Securing Web Applications

Addressing Common Web Application Security Requirements

Objectives

After completing this lesson, you should be able to

- Explain basic security concepts
- Set up Spring Security in a Web environment
- Use Spring Security to configure Authentication and Authorization
- Define Method-level Security

ℹ See: Spring Security Reference
http://docs.spring.io/spring-security/site/docs/current/reference/htmlsingle/

Agenda

- **Security Overview**
- URL Authorization
- Configuring Web Authentication
- Method Security
- Lab
- Advanced Security

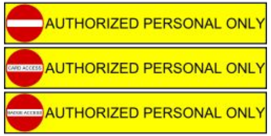
Security Concepts

- **Principal**
  - User, device or system that performs an action
- **Authentication**
  - Establishing that a principal's credentials are valid
- **Authorization**
  - Deciding if a principal is allowed to perform an action
- **Authority**
  - Permission or credential enabling access (such as a role)
- **Secured Resource**
  - Resource that is being secured

Authentication

- There are many authentication mechanisms
  - *Examples:* Basic, Digest, Form, X.509, OAuth
- There are many storage options for credential and authority data
  - *Examples:* in-memory (development), Database, LDAP

Authorization



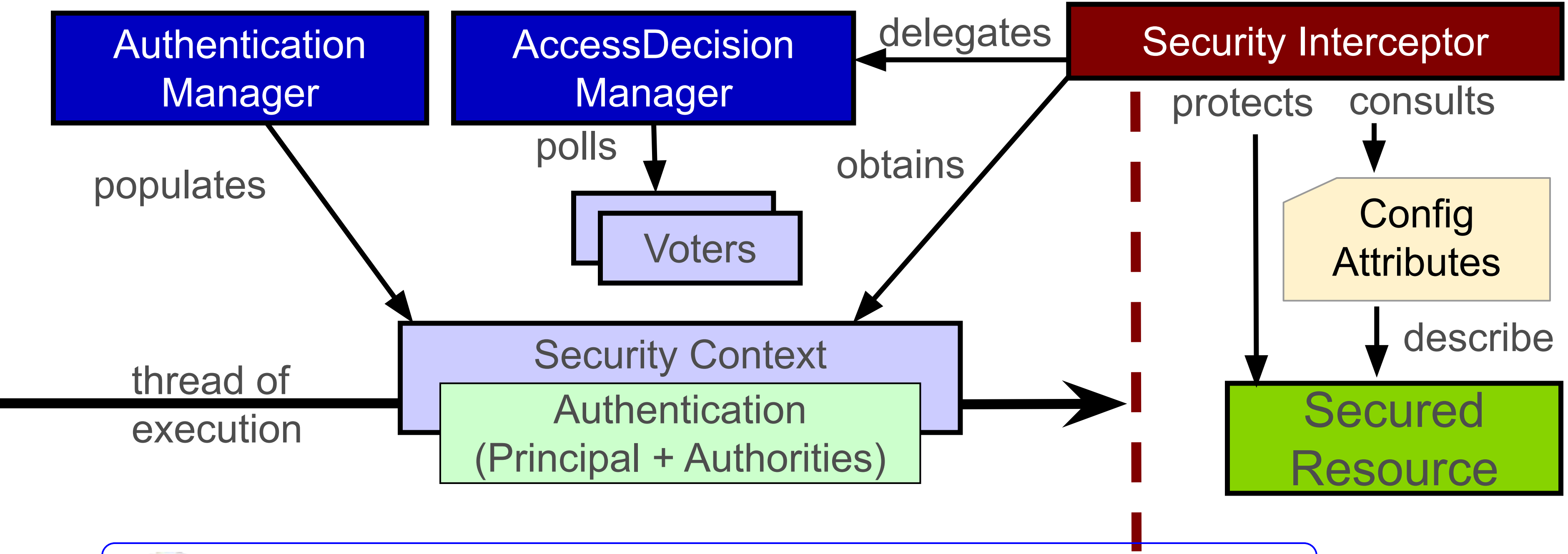
- Authorization depends on authentication
  - Before deciding if a user is permitted to perform an action, user identity must be established
- Authorization determines if you have the required *Authority*
- The decision process is often based on roles
  - *ADMIN* role can cancel orders
  - *MEMBER* role can place orders
  - *GUEST* role can browse the catalog

A *Role* is simply a commonly used type of *Authority.*

Spring Security Project

- **Portable**
  - Secured archive (JAR, WAR, EAR) can be deployed as-is
- **Separation of Concerns**
  - Business logic is *decoupled* from security concern
  - Authentication and Authorization are *decoupled*
    - Changes to authentication have *no impact* on authorization
- **Flexible & Extensible**
  - *Authentication:* Basic, Form, X.509, OAuth, Cookies, Single-Sign-On, …
  - *Storage:* LDAP, RDBMS, Properties file, custom DAOs, …
  - Highly customizable

Spring Security – the Big Picture



https://spring.io/guides/topicals/spring-security-architecture

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Setup and Configuration

Spring Security in a Web Environment

Three steps

1. Setup Filter chain (Spring Boot does this for you)
2. Configure security (authorization) rules
3. Setup Web Authentication

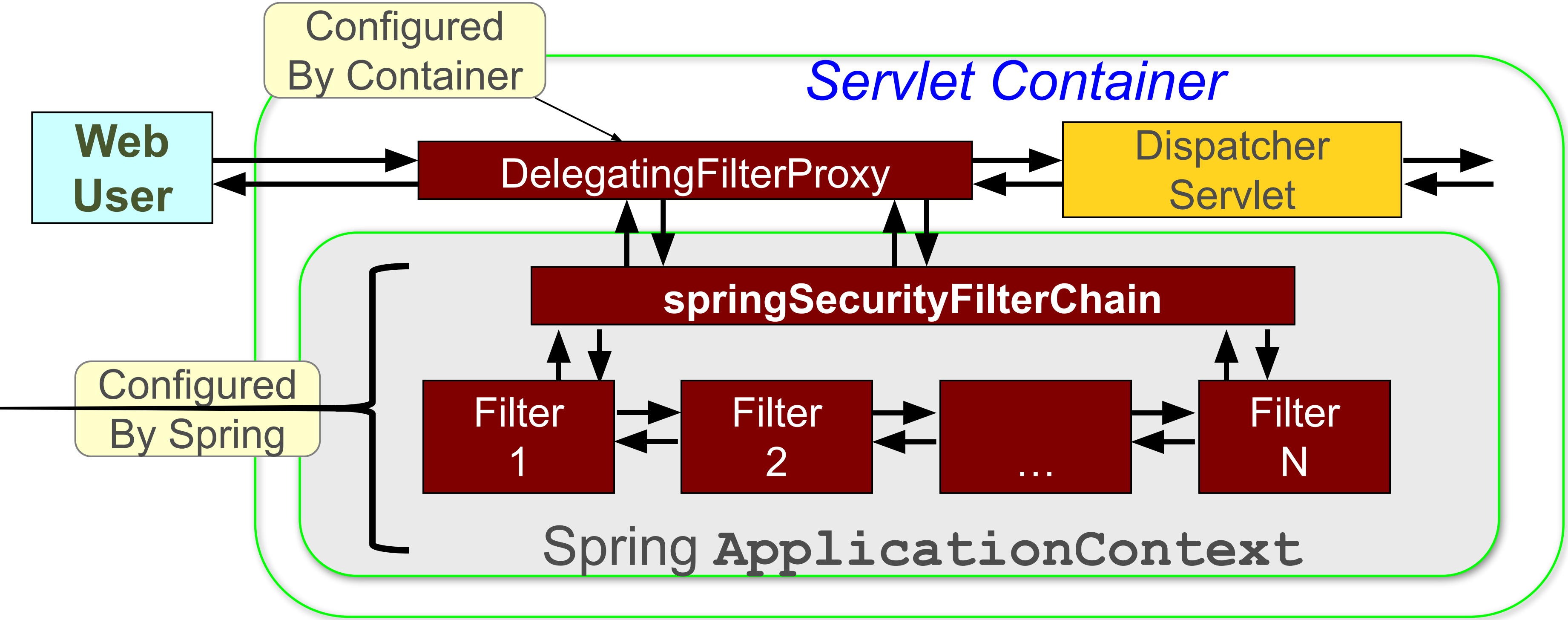
ℹ Spring Security is **not** limited to Web security, but that is all we will consider here, and it is configurable "out-of-the-box"

Spring Security Filter Chain – 1

- Implementation is a *chain* of Spring configured *filters*
  - Requires a **`DelegatingFilterProxy`** which *must* be called *springSecurityFilterChain*
  - Chain consists of many filters (next slide)
- Set up security filter chain using *one* of these options
  - Spring Boot does it automatically
  - Or subclass **`AbstractSecurityWebApplicationInitializer`**
  - Or declare as a **`<filter>`** in **`web.xml`**

For more details (and non-Boot examples) see “*Advanced security: working with filters*” at end of this topic.

