService;
import org.springframework.security.core.userdetails.ReactiveUserDetailsService;
import org.springframework.security.core.userdetails.UserDetails;
import org.springframework.stereotype.Service;
import reactor.core.publisher.Mono;

@Service
public class LibraryReactiveUserDetailsService implements ReactiveUserDetailsService {
①

    private final UserService userService; ②

    public LibraryReactiveUserDetailsService(UserService userService) {
        this.userService = userService;
    }

    @Override
    public Mono<UserDetails> findByUsername(String username) { ③
        return userService.findOneByEmail(username).map(LibraryUser::new);
    }
}
```

① To provide our own user store we have to implement the spring security's predefined interface *ReactiveUserDetailsService* which is the binding component between the authentication service and our *LibraryUser*

② To search and load the targeted user for authentication we use our existing *UserService*

③ This will be called when authentication happens to get user details for validating the password and adding this user to the security context

After completing this part of the workshop we now still have the auto-configured *SecurityWebFilterChain* but we have replaced the default user with our own users from our MongoDB persistent storage.

If you restart the application now you have to use the following user credentials to log in:

Table 2. User credentials

User	Password	Roles
user@example.com	user	USER
curator@example.com	curator	USER, CURATOR
admin@example.com	admin	USER, CURATOR, ADMIN

5.2.5. Automatic Password Encryption Updates

We already looked into the *DelegatingPasswordEncoder* and *PasswordEncoderFactories*. As these classes have knowledge about all encryption algorithms that are supported in spring security, the framework can detect an *outdated* encryption algorithm. By extending our already existing *LibraryReactiveUserDetailsService* class with the additionally provided interface *ReactiveUserDetailsPasswordService* we can now enable an automatic password encryption upgrade mechanism.

The *ReactiveUserDetailsPasswordService* interface just defines one more operation.

ReactiveUserDetailsPasswordService interface

```
package org.springframework.security.core.userdetails;

import reactor.core.publisher.Mono;

public interface ReactiveUserDetailsPasswordService {

    /**
     * Modify the specified user's password. This should change the user's password in
the
     * persistent user repository (datbase, LDAP etc).
     *
     * @param user the user to modify the password for
     * @param newPassword the password to change to
     * @return the updated UserDetails with the new password
     */
    Mono<UserDetails> updatePassword(UserDetails user, String newPassword);
}
```

First we need a user having a password that is encrypted using an *outdated* algorithm. We achieve this by modifying the existing *DataInitializer* class.

DataInitializer class

```
package com.example.library.server;

...

import org.springframework.security.crypto.password.DelegatingPasswordEncoder;
import org.springframework.security.crypto.password.MessageDigestPasswordEncoder;

...

/** Store initial users and books in mongodb. */
@Component
public class DataInitializer implements CommandLineRunner {

  ...

  private static final UUID ENCRYPT_UPGRADE_USER_IDENTIFIER =
      UUID.fromString("a7365322-0aac-4602-83b6-380bccb786e2"); ①

  ...

  private void createUsers() {
    final Logger logger = LoggerFactory.getLogger(this.getClass());

    DelegatingPasswordEncoder oldPasswordEncoder =
        new DelegatingPasswordEncoder(
            "MD5", Collections.singletonMap("MD5", new
MessageDigestPasswordEncoder("MD5"))); ②

    logger.info("Creating users with USER, CURATOR and ADMIN roles...");
    userRepository
        .saveAll(
            Flux.just(
                ...,
                new User(   ③
                    ENCRYPT_UPGRADE_USER_IDENTIFIER,
                    "old@example.com",
                    oldPasswordEncoder.encode("user"),
                    "Library",
                    "OldEncryption",
                    Collections.singletonList(Role.USER))))
        .log()
        .then(userRepository.count())
        .subscribe(c -> logger.info("{} users created", c));
  }

  ...
}
```

① We need an additional user with a password using an old encryption.

② To encrypt a user with an *outdated* password we have to add an additional password encoder for *MD5* encryption. Never do such a thing in production. Always use the default *PasswordEncoderFactories* class instead

③ Here we add another user with password encrypted by added *MD5* password encoder

To activate support for automatic password encryption upgrades we need to extend our existing *LibraryReactiveUserDetailsService* class.

LibraryReactiveUserDetailsService class

```
package com.example.library.server.security;

import com.example.library.server.business.UserService;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import
org.springframework.security.core.userdetails.ReactiveUserDetailsPasswordService;
import org.springframework.security.core.userdetails.ReactiveUserDetailsService;
import org.springframework.security.core.userdetails.UserDetails;
import org.springframework.stereotype.Service;
import reactor.core.publisher.Mono;

@Service
public class LibraryReactiveUserDetailsService implements ReactiveUserDetailsService,
ReactiveUserDetailsPasswordService { ①

    private static final Logger LOGGER =
LoggerFactory.getLogger(LibraryReactiveUserDetailsService.class); ②

    ...

    @Override
    public Mono<UserDetails> updatePassword(UserDetails user, String newPassword) { ③

        LOGGER.warn("Password upgrade for user with name '{}'", user.getUsername());

        // Only for demo purposes. NEVER log passwords in production!!!
        LOGGER.info("Password upgraded from '{}' to '{}'", user.getPassword(),
newPassword);

