User Details

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Chapter 1. Introduction

In previous sections we looked closely at how to authenticate a user obtained from a demonstration user source. The focus was on the obtained user and the processing that went on around it to enforce authentication using an example credential mechanism. There was a lot to explore with just a single user relative to establishing the security filter chain, requiring authentication, supplying credentials with the call, completing the authentication, and obtaining the authenticated user identity.

In this chapter we will focus on the `UserDetailsService` framework that supports the `AuthenticationProvider` so that we can implement multiple users, multiple user information sources, and to begin storing those users in a database.

1.1. Goals

You will learn:

- the interface roles in authenticating users within Spring
- how to configure authentication and authentication sources for use by a security filter chain
- how to implement access to user details from different sources
- how to implement access to user details using a database

1.2. Objectives

At the conclusion of this lecture and related exercises, you will be able to:

1. build various `UserDetailsService` implementations to host user accounts and be used as a source for authenticating users
2. build a simple in-memory `UserDetailsService`
3. build an injectable `UserDetailsService`
4. build a `UserDetailsService` using access to a relational database
5. configure an application to display the database UI
6. encode passwords

Chapter 2. AuthenticationManager

The focus of this chapter is on providing authentication to stored users and providing details about them. To add some context to this, lets begin the presentation flow with the `AuthenticationManager`.

`AuthenticationManager` is an abstraction the code base looks for in order to authenticate a set of credentials. Its input and output are of the same interface type — `Authentication` — but populated differently and potentially implemented differently.

The input `Authentication` primarily supplies the principal (e.g., username) and credentials (e.g., plaintext password). The output `Authentication` of a successful authentication supplies resolved `UserDetails` and provides direct access to granted authorities — which can come from those user details and will be used during later authorizations. Although the credentials (e.g., encrypted password hash) from the stored `UserDetails` is used to authenticate, it’s contents are cleared before returning the response to the caller.

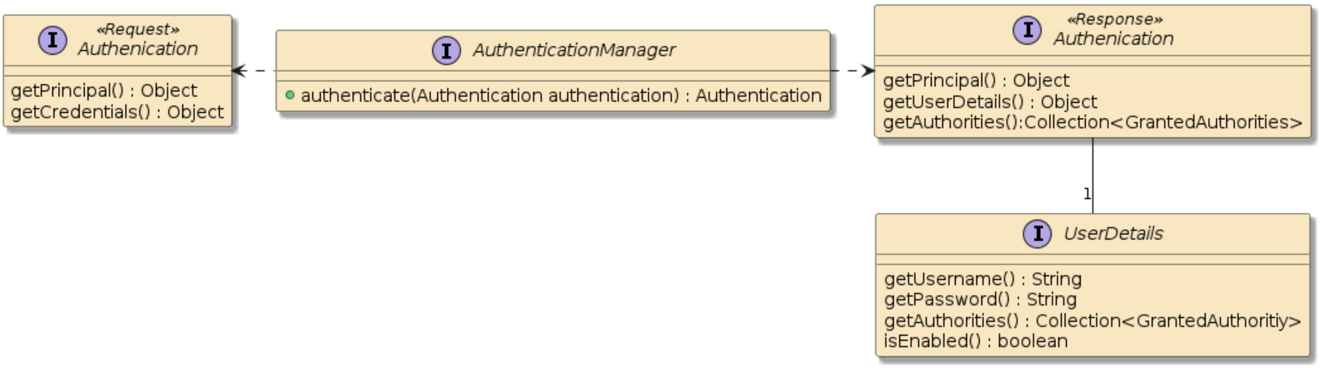

I
«Request»
Authenication
getPrincipal() : Object
getCredentials() : Object
I
AuthenticationManager
● authenticate(Authentication authentication) : Authentication
I
«Response»
Authenication
getPrincipal() : Object
getUserDetails() : Object
getAuthorities():Collection<GrantedAuthorities>
1
I
UserDetails
getUsername() : String
getPassword() : String
getAuthorities() : Collection<GrantedAuthoritiy>
isEnabled() : boolean

Figure 1. AuthenticationManager and UserDetails

2.1. ProviderManager

The `AuthenticationManager` is primarily implemented using the `ProviderManager` class and delegates authentication to its assigned `AuthenticationProviders` and/or parent `AuthenticationManager` to do the actual authentication. Some `AuthenticationProvider` classes are based off a `UserDetailsService` to provide `UserDetails`. However, that is not always the case — therefore the diagram below does not show a direct relationship between the `AuthenticationProvider` and `UserDetailsService`.