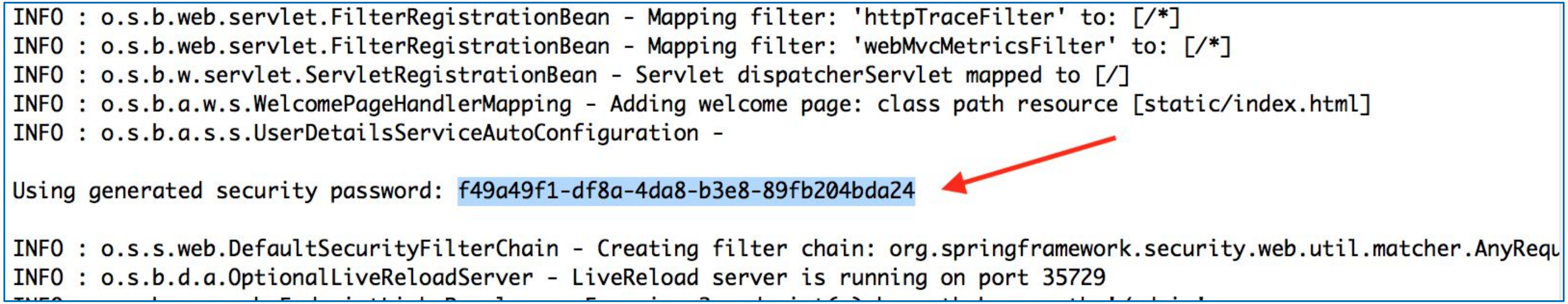
Spring Security Filter Chain – 2



🟥 *All* implement `javax.servlet.Filter`

Spring Boot Default Security Setup

- Sets up a single in-memory user called “user”
- Auto-generates a UUID password
- Relies on Spring Security’s content-negotiation strategy to determine whether to use httpBasic or formLogin
- All URLs require a logged-in user



```
INFO : o.s.b.web.servlet.FilterRegistrationBean - Mapping filter: 'httpTraceFilter' to: [/*]
INFO : o.s.b.web.servlet.FilterRegistrationBean - Mapping filter: 'webMvcMetricsFilter' to: [/*]
INFO : o.s.b.w.servlet.ServletRegistrationBean - Servlet dispatcherServlet mapped to [/]
INFO : o.s.b.a.w.s.WelcomePageHandlerMapping - Adding welcome page: class path resource [static/index.html]
INFO : o.s.b.a.s.s.UserDetailsServiceAutoConfiguration -

Using generated security password: f49a49f1-df8a-4da8-b3e8-89fb204bda24

INFO : o.s.s.web.DefaultSecurityFilterChain - Creating filter chain: org.springframework.security.web.util.matcher.AnyRequ
INFO : o.s.b.d.a.OptionalLiveReloadServer - LiveReload server is running on port 35729
```

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- Security Overview
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- Method Security
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- Advanced Security

Configuration in the Application Context

```
@EnableWebSecurity
public class SecurityConfig extends WebSecurityConfigurerAdapter {

   @Override
   protected void configure(HttpSecurity http) throws Exception {

   }

   @Autowired
   public void configureGlobal(AuthenticationManagerBuilder auth)
            throws Exception {

   }
}
```

Extend **`WebSecurityConfigurerAdapter`**

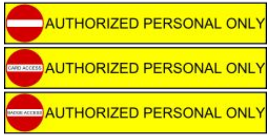
Optional for Spring Boot applications

Web-specific security settings

Global security settings (authentication manager, ...)

Note: @Autowired

Authorizing URLs



- Define specific authorization restrictions for URLs
- Support “*Ant-style*” pattern matching
  - `"/admin/*"` only matches `"/admin/xxx"`
  - `"/admin/**"` matches *any* path under `/admin`
    - Such as `"/admin/database/access-control"`

```
protected void configure(HttpSecurity http) throws Exception {
     http.authorizeRequests()
          .mvcMatchers("/admin/**").hasRole("ADMIN")
          …
}
```

Match *all* URLs starting with **/admin** (ANT-style path)

User must have **ADMIN** role

More on `authorizeRequests()`

- *Chain* multiple restrictions - evaluated in the order listed
  - First match is used, *put specific matches first*

```
protected void configure(HttpSecurity http) throws Exception {
  http
    .authorizeRequests()
       .mvcMatchers("/signup", "/about").permitAll()
       .mvcMatchers("/accounts/edit*").hasRole("ADMIN")
       .mvcMatchers("/accounts/**").hasAnyRole("USER",”ADMIN”)
       .anyRequest().authenticated();
```

Must be authenticated for any other request

Spring Security supports *roles* out-of-the-box – but *there are **no** predefined roles.*

Warning: URL Matching

- Older code may use **`antMatchers`**

```
http.authorizeRequests()
    // Only matches /admin
    .antMatchers("/admin").hasRole("ADMIN")
    // Matches /admin, /admin/, /admin.html, /admin.xxx
    .mvcMatchers("/admin").hasRole("ADMIN")
```

They look identical
– but are **not**

- Use **`mvcMatchers`**
  - Uses same matching rules as **`@RequestMapping`**
  - Newer API, less error-prone, *recommended*

RECOMMENDED
RECOMMENDED
RECOMMENDED

By-passing Security

- Some URLs need not be secured (such as static resources)
  - `permitAll()` allows open-access
    - But still processed by Spring Security
- Can by-pass Security completely

Different `configure()` method than earlier

```
@Configuration
@EnableWebSecurity
public class SecurityConfig extends WebSecurityConfigurerAdapter {
   @Override
   protected void configure(WebSecurity web) throws Exception {
      web.ignoring().mvcMatchers("/css/**", "/images/**", "/javascript/**");
   }
```