        return userService.findOneByEmail(user.getUsername())
                .doOnSuccess(u -> u.setPassword(newPassword))
                .flatMap(userService::update)
                .map(LibraryUser::new);
    }
}
```

① To provide our own user store we have to implement the spring security's predefined interface *ReactiveUserDetailsService* which is the binding component between the authentication service and our *LibraryUser*. Now we also add *ReactiveUserDetailsPasswordService* to enable automatic

password encryption upgrades

② To log the password upgrade action here we provide a logger. Please note: NEVER log passwords in production!!

③ This operation is called automatically by spring security if it detects a password that is encrypted using an *outdated* encryption algorithm like *MD5* message digest

Now restart the application and see what happens if we try to get the list of books using this new user (username='old@example.com', password='user').

In the console you should see the log output showing the old *MD5* password being updated to *bcrypt* password.

Never log any sensitive data like passwords, tokens etc., even in encrypted format. Also never put such sensitive data into your version control. And never let error details reach the client (via REST API or web application). Make sure you disable stacktraces in client error messages using property *server.error.include-stacktrace=never*

This is the end of step 2 of the workshop.

You find the completed code in project *02-library-server*.

In the next workshop part we also adapt the *SecurityWebFilterChain* to our needs and add authorization rules (in web and method layer) for our application.

5.3. Step 3: Add Authorization

In this part of the workshop we want to add our customized authorization rules for our application.

As a result of the previous workshop steps we now have authentication for all our web endpoints (including the actuator endpoints) and we can log in using our own users. But here security does not stop.

We know who is using our application (**authentication**) but we do not have control over what this user is allowed to do in our application (**authorization**).

As a best practice the authorization should always be implemented on different layers like the web and method layer. This way the authorization still prohibits access even if a user manages to bypass the web url based authorization filter by playing around with manipulated URL's.

Our required authorization rule matrix looks like this:

Table 3. Authorization rules for library-server

URL	Http method	Restricted	Roles with access
/**.css**,/.jpg,/*.ico,...	All	No	—
/books	POST	Yes	CURATOR
/books	DELETE	Yes	CURATOR

/users	All	Yes	ADMIN
/actuator/health	GET	No	—
/actuator/info	GET	No	—
/actuator/*	GET	Yes	ADMIN
/*	All	Yes	All authenticated ones

All the web layer authorization rules are configured in the *WebSecurityConfiguration* class by adding a new bean for *SecurityWebFilterChain*. Here we also already switch on the support for method layer authorization by adding the annotation *@EnableReactiveMethodSecurity*.

WebSecurityConfiguration class

```
package com.example.library.server.config;

...

@EnableWebFluxSecurity
@EnableReactiveMethodSecurity ①
public class WebSecurityConfiguration {

    @Bean ②
    public SecurityWebFilterChain springSecurityFilterChain(ServerHttpSecurity http) {
        return http
                .authorizeExchange()

.matchers(PathRequest.toStaticResources().atCommonLocations()).permitAll() ③
                .matchers(EndpointRequest.to("health")).permitAll() ④
                .matchers(EndpointRequest.to("info")).permitAll()
                .matchers(EndpointRequest.toAnyEndpoint()).hasRole(Role.ADMIN.name())
⑤
                .pathMatchers(HttpMethod.POST, "/books").hasRole(Role.CURATOR.name())
⑥
                .pathMatchers(HttpMethod.DELETE,
"/books").hasRole(Role.CURATOR.name())
                .pathMatchers("/users/**").hasRole(Role.ADMIN.name()) ⑦
                .anyExchange().authenticated() ⑧
                .and()
                .httpBasic().and().formLogin().and() ⑨
                .logout().logoutSuccessHandler(logoutSuccessHandler()) ⑩
                .and()
                .build();
    }

    @Bean ⑪
    public ServerLogoutSuccessHandler logoutSuccessHandler() {
        RedirectServerLogoutSuccessHandler logoutSuccessHandler = new
RedirectServerLogoutSuccessHandler();
        logoutSuccessHandler.setLogoutSuccessUrl(URI.create("/books"));
        return logoutSuccessHandler;
    }

    @Bean
    public PasswordEncoder passwordEncoder() {
        return PasswordEncoderFactories.createDelegatingPasswordEncoder();
    }

}
```

① This adds support for method level authorization

② Configures authentication and web layer authorization for all URL's of our REST api

③ All static resources (favicon.ico, css, images, …) can be accessed without authentication

④ Actuator endpoints for *health* and *info* can be accessed without authentication

⑤ All other actuator endpoints require authentication

⑥ Modifying access to books require authenticated user having the 'CURATOR' role

⑦ Access to users require authenticated user having the 'ADMIN' role

⑧ All other web endpoints require authentication

⑨ Authentication can be performed using basic authentication or form based login

⑩ After logging out it redirects to URL configured in the logout success handler

⑪ The configured login success handler redirects to /books resource

We also add a a *ServerLogoutSuccessHandler* bean to redirect back to the */books* endpoint after a logout to omit the error message we got so far by redirecting to a non-existing page.

We continue with authorization on the method layer by adding the rules to our business service classes *BookService* and *UserService*. To achieve this we use the *@PreAuthorize* annotations provided by spring security. Same as other spring annotations (e.g. @Transactional) you can put *@PreAuthorize* annotations on global class level or on method level.

Depending on your authorization model you may use *@PreAuthorize* to authorize using static roles or to authorize using dynamic expressions (usually if you have roles with permissions).

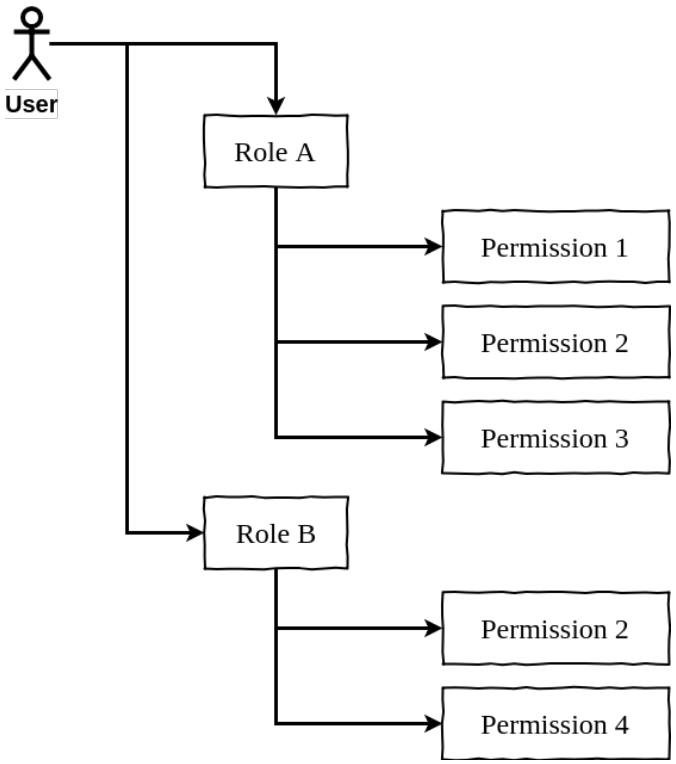


Figure 3. Roles and Permissions

If you want to have a permission based authorization you can use the predefined interface *PermissionEvaluator* inside the *@PreAuthorize* annotations like this:

```
class MyService {
    @PreAuthorize("hasPermission(#uuid, 'user', 'write')")
    void myOperation(UUID uuid) {...}
}
```

PermissionEvaluator class

```
package org.springframework.security.access;

...
public interface PermissionEvaluator extends AopInfrastructureBean {

    boolean hasPermission(Authentication authentication, Object targetDomainObject,
            Object permission);

    boolean hasPermission(Authentication authentication, Serializable targetId,
            String targetType, Object permission);
}
```

In the workshop due to time constraints we have to keep things simple so we just use static roles. Here it is done for the all operations of the book service.

BookService class

```
package com.example.library.server.business;

...
import org.springframework.security.access.prepost.PreAuthorize;
...

@Service
@PreAuthorize("hasAnyRole('USER', 'CURATOR', 'ADMIN')") ①
public class BookService {

    ...

    @PreAuthorize("hasRole('CURATOR')") ②
    public Mono<Void> create(Mono<BookResource> bookResource) {
        return bookRepository.insert(bookResource.map(this::convert)).then();
    }

    ...

    @PreAuthorize("hasRole('CURATOR')") ③
    public Mono<Void> deleteById(UUID uuid) {
        return bookRepository.deleteById(uuid).then();
    }
    ...
}
```

① In general all users (having either of these 3 roles) can access RESTful services for books

② Only users having role 'CURATOR' can access this RESTful service to create books

③ Only users having role 'CURATOR' can access this RESTful service to delete books

And now we add it the same way for the all operations of the user service.

UserService class

```
package com.example.library.server.business;
...
import org.springframework.security.access.prepost.PreAuthorize;
...
@Service
@PreAuthorize("hasRole('ADMIN')") ①
public class UserService {

    ...

    @PreAuthorize("isAnonymous() or isAuthenticated()") ②
    public Mono<UserResource> findOneByEmail(String email) {
        return userRepository.findOneByEmail(email).map(this::convert);
    }

    ...
}
```

① In general only users having role 'ADMIN' can access RESTful services for users

② As this operation is used by the *LibraryUserDetailsService* to perform authentication this has to be accessible for anonymous users (unless authentication is finished successfully anonymous users are unauthenticated users)

Now that we have the current user context available in our application we can use this to automatically set this user as the one who has borrowed a book or returns his borrowed book. The current user can always be evaluated using the *ReactiveSecurityContextHolder* class. But a more elegant way is to just let the framework put the current user directly into our operation via *@AuthenticationPrincipal* annotation.

BookRestController class

```
package com.example.library.server.api;

import org.springframework.security.core.annotation.AuthenticationPrincipal;

@RestController
public class BookRestController {

    ...

    @PostMapping("/books/" + PATH_BOOK_ID + "/borrow")
    public Mono<Void> borrowBookById(
            @PathVariable(PATH_VARIABLE_BOOK_ID) UUID bookId, @AuthenticationPrincipal
LibraryUser user) { ①
        return bookService.borrowById(bookId, user.getUserResource().getId());
    }

    @PostMapping("/books/" + PATH_BOOK_ID + "/return")
    public Mono<Void> returnBookById(@PathVariable(
            PATH_VARIABLE_BOOK_ID) UUID bookId, @AuthenticationPrincipal LibraryUser
user) { ②
        return bookService.returnById(bookId, user.getUserResource().getId());
    }

    ...
}
```

① Now that we have an authenticated user context we can add the current user as the one to borrow a book

② Now that we have an authenticated user context we can add the current user as the one to return his borrowed a book

So please go ahead and re-start the application and try to borrow a book with an authenticated user. If you are an IntelliJ user you can use the provided *book.http* file in subdirectory *http*.

At first you will notice that even with the correct basic authentication header you get an error message like this one:

CSRF error output

```
POST http://localhost:8080/books

HTTP/1.1 403 Forbidden
transfer-encoding: chunked
Content-Type: text/plain
Cache-Control: no-cache, no-store, max-age=0, must-revalidate
Pragma: no-cache
Expires: 0
X-Content-Type-Options: nosniff
X-Frame-Options: DENY
X-XSS-Protection: 1 ; mode=block

CSRF Token has been associated to this client

Response code: 403 (Forbidden)
```

The library-server expects a CSRF token in the request but did not find one. If you use common UI frameworks like Thymeleaf or JSF (on the serverside) or a clientside one like Angular then these already handle this CSRF processing.

In our case we do not have such handler. To successfully tra the borrow book request you have to switch off CSRF in the library server.
This is done like this in the *WebSecurityConfiguration* class.

Disable CSRF