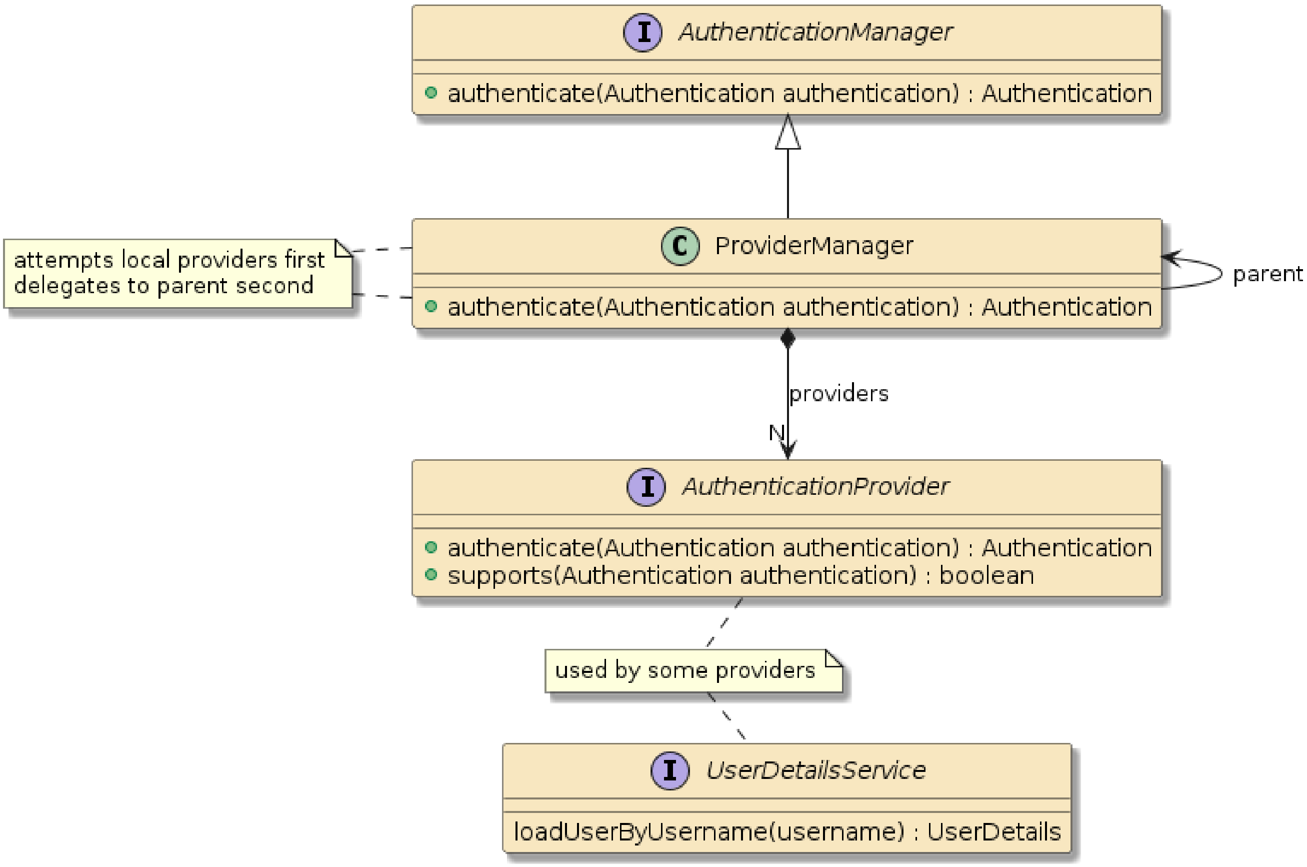

I AuthenticationManager
authenticate(Authentication authentication) : Authentication
C ProviderManager
authenticate(Authentication authentication) : Authentication
parent
attempts local providers first
delegates to parent second
providers
N
I AuthenticationProvider
authenticate(Authentication authentication) : Authentication
supports(Authentication authentication) : boolean
used by some providers
I UserDetailsService
loadUserByUsername(username) : UserDetails