These URLs pass straight through, no checks

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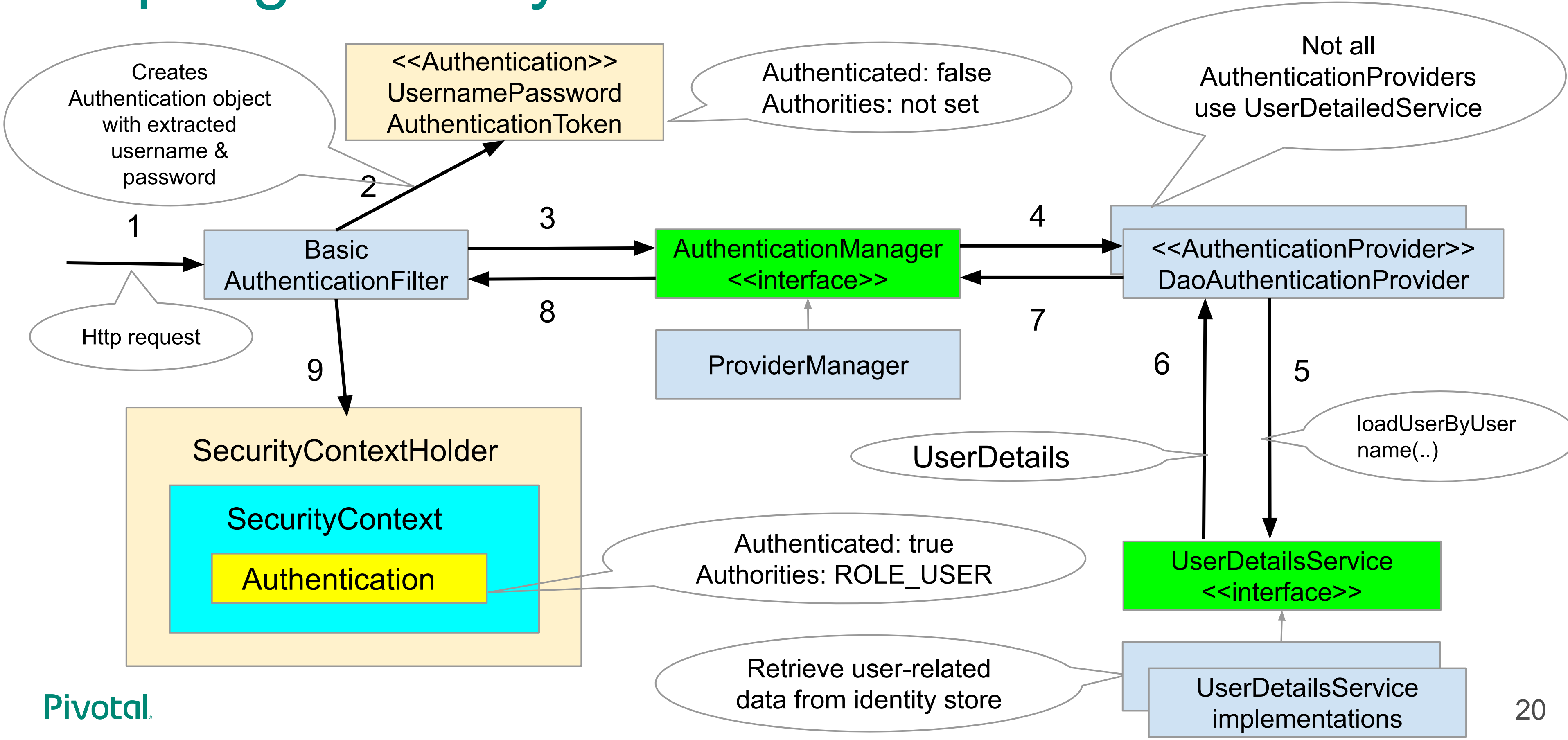
Spring Security Authentication Flow


Creates Authentication object with extracted username & password
<<Authentication>> UsernamePassword AuthenticationToken
Authenticated: false
Authorities: not set
Not all AuthenticationProviders use UserDetailedService
1
2
3
4
Http request
Basic AuthenticationFilter
AuthenticationManager <<interface>>
<<AuthenticationProvider>> DaoAuthenticationProvider
8
7
ProviderManager
9
6
5
loadUserByUsername(..)
UserDetails
SecurityContextHolder
SecurityContext
Authentication
Authenticated: true
Authorities: ROLE_USER
UserDetailsService <<interface>>
Retrieve user-related data from identity store
UserDetailsService implementations

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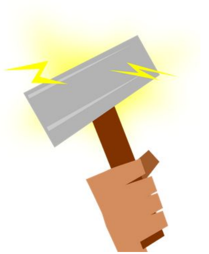
In-Memory Authentication Manager



- Example of a built-in **`UserDetailsService`**
  - **`configureGlobal()`** – security for *whole* application
  - Can be shared by web and method security

Not web-specific

```
@Autowired
public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {
    PasswordEncoder passwordEncoder =
        PasswordEncoderFactories.createDelegatingPasswordEncoder();
    auth
      .inMemoryAuthentication()
        .withUser("thor").password(passwordEncoder.encode(”hammer")).roles("SUPPORT").and()
        .withUser("loki").password(passwordEncoder.encode(”trouble")).roles("USER").and()
        .withUser("odin").password(passwordEncoder.encode(”king")).roles("ADMIN");
}
```

Returns a *UserDetailsManagerConfigurer*

login

password

Supported roles

Sourcing Users from a Database – 1

```
private DataSource dataSource;

@Autowired
public void setDataSource(DataSource dataSource) throws Exception {
    this.dataSource = dataSource;
}

@Autowired
public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {
    auth.jdbcAuthentication().dataSource(dataSource);
}
```

Can customize queries using methods:

```
usersByUsernameQuery(<custom-query>)
authoritiesByUsernameQuery(<custom-query>)
groupAuthoritiesByUsername(<custom-query>)
```

Sourcing Users from a Database – 2

Queries RDBMS for users and their authorities

- Provides default queries
  - SELECT username, password, enabled FROM users WHERE username = ?
  - SELECT username, authority FROM authorities WHERE username = ?
- Groups also supported
  - **`groups`**, **`group_members`**, **`group_authorities`** tables
  - See online documentation for details

Password Encoding – 1

Note: *sha* and *md5* only suitable for testing – too insecure

- Can encode passwords using a *one-way* hash
  - sha256, bcrypt, (sha, md5, …)
  - Use with *any* authentication mechanism

```
auth.inMemoryAuthentication()
    .passwordEncoder(new StandardPasswordEncoder());
```

SHA-256 by default

- Add a “salt” string to make encryption stronger
  - Salt prepended to password before hashing

```
auth.jdbcAuthentication().dataSource(dataSource)
    .passwordEncoder(new StandardPasswordEncoder(“Spr1nGi$Gre@t”));
```

Encoding with a 'salt' string

Password Encoding – 2

`BCryptPasswordEncoder` is recommended – uses Blowfish

- BCrypt is recommended over SHA-256
  - Secure passwords further by specifying a “strength” (N)
  - Internally the hash is rehashed 2^N times, default is 2^{10}

```
auth...passwordEncoder(new BCryptPasswordEncoder(12));
```

Encoding using '*strength*' 12

- Store *only* encrypted passwords

```
 auth.inMemoryAuthentication().withUser("hughie")
    .password("$2a$10$aMxNkanIJ...lEuylt87PNlicYpI1y.lG0C.")
    .roles("GENERAL")
```

Challenges of Password Encoding Schemes

- Should be future-proof
  - Encoding schemes that are considered secure today will not provide the same level of security in the future
  - New encoding schemes will emerge in the future

- Should accommodate old password formats
  - Old format passwords should be able to used with no/minimum effort

- Should allow usage of multiple password formats
  - Old and new format passwords should be able to co-exist

Spring Security framework should address these challenges.

DelegatingPasswordEncoder to the Rescue

- Introduced in Spring Security 5 (and Spring Boot 2)
- Uses new password storage format: *{id}encodedPassword*
  - {id} represents a logical name of a specific encoder
- Delegates to another PasswordEncoder based upon a prefixed id
- Uses BCrypt as a default “best practice” encoding scheme for now

```
@Autowired
public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {
    PasswordEncoder passwordEncoder =
         PasswordEncoderFactories.createDelegatingPasswordEncoder();
    auth
        .inMemoryAuthentication()
            .withUser("thor").password(passwordEncoder.encode(”hammer")).roles("SUPPORT");
}
```

```
Generates {bcrypt}$2a$10$dXJ3SW6G7P50lGmMkkmwe.20cQQubK3.HZWzG3YB1tlRy.fqvM/BG
```

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Enabling HTTP Authentication - 1

- Use the **`HttpSecurity`** object again
  - *Example:* HTTP Basic

```
protected void configure(HttpSecurity http) throws Exception {
  http
    .authorizeRequests()
        .mvcMatchers("/admin/**").hasRole("ADMIN")
        .mvcMatchers("/accounts/**").hasAnyRole("USER",”ADMIN”)
    .and()
       .httpBasic();                          //  Enable HTTP Basic
}
```

Browser will prompt for username & password

Enabling HTTP Authentication - 2

Form based login

```
protected void configure(HttpSecurity http) throws Exception {
  http
    .authorizeRequests()
      .mvcMatchers("/admin/**").hasRole("ADMIN")...
      .and()                                  //  method chaining!

    .formLogin()                              //  setup form-based authentication
      .loginPage("/login")                    //  URL to use when login is needed
      .permitAll()                            //  any user can access
      .and()                                  //  method chaining!

    .logout()                                 //  configure logout
      .logoutSuccessUrl("/home")              //  go here after successful logout
      .permitAll();                           //  any user can access
}
```

Default: `/login?logout`

An Example Login Page

URL that indicates an authentication request.
Default: POST to same URL used to display the form.

```
<form action="/login" method="POST">
   <input type="text" name="username"/>
   <br/>
   <input type="password" name="password"/>
   <br/>
   <input type="submit" name="submit" value="LOGIN"/>
</form>
```

login.html

The expected keys for generation of an authentication request token

Other Authentication Options

- Implement a custom **`UserDetailsService`**
  - Delegate to an existing User repository or DAO
- LDAP (via **`LdapAuthenticationProvider)`**
- X.509 Certificates
- JAAS Login Module
- Single-Sign-On
  - OAuth, SAML
  - CA SSO (SiteMinder), Kerberos
  - JA-SIG Central Authentication Service (CAS)

Authorization is *not* affected by changes to Authentication!