```
...
@Bean
public SecurityWebFilterChain springSecurityFilterChain(ServerHttpSecurity http) {
    return http
        .csrf().disable() ①
        .authorizeExchange()
        .matchers(PathRequest.toStaticResources().atCommonLocations()).permitAll()
    ...
```

① Add this line to disable CSRF.

Restart the application and retry to borrow a book. This time the request should be successful.

Do not disable CSRF on productive servers if you use session cookies, otherwise you are vulnerable to CSRF attacks. You may safely disable CSRF for servers that use a stateless authentication approach with bearer tokens like for OAuth2 or OpenID Connect.

In this workshop step we added the authorization to web and method layers. So now for particular RESTful endpoints access is only permitted to users with special roles.

You find the completed code in project *03-library-server*.

But how do you know that you have implemented all the authorization rules and did not leave a big security leak for your RESTful API? Or you may change some authorizations later by accident?

To be on a safer side here you need automatic testing. Yes, this can also be done for security! We will see how this works in the next workshop part.

5.4. Step 4: Security Testing

Now it is time to prove that we have implemented these authorization rules correctly with automatic testing.

We start testing the rules on method layer for all operations regarding books.

The tests will be implemented using the new JUnit 5 version as Spring 5.0 now supports this as well. In *BookServiceTest* class we also use the new convenience annotation *@SpringJUnitConfig* which is a shortcut of *@ExtendWith(value=SpringExtension.class)* and *@ContextConfiguration*.

As you can see in the following code only a small part is shown as a sample here to test the *BookService.create()* operation. Authorization should always be tested for positive **AND** negative test cases. Otherwise you probably miss an authorization constraint. Depending on the time left in the workshop you can add some more test cases as you like or just look into the completed application *04-library-server*.

BookServiceTest class

```
package com.example.library.server.business;

...

@DisplayName("Verify that book service")
@SpringJUnitConfig(LibraryServerApplication.class) ①
class BookServiceTest {

  @Autowired
  private BookService bookService;

  @MockBean ②
  private BookRepository bookRepository;

  @MockBean
  private UserRepository userRepository;

  @MockBean
  private IdGenerator idGenerator;

  @DisplayName("grants access to create a book for role 'CURATOR'")
  @Test
  @WithMockUser(roles = "CURATOR")
  void verifyCreateAccessIsGrantedForCurator() { ③
```

```
    when(bookRepository.insert(Mockito.<Mono<Book>>any())).thenReturn(Flux.just(new
Book()));
    StepVerifier.create(bookService.create(Mono.just(new
BookResource(UUID.randomUUID(),
                    "123456789", "title", "description",
Collections.singletonList("author"),
                    false, null)
            ))).verifyComplete();
  }

  @DisplayName("denies access to create a book for roles 'USER' and 'ADMIN'")
  @Test
  @WithMockUser(roles = {"USER", "ADMIN"})
  void verifyCreateAccessIsDeniedForUserAndAdmin() { ④
    StepVerifier.create(bookService.create(Mono.just(new
BookResource(UUID.randomUUID(),
            "123456789", "title", "description", Collections.singletonList("author"),
            false, null)
    ))).verifyError(AccessDeniedException.class);
  }

  @DisplayName("denies access to create a book for anonymous user")
  @Test
  void verifyCreateAccessIsDeniedForUnauthenticated() { ⑤
    StepVerifier.create(bookService.create(Mono.just(new
BookResource(UUID.randomUUID(),
            "123456789", "title", "description", Collections.singletonList("author"),
            false, null)
    ))).verifyError(AccessDeniedException.class);
  }

  ...

}
```

① As this is a JUnit 5 based integration test we use *@SpringJUnitConfig* to add spring JUnit 5 extension and configure the application context

② All data access (the repositories) is mocked

③ Positive test case of access control for creating books with role 'CURATOR'

④ Negative test case of access control for creating books with roles 'USER' or 'ADMIN'

⑤ Negative test case of access control for creating books with anonymous user

For sure you have to add similar tests as well for the user part.

UserServiceTest class

```
package com.example.library.server.business;

...
```

```
@DisplayName("Verify that user service")
@SpringJUnitConfig(LibraryServerApplication.class) ①
class UserServiceTest {

  @Autowired
  private UserService userService;

  @MockBean
  private UserRepository userRepository;

  @SuppressWarnings("unused")
  @MockBean
  private IdGenerator idGenerator;

  @DisplayName("grants access to find one user by email for anonymous user")
  @Test
  void verifyFindOneByEmailAccessIsGrantedForUnauthenticated() { ②
    when(userRepository.findOneByEmail(any())).thenReturn(Mono.just(new
User(UUID.randomUUID(),
            "test@example.com", "secret", "Max", "Maier",
            Collections.singletonList(Role.USER))));

StepVerifier.create(userService.findOneByEmail("test@example.com")).expectNextCount(1)
.verifyComplete();
  }

  @DisplayName("grants access to find one user by email for roles 'USER', 'CURATOR'
and 'ADMIN'")
  @Test
  @WithMockUser(roles = {"USER", "CURATOR", "ADMIN"})
  void verifyFindOneByEmailAccessIsGrantedForAllRoles() { ③
    when(userRepository.findOneByEmail(any())).thenReturn(Mono.just(new
User(UUID.randomUUID(),
            "test@example.com", "secret", "Max", "Maier",
            Collections.singletonList(Role.USER))));

StepVerifier.create(userService.findOneByEmail("test@example.com")).expectNextCount(1)
.verifyComplete();
  }

  @DisplayName("denies access to create a user for roles 'USER' and 'CURATOR'")
  @Test
  @WithMockUser(roles = {"USER", "CURATOR"})
  void verifyCreateAccessIsDeniedForUserAndCurator() { ④
    StepVerifier.create(userService.create(Mono.just(new
UserResource(UUID.randomUUID(),
            "test@example.com", "secret", "Max", "Maier",

Collections.singletonList(Role.USER)))).verifyError(AccessDeniedException.class);
  }
```