Figure 2. ProviderManager

2.2. AuthenticationManagerBuilder

It is the job of the `AuthenticationManagerBuilder` to assemble an `AuthenticationManager` with the required `AuthenticationProviders` and — where appropriate — `UserDetailsService`. The `AuthenticationManagerBuilder` is configured during the assembly of the `SecurityFilterChain` in both the legacy WebSecurityConfigurerAdapter and modern Component-based approaches.

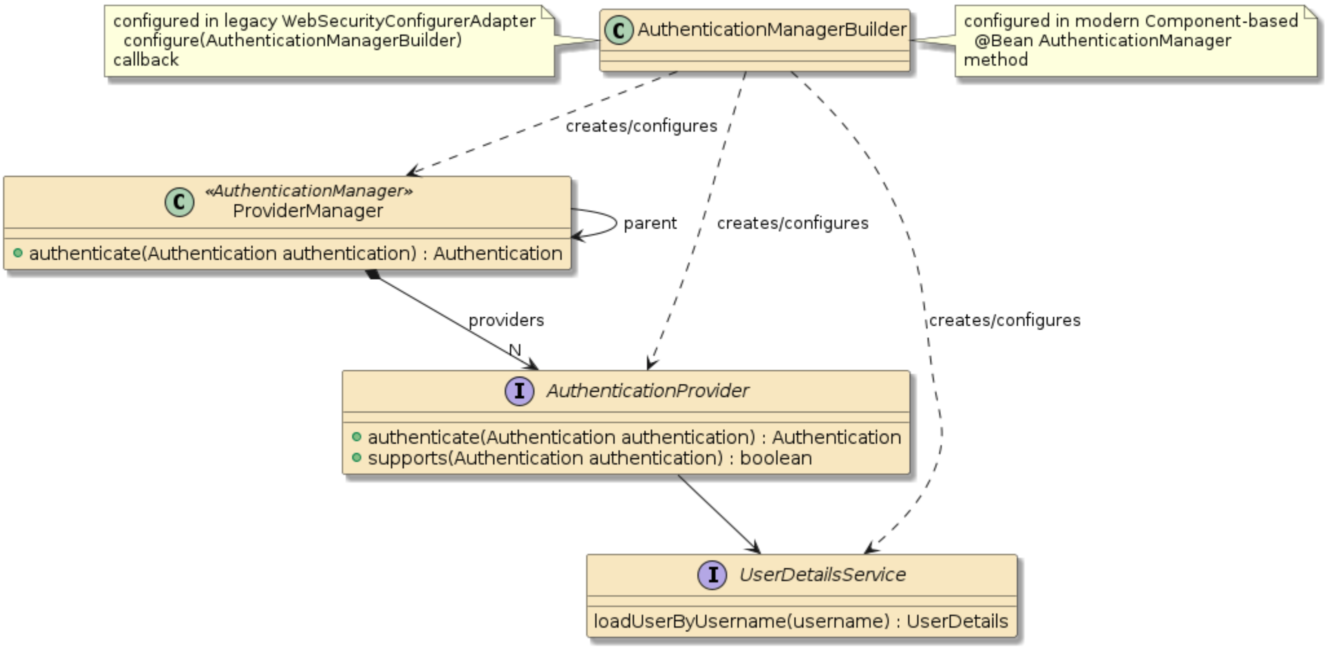

configured in legacy WebSecurityConfigurerAdapter
configure(AuthenticationManagerBuilder)
callback
C AuthenticationManagerBuilder
configured in modern Component-based
@Bean AuthenticationManager
method
creates/configures
C «AuthenticationManager»
ProviderManager
authenticate(Authentication authentication) : Authentication
parent
creates/configures
providers
N
creates/configures
I AuthenticationProvider
authenticate(Authentication authentication) : Authentication
supports(Authentication authentication) : boolean
I UserDetailsService
loadUserByUsername(username) : UserDetails