Agenda

- Security Overview
- URL Authorization
- Configuring Web Authentication
- **Method Security**
- Lab
- Advanced Security

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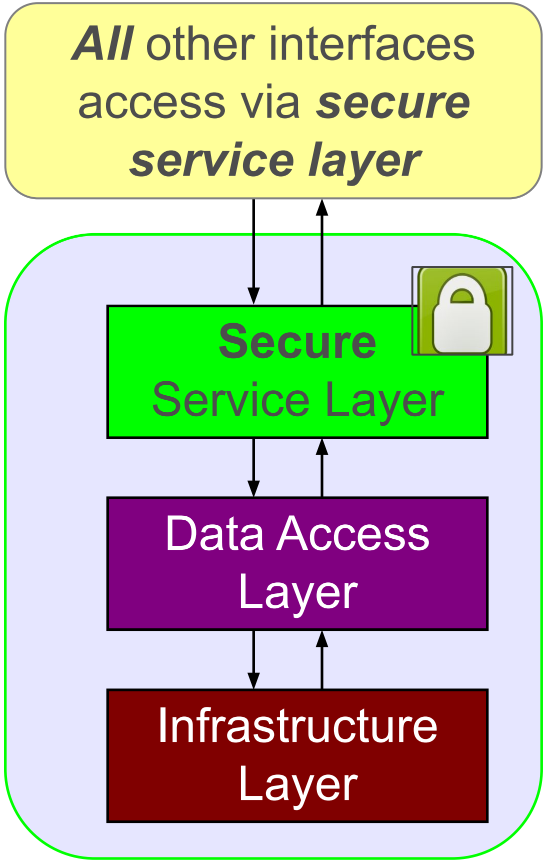
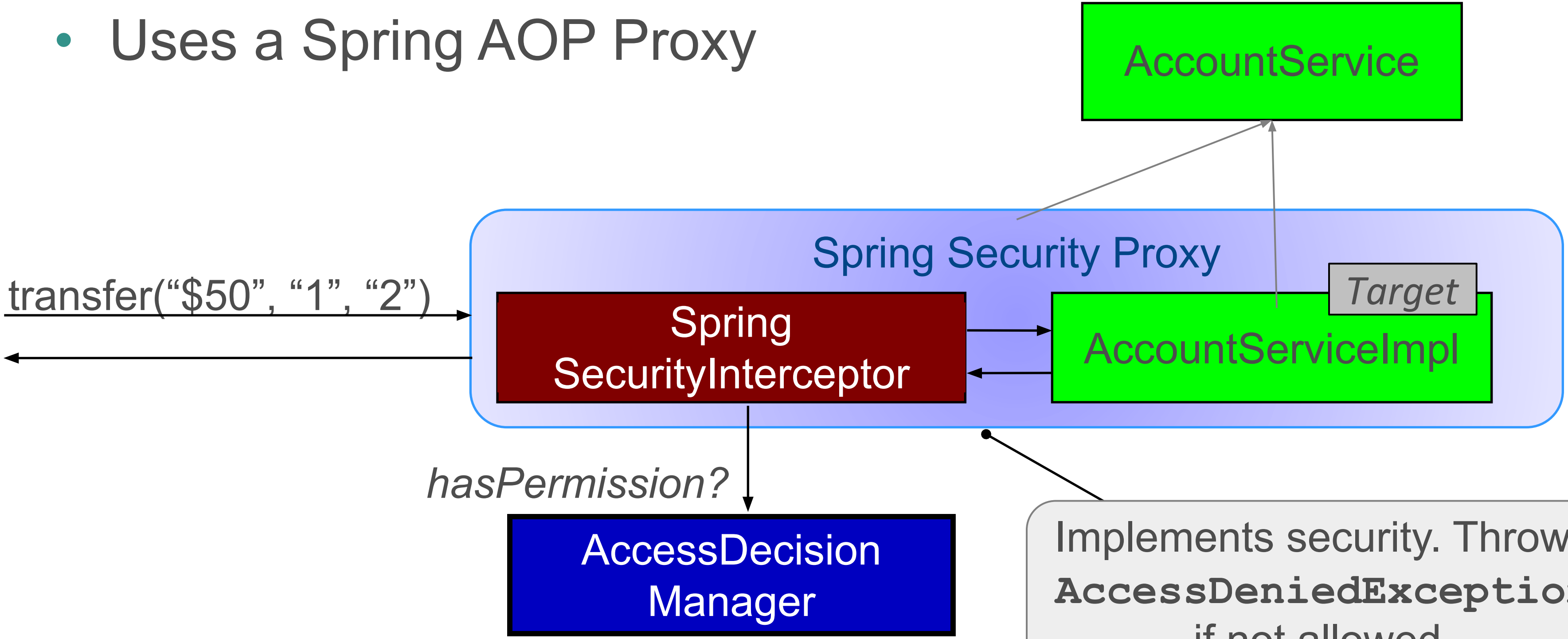
Method Security

- Spring Security uses AOP for method-level security
  - Annotations: either Spring's own or JSR-250
- Recommendation:
  - Secure your services
  - Do *not* access other layers directly
    - Bypasses security (and probably transactions) on your service layer


All other interfaces access via ***secure service layer***
Secure Service Layer
Data Access Layer
Infrastructure Layer

Method Security – How it Works

- Uses a Spring AOP Proxy



Implements security. Throws `AccessDeniedException` if not allowed.

Method Security - JSR-250

JSR-250 annotations must be enabled

- Only supports **role-based** security (hence the name)

```
@EnableGlobalMethodSecurity(jsr250Enabled=true)
```

```
import javax.annotation.security.RolesAllowed;

public class ItemManager {
  @RolesAllowed("ROLE_MEMBER")
  public Item findItem(long itemNumber) {
     ...
  }
}
```

Can also place at class level

```
@RolesAllowed({"ROLE_MEMBER", "ROLE_USER"})
```

Internally role authorities are stored with **`ROLE_`** prefix. APIs seen previously hide this. Here you *must* use full name

Method Security with SpEL

- Use Pre/Post annotations for SpEL

```
@EnableGlobalMethodSecurity(prePostEnabled=true)
```

```
import org.springframework.security.annotation.PreAuthorize;

public class ItemManager {
   // Members may only find their own order items
   @PreAuthorize("hasRole('MEMBER')   &&  " +
                                 "#order.owner.id == principal.user.id")
   public Item findItem(Order order, long itemNumber) {
      ...
   }
}
```

Full role-names *not* required. **`ROLE_`** prepended automatically.