```
  ...
}
```

① As this is a JUnit 5 based integration test we use *@SpringJUnitConfig* to add spring JUnit 5 extension and configure the application context

② Positive test case of access control for finding a user by email for anonymous user

③ Positive test case of access control for finding a user by email with all possible roles

④ Negative test case of access control for creating user with roles 'USER' or 'CURATOR'

The testing part is the last part of adding security to the reactive style of the *library-server* project.

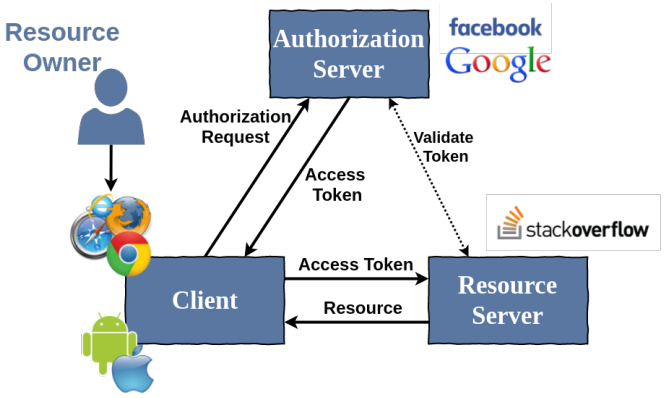
You find the completed code in project *04-library-server*.

In the last workshop part we will look at the new OAuth2 login client and resource server introduced in Spring Security 5.0 and 5.1.

5.5. Step 5: OAuth2/OpenID Connect

5.5.1. OAuth 2.0

OAuth 2.0 is the base protocol for authorizing 3rd party authentication services for using business services in the internet like stackoverflow.



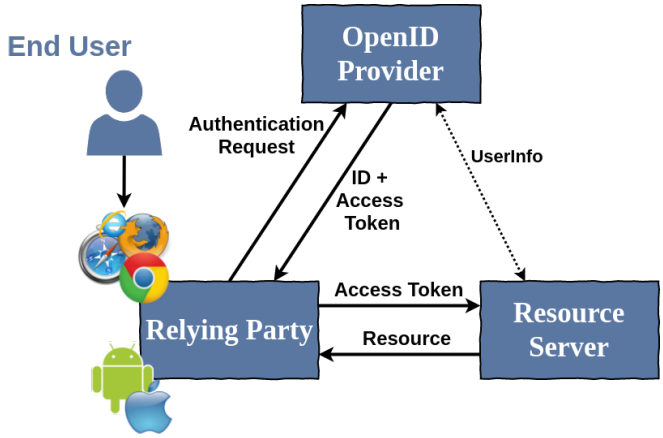
Authorizations are permitted via scopes that the user has to confirm before using the requested service.

Depending on the application type OAuth 2.0 provides the following grants (flows):

- Authorization Code Grant
- Authorization Code Grant with PKCE
- Implicit Grant
- Resource Owner Password Credentials Grant
- Client Credentials Grant

5.5.2. OpenID Connect 1.0

OpenID Connect 1.0 (OIDC) is build upon OAuth2 and provides additional identity information to OAuth2. For common enterprise applications that typically require authentication OpenID Connect should be used. OIDC adds JSON web tokens (JWT) as mandatory format for id tokens to the spec. In OAuth2 the format of bearer tokens is not specified.



OIDC adds an id token in addition to the access token of OAuth2 and specifies a user info endpoint to retrieve further user information using the access token.

OIDC supports the following grant flows:

- Authorization Code Flow
- Implicit Flow
- Hybrid Flow

5.5.3. Tokens in OIDC and OAuth 2.0

Tokens can be used in two ways:

1. Self-contained token (containing all information directly in token payload, e.g. JWT)
2. Reference token (token is used to look up further information)

5.5.4. OAuth2/OIDC in Spring Security 5

Spring Security 5.0 introduced new support for OAuth2/OpenID Connect (OIDC) directly in spring security.

In short Spring Security 5.0 adds a completely rewritten implementation for OAuth2/OIDC which now is largely based on a third party library Nimbus OAuth 2.0 SDK instead of implementing all these functionality directly in Spring itself.

Spring Security 5.0 only provides the client side for servlet-based clients.

Spring Security 5.1 adds the resource server support and reactive support for reactive clients and resource server as well.

Spring Security 5.2 adds client support for authorization code flow with PKCE.

Spring Security 5.3 will add a basic OAuth2/OIDC authorization server again (for local dev and

demos but not for productive use).

Before Spring Security 5.0 and Spring Boot 2.0 to implement OAuth2 you needed the separate project module Spring Security OAuth2.

Now things have changed much, so it heavily depends now on the combination of Spring Security and Spring Boot versions that are used how to implement OAuth2/OIDC.

Therefore you have to be aware of different approaches for Spring Security 4.x/Spring Boot 1.5.x and Spring Security 5.x/Spring Boot 2.x.

Table 4. OAuth2 support in Spring Security + Spring Boot

Spring Security	Spring Boot	Client	Resource server	Authorization server	Reactive (WebFlux)
4.x	1.5.x	X[1]	X[1]	X[1]	—
5.0	2.0.x	X[2]	(X)[3]	(X)[3]	—
5.1	2.1.2	X[2]	X[4]	(X)[3]	X[5]
5.2	2.2.0	X[2]	X[4]	(X)[3]	X[5]
5.3	2.3.0	X[2]	X[4]	X[6]	X[5]

[1] Spring Boot auto-config and separate Spring Security OAuth project
[2] New rewritten OAuth2 login client included in Spring Security 5.0
[3] No direct support in Spring Security 5.0/Spring Boot 2.0. For auto-configuration with Spring Boot 2.0 you still have to use the separate Spring Security OAuth project together with Spring Security OAuth2 Boot compatibilty project
[4] New refactored support for resource server as part of Spring Security 5.1
[5] OAuth2 login client and resource server with reactive support as part of Spring Security 5.1.
[6] New OAuth2 authorization server is planned as part of Spring Security 5.2

The OAuth2/OpenID Connect Authorization Server provided by Spring Security 5.3 will mainly suit for fast prototyping and demo purposes. For production please use one of the officially certified products like for example KeyCloak, UAA, IdentityServer, Auth0 or Okta.