Figure 3. AuthenticationManagerBuilder

One can custom-configure the AuthenticationProviders for the AuthenticationManagerBuilder in the legacy WebSecurityConfigurerAdapter approach by overriding the configure() callback.

Configure AuthenticationManagerBuilder using legacy WebSecurityConfigurerAdapter

```
@Configuration(proxyBeanMethods = false)
public static class APIConfiguration extends WebSecurityConfigurerAdapter {
    @Override
    protected void configure(AuthenticationManagerBuilder auth) throws Exception {
        ... ①
    }
```

① can custom-configure AuthenticationManagerBuilder here during a configure() callback

One can custom-configure the AuthenticationProviders for the AuthenticationManagerBuilder in the modern Component-based approach by obtaining it from an injected HttpSecurity object using the getSharedObject() call.

Configure AuthenticationManagerBuilder using modern Component-based Approach

```
@Bean
public AuthenticationManager authnManager(HttpSecurity http, ...) throws Exception {
    AuthenticationManagerBuilder builder =
                        http.getSharedObject(AuthenticationManagerBuilder.class);
    ...①

    builder.parentAuthenticationManager(null); //prevent from being recursive ②
    return builder.build();
}
```

① can obtain and custom-configure AuthenticationManagerBuilder using injected HttpSecurity object

② I found the need to explicitly define "no parent" in the modern Component-based approach

2.3. AuthenticationManagerBuilder Builder Methods

We can use the local builder methods to custom-configure the AuthenticationManagerBuilder. These allow us to assemble one or more of the well-known AuthenticationProvider types. The following is an example of configuring an InMemoryUserDetailsManager that our earlier examples used in the previous chapters. However, in this case we get a chance to explicitly populate with users.

⚠ This is an early example demonstration toy

Example InMemoryAuthentication Configuration

```
PasswordEncoder encoder = ...
builder.inMemoryAuthentication()  ①
        .passwordEncoder(encoder) ②
        .withUser("user1").password(encoder.encode("password1")).roles() ③
```

```
          .and()
          .withUser("user2").password(encoder.encode("password1")).roles();
```

① adds a UserDetailsService to AuthenticationManager implemented in memory

② AuthenticationProvider will need a password encoder to match passwords during authentication

③ users placed directly into storage must have encoded password

2.3.1. Assembled AuthenticationProvider

The results of the builder configuration are shown below where the builder assembled an AuthenticationManager (ProviderManager) and populated it with an AuthenticationProvider (DaoAuthenticationProvider) that can work with the UserDetailsService (InMemoryUserDetailsManager) we identified.

The builder also populated the UserDetailsService with two users: user1 and user2 with an encoded password using the PasswordEncoder also set on the AuthenticationProvider.