Summary

- Spring Security
  - Secure URLs using a chain of Servlet filters
  - And/or methods on Spring beans using AOP proxies
- Out-of-the-box setup usually sufficient – you define:
  - URL and/or method restrictions
  - How to login (typically using an HTML form)
  - Supports in-memory, database, LDAP credentials (and more)
  - Password encryption using familiar hashing techniques

Lab: Securing a RESTful application

Lab project:
40-security

Anticipated Lab time:
20 Minutes

Optional Topics: Filter Details, Configuration Choices, Legacy Apps

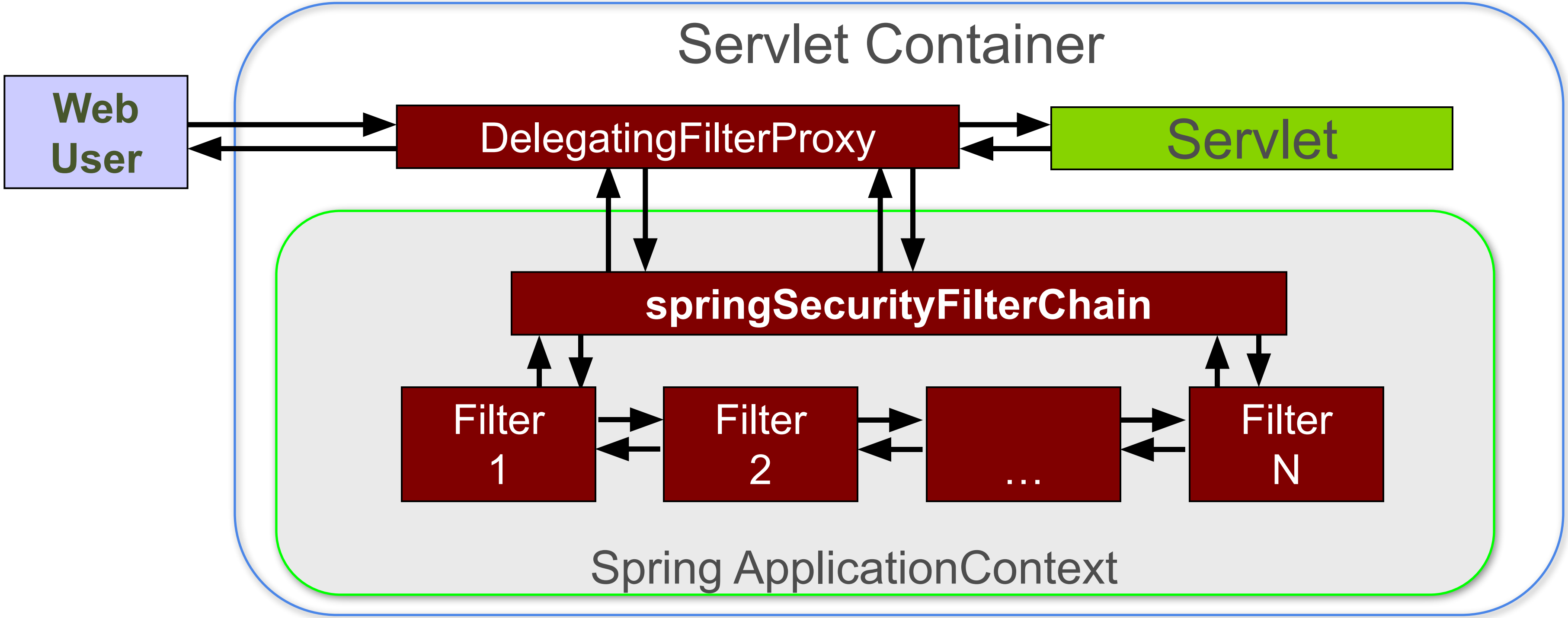
Agenda

- Security Overview
- URL Authorization
- Configuring Web Authentication
- Method Security
- Lab
- **Advanced Security**
  - **Working with Filters**
  - Configuration Choices
  - Legacy Applications

Spring Security in a Web Environment

- *SpringSecurityFilterChain*
  - **Always** first filter in chain
- This single proxy filter delegates to a chain of Spring-managed filters to:
  - Drive authentication
  - Enforce authorization
  - Manage logout
  - Maintain SecurityContext in HttpSession
  - and more

Web Security Filter Configuration

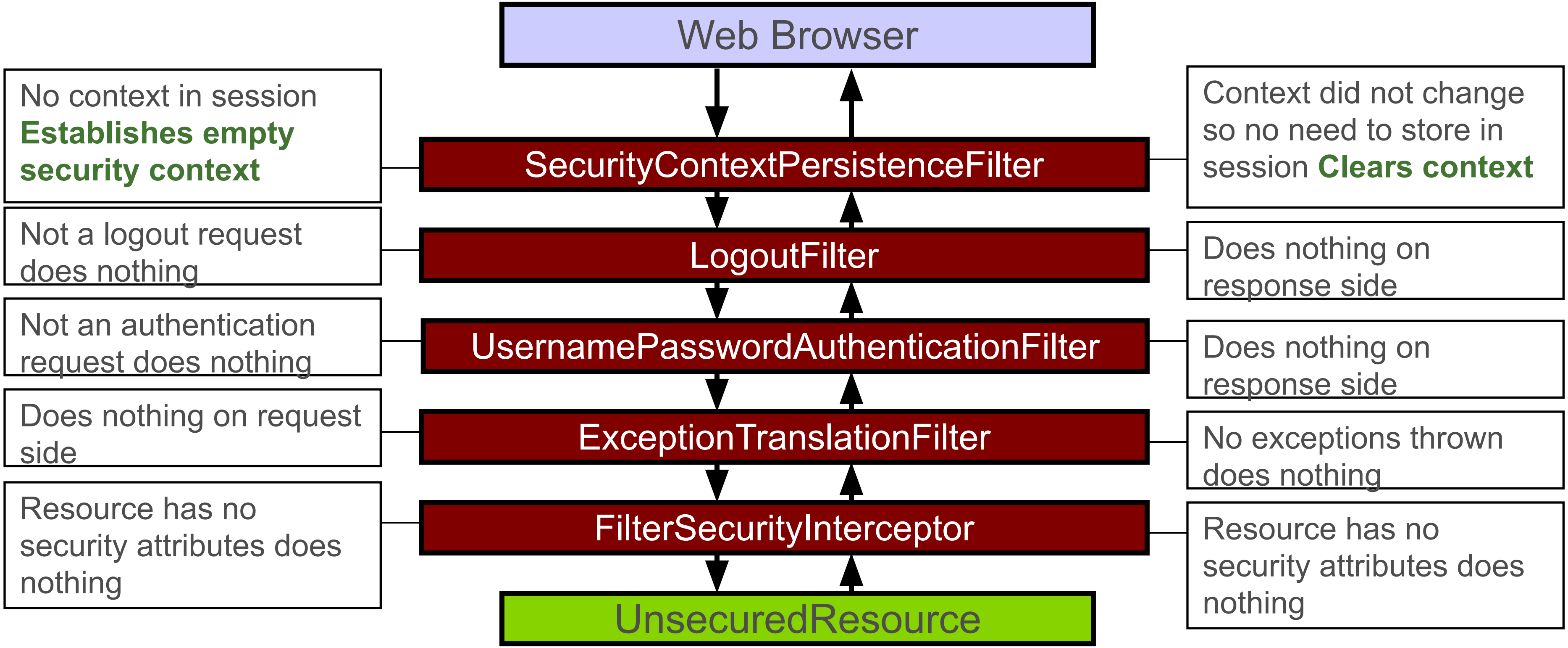


The Filter Chain

- Spring Security uses a chain of many, many filters
  - Filters initialized with correct values by default
  - Manual configuration is not required **unless you want to customize Spring Security's behavior**
  - It is still important to understand how they work underneath

Spring Security originally developed independently of Spring – called *ACEGI Security* and involved far more manual configuration