You can find more information on building OAuth2 secured microservices with Spring Boot **1.5.x** in

- Spring Boot 1.5 Reference Documentation
- Spring Security OAuth2 Developers Guide

You can find more information on building OAuth2 secured microservices with Spring Boot **2.1** and Spring Security **5.1** in

- Spring Boot 2.1 Reference Documentation
- Spring Security OAuth2/OIDC Login Client Reference Documentation
- Spring Security OAuth2/OIDC Resource Server Reference Documentation
- Spring Security OAuth Boot 2 Auto-config Documentation

- Spring Security OAuth2 Developers Guide

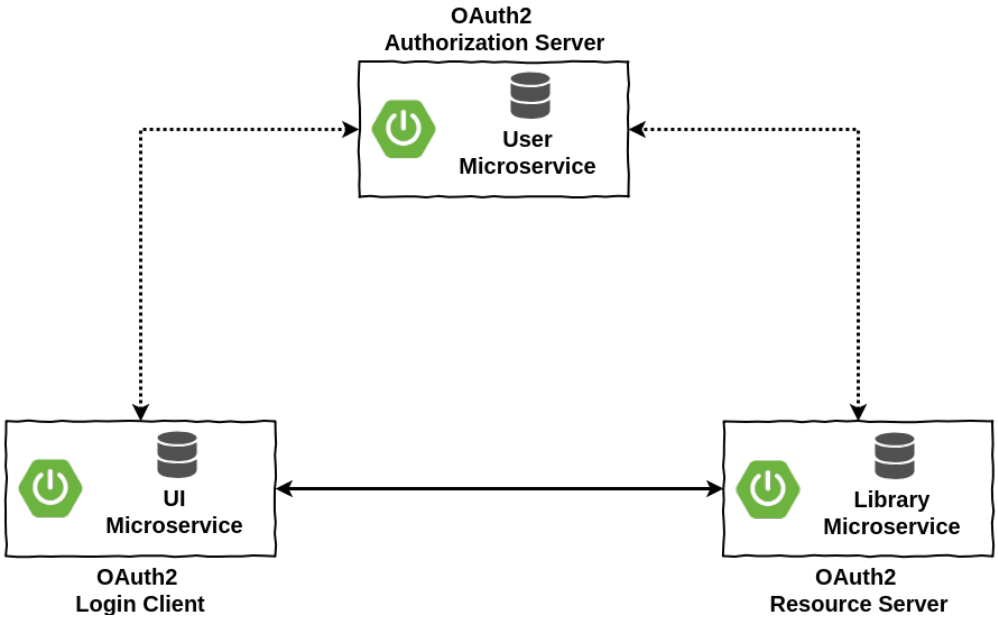
In this workshop we will now look at what Spring Security 5.1 provides as new OAuth2/OIDC Login Client and Resource Server - In a reactive way.

5.5.5. What we will build

In the *05-oauth2* project you will be provided the following sub-projects:

- **initial-library-server**: The reactive version of the library server (almost similar to workshop step *00-library-server*)
- **initial-oauth2-login-client**: Initial code for this workshop part to implement the new OAuth2 Login Client
- **oauth2-login-client**: Complete code of the new OAuth2 Login Client (for reference)
- **oauth2-library-server**: Complete code of the reactive library OAuth2 resource server

The spring implementation of the authorization server previously used (based on Spring Boot 1.5.x) is not fully compliant with OIDC and therefore not usable any more with OAuth2/OIDC implementation of Spring Security 5.1.



These microservices have to be configured to be reachable via the following URL addresses (Port 8080 is the default port in spring boot).

Table 5. Microservice URL Adresses

Microservice	URL
Identity Management Service (OKTA)	https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7
Library Client (OAuth2 Login Client)	http://localhost:8081
Library Server (OAuth2 Resource Server)	http://localhost:8080

So now let's start. Again, you will just use the provided *uaa* identity management server, the *initial-library-server* and the *initial-oauth2-login-client* as starting point and implement a OAuth2 resource server and login client based on the project.

But first read important information about how to start the required *uaa* identity management server.

5.5.6. Okta Identity Server

For this workshop the OpenID Connect certified OKTA identity provider service is used. This service provides solutions for authentication, authorization and user administration. For our purposes we will use this service to issue OpenID Connect compliant JSON web tokens.

You may look into OpenID Connect certified products to find a suitable identity management server for your project.

Every OpenID Connect 1.0 compliant identity server must provide a page at the endpoint */.../.well-known/openid-configuration*

To see the configuration please open the following url in your web browser: Well known OIDC configuration

The important information provided by this is:

Table 6. Identity Server Configuration

Entry	Description	Value
issuer	Issuer url for issued tokens by this identity server	https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7
authorization_endpoint	Handles authorization, usually asking for credentials and returns an authorization code	https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/authorize
token_endpoint	Token endpoint (exchanges given authorization code for access token)	https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/token
userinfo_endpoint	Endpoint for requesting further user information	https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/userinfo

jwks_uri	Uri for loading public keys to verify signatures of JSON web tokens	https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/keys

The OKTA identity service has been preconfigured with the following user credentials for login:

Table 7. User credentials

User	Password	Roles
user@example.com	Library_access#1	USER
admin@example.com	Library_access#2	USER, CURATOR, ADMIN
curator@example.com	Library_access#3	USER, CURATOR

5.5.7. Resource Server (Library-Server)

For this workshop part the well-known library-server application is used and will be extended to act as a OAuth2 resource server.

Gradle dependencies

To use the new OAuth2 resource server support of Spring Security 5.1 you have to add the following required dependencies to the existing gradle build file.

gradle.build file