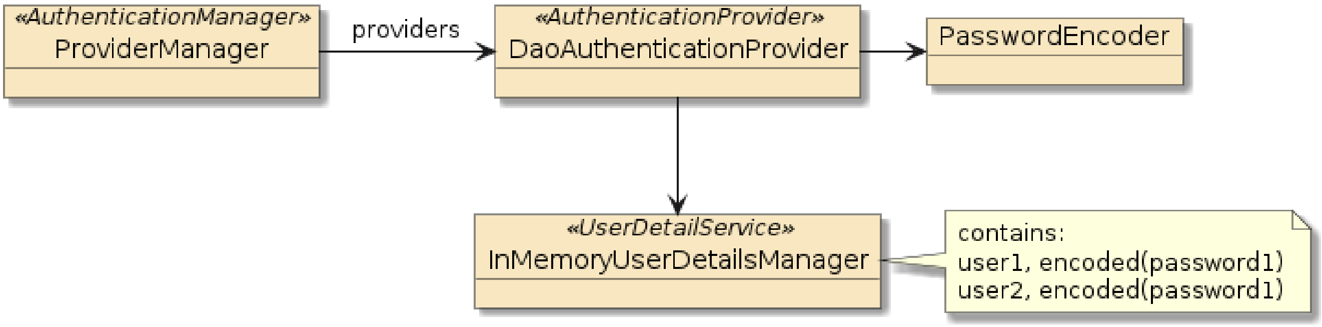


Figure 4. Example InMemoryUserDetailsManager

2.3.2. Builder Authentication Example

With that in place — we can authenticate our two users using the UserDetailsService defined and populated using the builder.

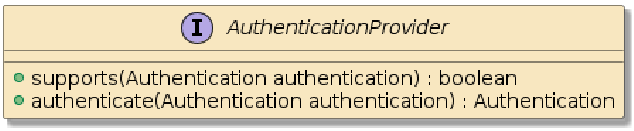
Builder Authentication Example

```
$ curl http://localhost:8080/api/authn/hello?name=jim -u user1:password1
hello, jim :caller=user1

$ curl http://localhost:8080/api/authn/hello?name=jim -u user2:password1
hello, jim :caller=user2

$ curl http://localhost:8080/api/authn/hello?name=jim -u userX:password -v
< HTTP/1.1 403
```

2.4. AuthenticationProvider

The AuthenticationProvider can can answer two (2) questions:

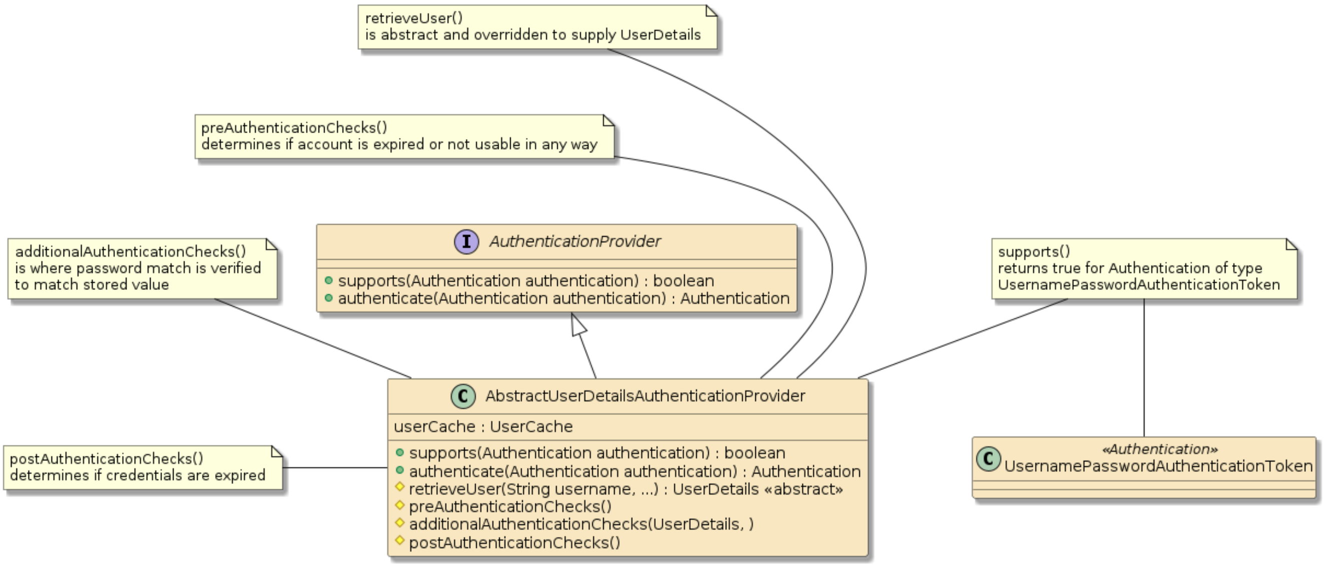
- do you support this type of authentication
- can you authenticate this attempt