Access Unsecured Resource Prior to Login



Web Browser

No context in session **Establishes empty security context**

SecurityContextPersistenceFilter

Context did not change so no need to store in session **Clears context**

Not a logout request does nothing

LogoutFilter

Does nothing on response side

Not an authentication request does nothing

UsernamePasswordAuthenticationFilter

Does nothing on response side

Does nothing on request side

ExceptionTranslationFilter

No exceptions thrown does nothing

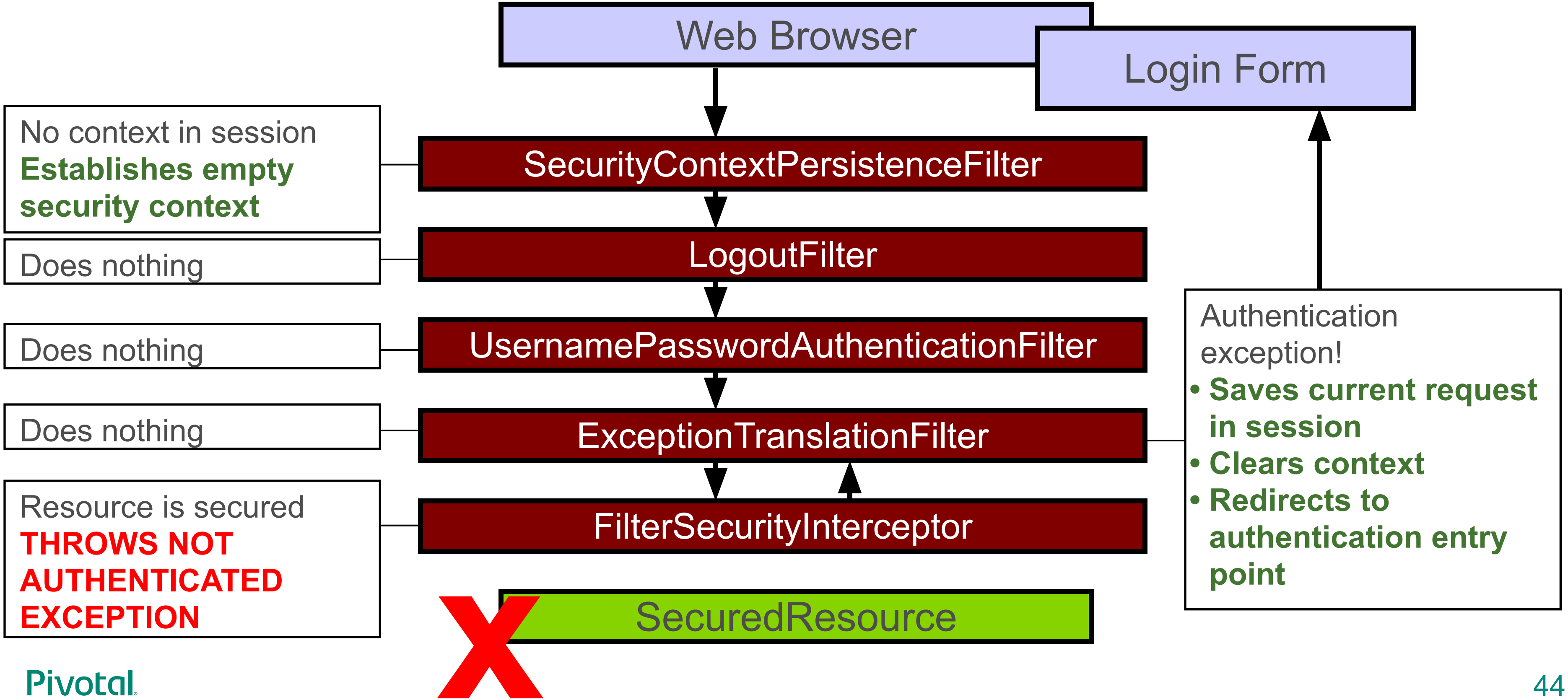
Resource has no security attributes does nothing

FilterSecurityInterceptor

Resource has no security attributes does nothing

UnsecuredResource

Access Secured Resource Prior to Login



No context in session
Establishes empty security context

Does nothing

Does nothing

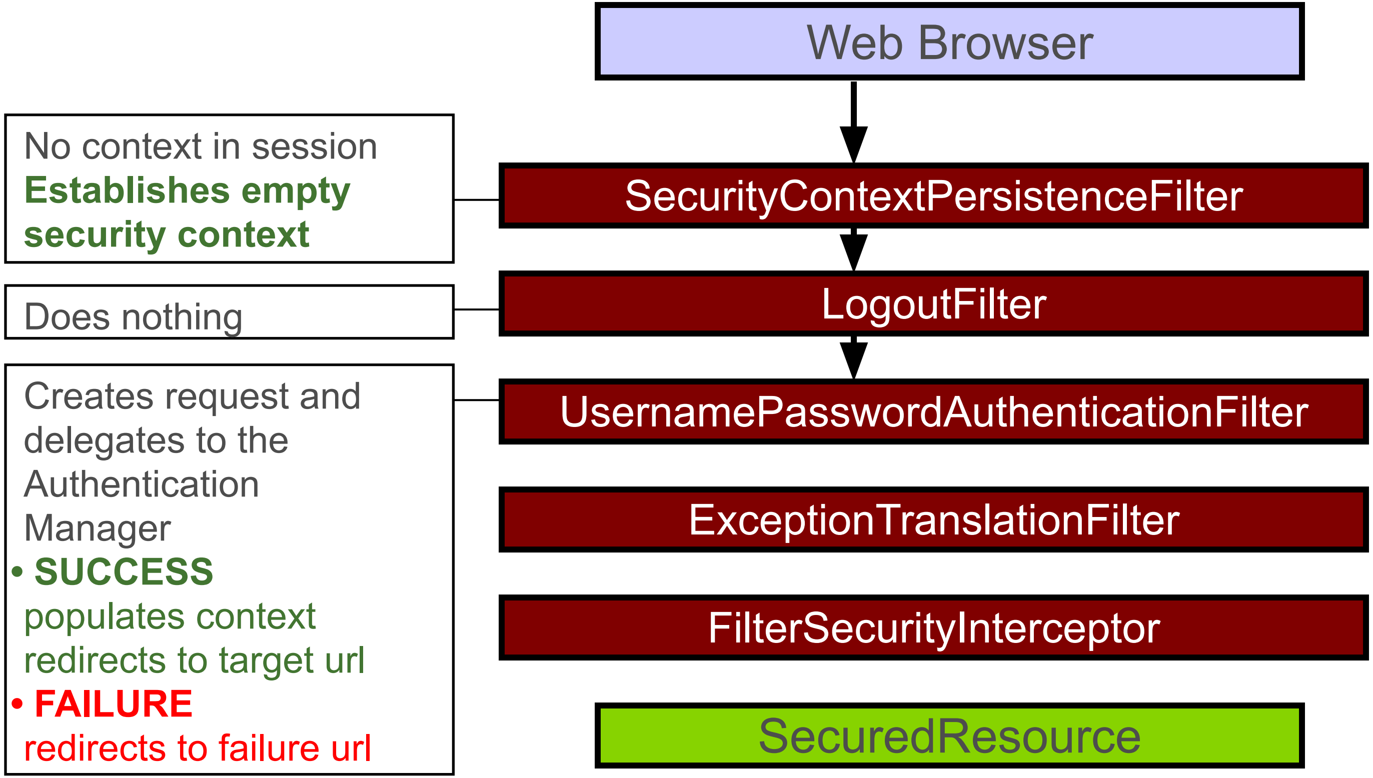
Does nothing

Resource is secured
THROWS NOT AUTHENTICATED EXCEPTION

Authentication exception!
- **Saves current request in session**
- **Clears context**
- **Redirects to authentication entry point**

Web Browser
Login Form
SecurityContextPersistenceFilter
LogoutFilter
UsernamePasswordAuthenticationFilter
ExceptionTranslationFilter
FilterSecurityInterceptor
SecuredResource