```
dependencies {
    ...
    compile('org.springframework.security:spring-security-oauth2-resource-server') ①
    compile('org.springframework.security:spring-security-oauth2-jose') ②
    ...
}
```

① This contains all code to build an OAuth 2.0/OIDC resource server

② This contains Spring Security's support for the JOSE (Javascript Object Signing and Encryption) framework. This is needed to support for example JSON Web Token (JWT)

These dependencies already have been added to the initial project.

You may look into the spring security oauth2 boot reference documentation Spring Boot 2.1 Reference Documentation and the Spring Security 5.1 Reference Documentation on how to implement a resource server.

Implementation steps

First step is to configure an OAuth2 resource server. For this you have to register the corresponding identity server/authorization server to use.

application.yml file

```
spring:
  security:
    oauth2:
      resourceserver:
        jwt:
          issuer-uri: https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7
①
```

① The issuer url is used to look up the well known configuration page to get all required configuration settings to set up a resource server

The issuer URI is used to retrieve the well known OpenID Connect configuration.

https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/.well-known/openid-configuration

```
{
  "issuer": "https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7",
  "authorization_endpoint": "https://dev-
667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/authorize",
  "token_endpoint": "https://dev-
667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/token",
  "userinfo_endpoint": "https://dev-
667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/userinfo",
  "registration_endpoint": "https://dev-667216.oktapreview.com/oauth2/v1/clients",
  "jwks_uri": "https://dev-
667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/v1/keys",
  "response_types_supported": [
    "code",
    "id_token",
    "code id_token",
    "code token",
    "id_token token",
    "code id_token token"
  ],
  "response_modes_supported": [
    "query",
    "fragment",
    "form_post",
    "okta_post_message"
  ],
  "grant_types_supported": [
    "authorization_code",
    "implicit",
    "refresh_token",
    "password"
  ],
  ...
}
```

WebSecurityConfiguration.java file

```
package com.example.library.server.config;

import com.example.library.server.common.Role;
import
org.springframework.boot.actuate.autoconfigure.security.reactive.EndpointRequest;
import org.springframework.boot.autoconfigure.security.reactive.PathRequest;
import org.springframework.context.annotation.Bean;
import org.springframework.http.HttpMethod;
import
org.springframework.security.config.annotation.method.configuration.EnableReactiveMeth
odSecurity;
import
org.springframework.security.config.annotation.web.reactive.EnableWebFluxSecurity;
import org.springframework.security.config.web.server.ServerHttpSecurity;
import
org.springframework.security.oauth2.server.resource.authentication.ReactiveJwtAuthenti
cationConverterAdapter;
import org.springframework.security.web.server.SecurityWebFilterChain;

@EnableWebFluxSecurity
@EnableReactiveMethodSecurity
public class WebSecurityConfiguration {

    @Bean
    public SecurityWebFilterChain springSecurityFilterChain(ServerHttpSecurity http) {
        http
                .csrf().disable()
                .authorizeExchange()

.matchers(PathRequest.toStaticResources().atCommonLocations()).permitAll()
                .matchers(EndpointRequest.to("health")).permitAll()
                .matchers(EndpointRequest.to("info")).permitAll()
                .matchers(EndpointRequest.toAnyEndpoint()).hasRole(Role.ADMIN.name())
①
                .pathMatchers(HttpMethod.POST, "/books").hasAuthority("SCOPE_curator")
                .pathMatchers(HttpMethod.DELETE,
"/books").hasAuthority("SCOPE_curator")
                .pathMatchers("/users/**").hasAuthority("SCOPE_admin")
                .pathMatchers("/books/**").hasAuthority("SCOPE_user")
                .anyExchange().authenticated()
                .and()
                .oauth2ResourceServer() ②
                .jwt() ③
                .jwtAuthenticationConverter(new
ReactiveJwtAuthenticationConverterAdapter(
                        new GrantedAuthoritiesGroupExtractor())); ④
        return http.build();
    }
}
```

① OAuth2 scopes are automatically mapped to *SCOPE_xxx* authorities (like the standard *ROLE_xxx* ones)

② Autoconfiguration for an OAuth2 resource server

③ Configures JSON web token (JWT) handling for this resource server

④ Configures a JWT authentication converter acting as authorities extractor

To start the resource server simply run the class *LibraryServerApplication* in project *05-oauth2-client/initial-library-server*.

In the following paragraphs we now proceed to the workshop part where your interaction is required again: The OAuth2 login client.

5.5.8. OAuth2 Login Client

Gradle dependencies

To use the new OAuth2 client support of Spring Security 5.0 you have to add the following required dependencies to the existing gradle build file.

gradle.build file

```
dependencies {
    ...
    implementation('org.springframework.boot:spring-boot-starter-oauth2-client') ①
    ...
}
```

① Spring Boot starter for OAuth2 client including core OAuth2/OIDC client and JOSE (Javascript Object Signing and Encryption) framework to support for example JSON Web Token (JWT)

These dependencies already have been added to the initial project.

Implementation steps

First step is to configure an OAuth2 login client. For this you have to register the corresponding identity server/authorization server to use. Here you have two possibilities:

1. You can just use one of the predefined ones (Facebook, Google, etc.)
2. You register your own custom server

Spring security provides the enumeration *CommonOAuth2Provider* which defines registration details for a lot of well known identity providers.

CommonOAuth2Provider class

```
package org.springframework.security.config.oauth2.client;
...
public enum CommonOAuth2Provider {

    GOOGLE {

        @Override
        public Builder getBuilder(String registrationId) {
            ClientRegistration.Builder builder = getBuilder(registrationId,
                    ClientAuthenticationMethod.BASIC, DEFAULT_LOGIN_REDIRECT_URL);
            builder.scope("openid", "profile", "email");
            builder.authorizationUri("https://accounts.google.com/o/oauth2/v2/auth");
            builder.tokenUri("https://www.googleapis.com/oauth2/v4/token");
            builder.jwkSetUri("https://www.googleapis.com/oauth2/v3/certs");
            builder.userInfoUri("https://www.googleapis.com/oauth2/v3/userinfo");
            builder.userNameAttributeName(IdTokenClaimNames.SUB);
            builder.clientName("Google");
            return builder;
        }
    },

    GITHUB {

        @Override
        public Builder getBuilder(String registrationId) {
            ...
        }
    },

    FACEBOOK {

        @Override
        public Builder getBuilder(String registrationId) {
            ...
        }
    },
    ...
}
```

To use one of these providers is quite easy. Just reference the enumeration constant as the provider.

Google provider properties class

```
spring:
  security:
    oauth2:
      client:
        registration:
          google-login: ①
            provider: google ②
            client-id: google-client-id
            client-secret: google-client-secret
```

① The registration id is set to *google-login*

② The provider is set to the predefined *google* client which points to *CommonOAuth2Provider.GOOGLE*

But in this workshop we will focus on the second possibility and use our own local authorization server.
To achieve this we add the following sections to the *application.yml* file.

application.yml client configuration

```
spring:
  security:
    oauth2:
      client:
        registration:
          library-client: ①
            provider: okta ②
            client-id: 0oajbryix1d8ABX1i0h7 ③
            client-secret: IO_t-KoGka55dz0AVx94mraOig4zclp4ri4Y92vl ④
            redirect-uri-template: "{baseUrl}/login/oauth2/code/{registrationId}" ⑤
            scope: openid, profile, email, offline_access ⑥
        provider:
          okta: ⑦
            issuer-uri: https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7
⑧
```

① The registration id for the client

② References the registered identity provider to use for this OAuth2 client

③ The client id to use at the identity provider

④ The client secret to use at the identity provider

⑤ The pattern to build the required redirect URL back from authorization server to this client

⑥ The required OAuth2 scopes to use at the identity provider

⑦ Name of the identity provider (Okta identity provider service)

⑧ The issuer URI for tokens (is used to read the identity provider configuration from https://dev-667216.oktapreview.com/oauth2/ausjbx4pq5Wg0kZx10h7/.well-known/openid-configuration)

As the library-server is now configured as an OAuth2 resource server it requires a valid JWT token to successfully call the */books* endpoint now.

From client side we use the new *WebClient* for calls to the RESTful service. WebClient is the successor of *RestTemplate* and works for both worlds (Servlet-based and reactive).

To support JWT tokens in calls we have to add a client interceptor to the *RestTemplate*. The following code snippet shows how this is done:

WebClientConfiguration class

```
package com.example.oauth2loginclient.config;

import org.springframework.context.annotation.Bean;
import org.springframework.context.annotation.Configuration;
import
org.springframework.security.oauth2.client.registration.ReactiveClientRegistrationRepo
sitory;
import
org.springframework.security.oauth2.client.web.reactive.function.client.ServerOAuth2Au
thorizedClientExchangeFilterFunction;
import
org.springframework.security.oauth2.client.web.server.ServerOAuth2AuthorizedClientRepo
sitory;
import org.springframework.web.reactive.function.client.WebClient;

@Configuration
public class WebClientConfiguration {

    @Bean
    WebClient webClient(ReactiveClientRegistrationRepository
clientRegistrationRepository,
                        ServerOAuth2AuthorizedClientRepository
authorizedClientRepository) {
        ServerOAuth2AuthorizedClientExchangeFilterFunction oauth = ①
                new
ServerOAuth2AuthorizedClientExchangeFilterFunction(clientRegistrationRepository,

authorizedClientRepository);
        oauth.setDefaultClientRegistrationId("library-app"); ②
        return WebClient.builder()
                .filter(oauth) ③
                .build();
    }
}
```

① Creates a filter for handling all the OAuth2 token stuff (i.e. initiating the OAuth2 code grant flow)

② Registration id for client for automatic token handling

③ Add the filter to webclient

Finally we need an updated client side security configuration to allow client endpoints and enable the OAuth2 client features:

SecurityConfiguration class

```
package com.example.oauth2loginclient.config;

import org.springframework.context.annotation.Bean;
import org.springframework.context.annotation.Configuration;
import
org.springframework.security.config.annotation.web.reactive.EnableWebFluxSecurity;
import org.springframework.security.config.web.server.ServerHttpSecurity;
import org.springframework.security.web.server.SecurityWebFilterChain;

@EnableWebFluxSecurity
@Configuration
public class SecurityConfiguration {

    @Bean
    SecurityWebFilterChain configure(ServerHttpSecurity http) throws Exception {
        http.authorizeExchange() ①
                .anyExchange().authenticated() ②
                .and()
                .oauth2Login() ③
                .and()
                .oauth2Client(); ④
        return http.build();
    }
}
```

① Starting point for authorization rules (analogous to authorizeRequests in servlet world)

② Secure all client side endpoints

③ Add OAuth2/OIDC login feature

④ Add OAuth2/OIDC standard client feature

Run all the components

Finally start the two components:

- Run *LibraryServerApplication* class in project *05-oauth2/initial-library-server*
- Run *OAuth2LoginClientApplication* class in project *05-oauth2/initial-oauth2-login-client*

Now when you access localhost:8081/userinfo you should be redirected to the OKTA identity server. After logging in you should get the current authenticated user info back from identity server.

Here you can log in using one of these predefined users:

Table 8. User credentials

User	Password	Roles

user@example.com	Library_access#1	USER
admin@example.com	Library_access#2	USER, CURATOR, ADMIN
curator@example.com	Library_access#3	USER, CURATOR

You can now access localhost:8081/books as well. This returns the book list from the library-server (resource server).

You find the completed code in project *05-oauth2/oauth2-login-client* and *05-oauth2/oauth2-library-server*.

This concludes our Spring Security 5.1 hands-on workshop. I hope you learned a lot regarding security and especially Spring Security 5.1.

Chapter 6. Feedback

Please provide feedback for this workshop directly to organization of the Frankfurter Entwicklertag using the provided QR code.

If you have further feedback for this workshop, suggestions for improvements or you want me to conduct this workshop somewhere else please do not hesitate to contact me via

- Mail: andreas.falk@novatec-gmbh.de
- Twitter: @andifalk
- LinkedIn: andifalk

Thank YOU very much for being part of this workshop :-)

Appendix A: Online References

- OWASP Top 10 2017
- OWASP ProActive Controls 2018
- OWASP Testing Guide
- OAuth2 Specifications
- OpenID Connect 1.0 Specification
- Spring Boot 1.5 Reference Guide
- Spring Boot 2.1 Reference Guide
- Spring Security 4.x Reference Guide
- Spring Security 5.1 Reference Guide
- *Legacy* Spring Security OAuth Reference Guide
- *Legacy* Spring Security OAuth2 Boot Reference Guide
- Reactive Spring Security 5 Workshop Code

Appendix B: Book References

- Iron-Clad Java: Building Secure Web Applications (Oracle Press, ISBN: 978-0071835886)
- OAuth 2 in Action (Manning Publications, ISBN: 978-1617293276)
- Spring in Action 5th Edition (Manning Publications, ISBN: 978-1617294945