Submit Login Request



No context in session
Establishes empty security context

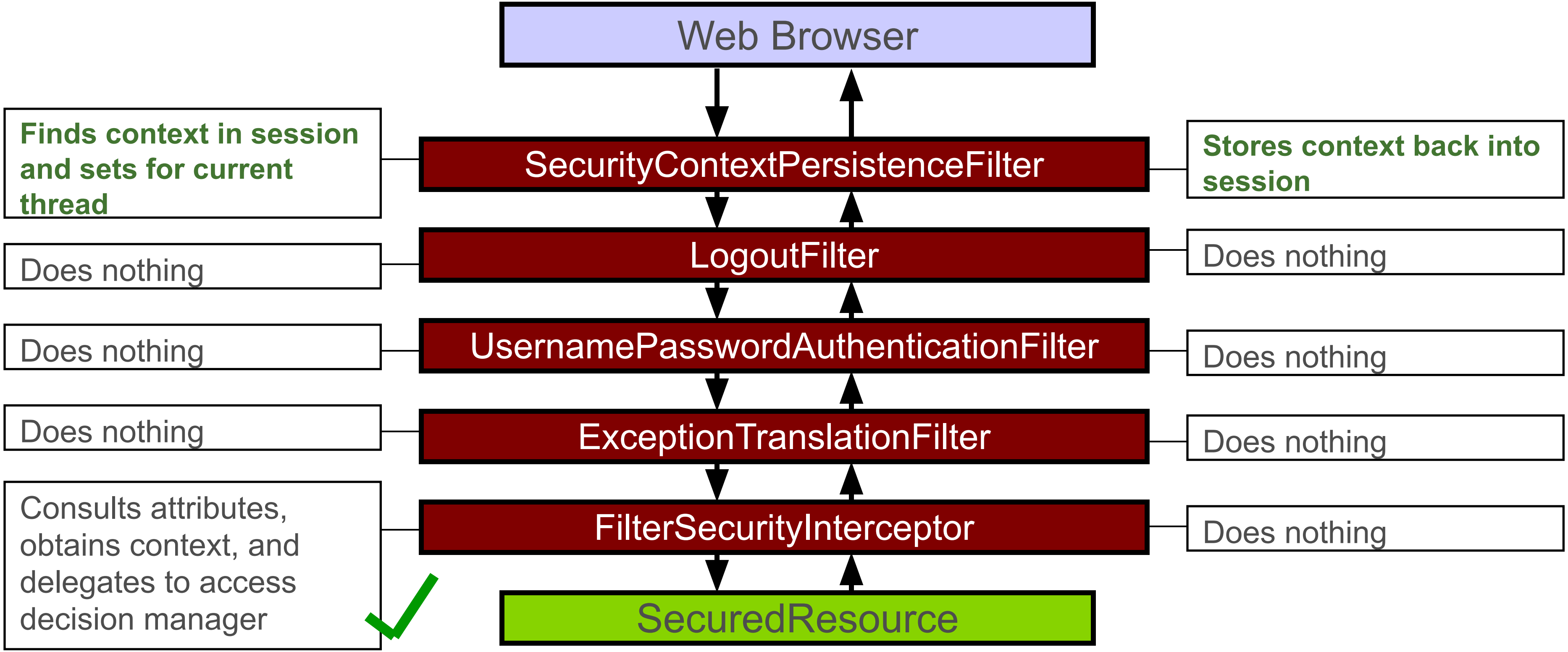
Does nothing

Creates request and delegates to the Authentication Manager

- **SUCCESS**
  populates context
  redirects to target url
- **FAILURE**
  redirects to failure url

Web Browser
SecurityContextPersistenceFilter
LogoutFilter
UsernamePasswordAuthenticationFilter
ExceptionTranslationFilter
FilterSecurityInterceptor
SecuredResource

Access Resource With Required Role



Web Browser

Finds context in session and sets for current thread | SecurityContextPersistenceFilter | **Stores context back into session**

Does nothing | LogoutFilter | Does nothing

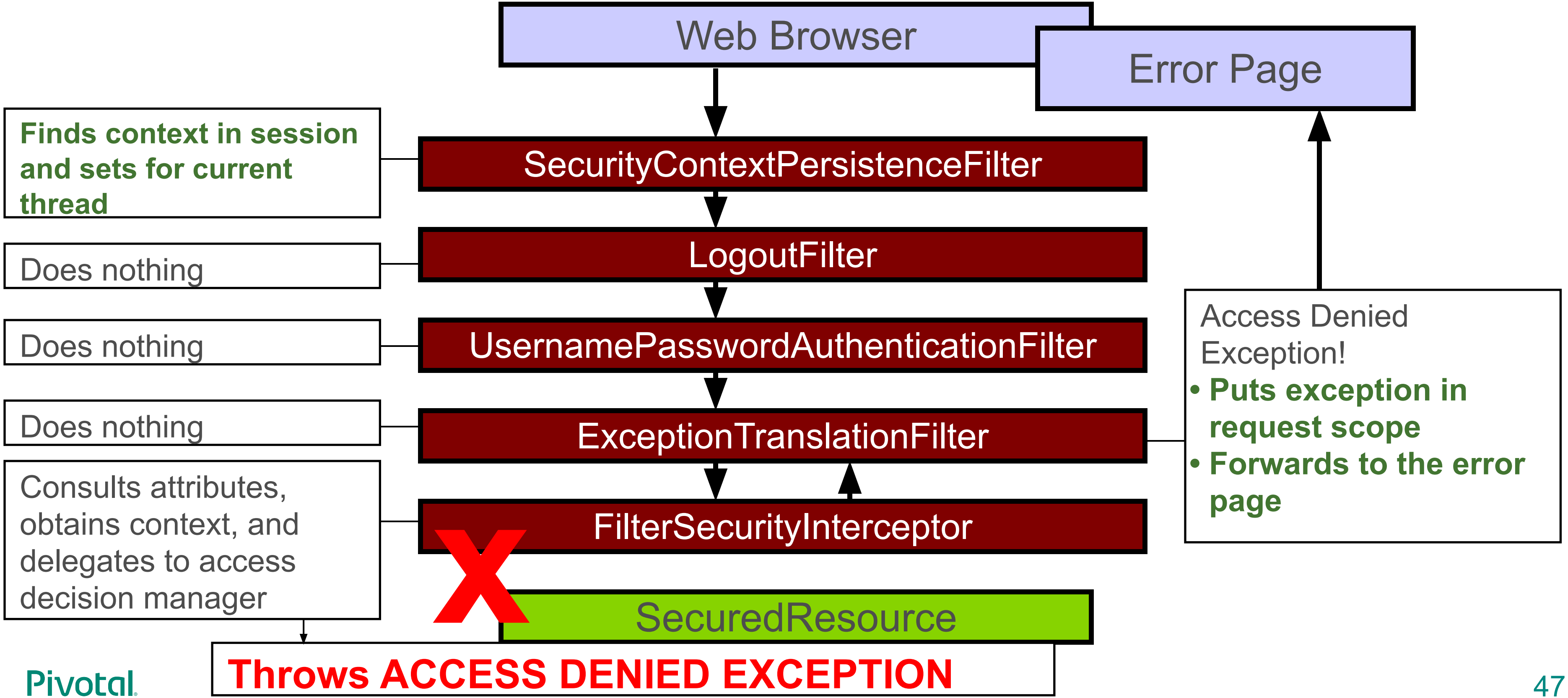
Does nothing | UsernamePasswordAuthenticationFilter | Does nothing

Does nothing | ExceptionTranslationFilter | Does nothing

Consults attributes, obtains context, and delegates to access decision manager ✓ | FilterSecurityInterceptor | Does nothing

SecuredResource

Access Resource Without Required Role



Web Browser

Error Page

SecurityContextPersistenceFilter

Finds context in session and sets for current thread

LogoutFilter

Does nothing

UsernamePasswordAuthenticationFilter

Does nothing

ExceptionTranslationFilter

Does nothing

FilterSecurityInterceptor

Consults attributes, obtains context, and delegates to access decision manager

SecuredResource

Throws ACCESS DENIED EXCEPTION

Access Denied Exception!

- **Puts exception in request scope**
- **Forwards to the error page**

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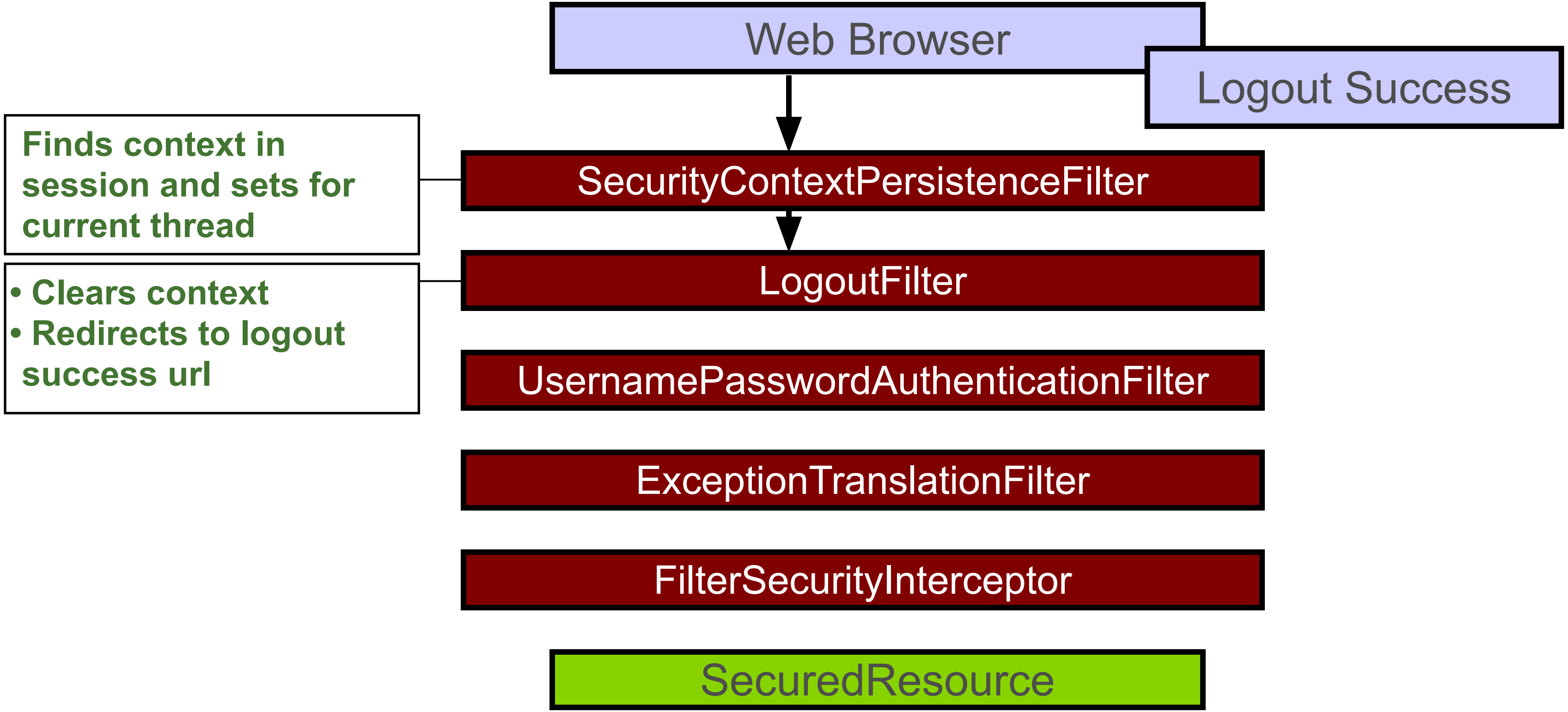
Submit Logout Request


Web Browser
Logout Success
SecurityContextPersistenceFilter
LogoutFilter
UsernamePasswordAuthenticationFilter
ExceptionTranslationFilter
FilterSecurityInterceptor
SecuredResource

Finds context in session and sets for current thread

- Clears context
- Redirects to logout success url

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The Filter Chain: Summary

#	Filter Name	Main Purpose
1	`SecurityContext PersistenceFilter`	Establishes SecurityContext and maintains between HTTP requests
2	`LogoutFilter`	Clears SecurityContextHolder when logout requested
3	`UsernamePassword AuthenticationFilter`	Puts Authentication into the SecurityContext on login request.
4	`Exception TranslationFilter`	Converts SpringSecurity exceptions into HTTP response or redirect
5	`FilterSecurity Interceptor`	Authorizes web requests based on on config attributes and authorities

Custom Filter Chain – Replace Filter

- Filters can be **replaced** in the chain
  - Replace an existing filter with your own
    - Replacement must *extend* the filter being replaced

```
public class MyCustomLoginFilter
  extends UsernamePasswordAuthenticationFilter {}
```

```
@Bean
public Filter loginFilter() {
    return new MyCustomLoginFilter();
}
```

```
http.addFilter ( loginFilter() );
```

Custom Filter Chain – Add Filter

- Filters can be **added** to the chain
  - *After* any filter

```
public class MyExtraFilter implements Filter { ... }
```

```
@Bean
public Filter myExtraFilter() {
    return new MyExtraFilter();
}
```

```
http.addFilterAfter ( myExtraFilter(),
                  UsernamePasswordAuthenticationFilter.class );
```

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- **Advanced Security**
  - Working with Filters
  - **Configuration Choices**
  - Legacy Applications

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Configuration Choices

1. Add an autowired method to your security configuration
   - As shown in these slides: **`configureGlobal(...)`**
2. Override **`WebSecurityConfigurerAdapter`**'s **`configure(AuthenticationManagerBuilder auth)`**
   - Defines users/roles for web-configuration *only*,
   - Users *would not* be recognized by method security
3. Extend **`GlobalAuthenticationConfigurerAdapter`**
   - Equivalent to option 1, more control
   - Can setup *multiple* authentication schemes

`@Profile` with Security Configuration

```
public class SecurityBaseConfig extends WebSecurityConfigurerAdapter {
  protected void configure(HttpSecurity http) throws Exception {
    http.authorizeRequests().mvcMatchers("/resources/**").permitAll();
  }
}
```

```
@Configuration
@EnableWebSecurity
@Profile(“development”)
public class SecurityDevConfig extends SecurityBaseConfig {
  @Autowired
  public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {
     auth.inMemoryAuthentication()
           .withUser("hughie").password("hughie").roles("GENERAL");
  }
}
```

Use in-memory provider

@Profile with Security Configuration

```
public class SecurityBaseConfig extends WebSecurityConfigurerAdapter {
  protected void configure(HttpSecurity http) throws Exception {
    http.authorizeRequests().mvcMatchers("/resources/**").permitAll();
  }
}
```

```
@Configuration
@EnableWebSecurity
@Profile(“!development”)
public class SecurityProdConfig extends SecurityBaseConfig {
  @Autowired
  public void configureGlobal(AuthenticationManagerBuilder auth) throws Exception {
      auth.jdbcAuthentication().dataSource(dataSource);
  }
}
```

Use database provider

Use this profile when “development” *not* defined

Agenda

- Security Overview
- URL Authorization
- Configuring Web Authentication
- Method Security
- Lab
- **Advanced Security**
  - Working with Filters
  - Configuration Choices
  - **Legacy Applications**

Pivotal

Configuration without Spring Boot

Servlet 2 using ***web.xml***

- Define the DelegatingFilterProxy

This name is mandatory - delegates to a Spring bean with *same* name

```
<filter>
   <filter-name>springSecurityFilterChain</filter-name>
   <filter-class>
       org.springframework.web.filter.DelegatingFilterProxy
   </filter-class>
</filter>

<filter-mapping>
   <filter-name>springSecurityFilterChain</filter-name>
   <url-pattern>/*</url-pattern>
</filter-mapping>
```

web.xml

Configuration without Spring Boot

Servlet 3 WebApplicationInitializer

- Declare your own subclass of **`AbstractSecurityWebApplicationInitializer`**
  - Sets up the **`DelegatingFilterProxy`**
  - Automatically called by Spring because it implements **`WebApplicationInitializer`**

```
import org.springframework.security.web.
      context.AbstractSecurityWebApplicationInitializer;

public class SecurityWebApplicationInitializer
      extends AbstractSecurityWebApplicationInitializer {
}
```

Class is meant to be empty – nothing else is required

Method Security - @Secured

You may see this in older applications

```
@EnableGlobalMethodSecurity(securedEnabled=true)
```

Annotation must be enabled

```
import org.springframework.security.annotation.Secured;

public class ItemManager {
  @Secured("IS_AUTHENTICATED_FULLY")
  public Item findItem(long itemNumber) {
     ...
  }
}
```

Can also place at class level

```
@Secured("ROLE_MEMBER")
@Secured({"ROLE_MEMBER", "ROLE_USER"})
```

*Spring 2.0 syntax, **not** limited to roles. But SpEL **not** supported.*