AuthenticationProvider
supports(Authentication authentication) : boolean
authenticate(Authentication authentication) : Authentication

2.5. AbstractUserDetailsAuthenticationProvider

For username/password authentication, Spring provides an `AbstractUserDetailsAuthenticationProvider` that supplies the core authentication workflow that includes:

- a `UserCache` to store `UserDetails` from previous successful lookups
- obtaining the `UserDetails` if not already in the cache
- pre and post-authorization checks to verify such things as the account locked/disabled/expired or the credentials expired.
- additional authentication checks where the password matching occurs


retrieveUser()
is abstract and overridden to supply UserDetails
preAuthenticationChecks()
determines if account is expired or not usable in any way
additionalAuthenticationChecks()
is where password match is verified
to match stored value
AuthenticationProvider
supports(Authentication authentication) : boolean
authenticate(Authentication authentication) : Authentication
supports()
returns true for Authentication of type
UsernamePasswordAuthenticationToken
AbstractUserDetailsAuthenticationProvider
userCache : UserCache
supports(Authentication authentication) : boolean
authenticate(Authentication authentication) : Authentication
retrieveUser(String username, ...) : UserDetails «abstract»
preAuthenticationChecks()
additionalAuthenticationChecks(UserDetails,)
postAuthenticationChecks()
postAuthenticationChecks()
determines if credentials are expired
«Authentication»
UsernamePasswordAuthenticationToken

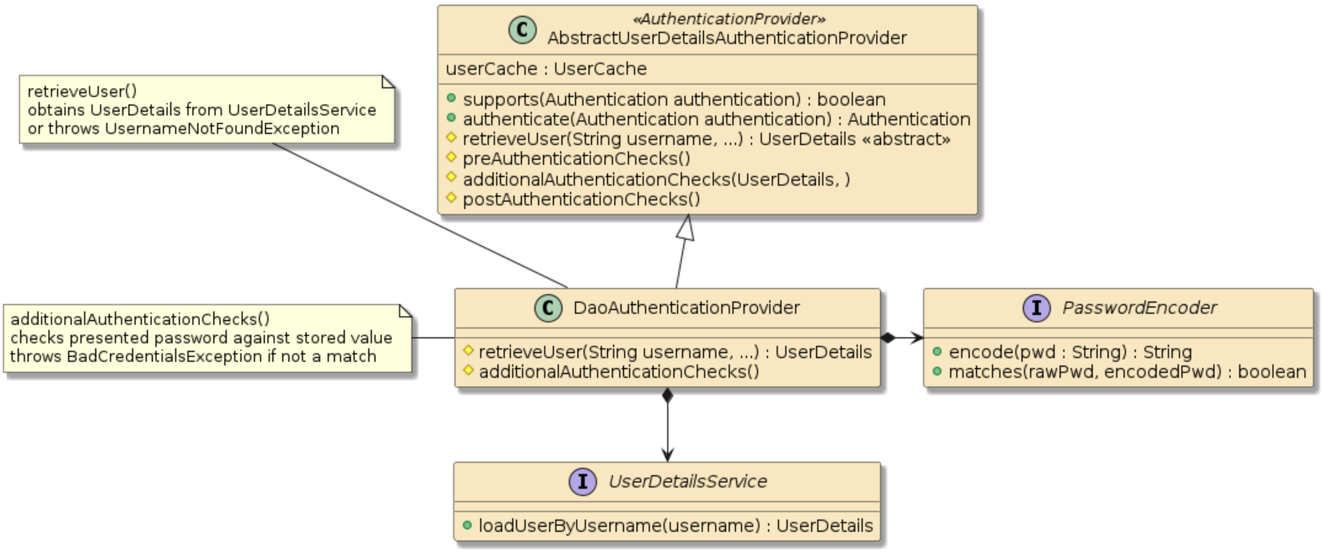
The instance will support any authentication token of type `UsernamePasswordAuthenticationToken` but will need at least two things:

- user details from storage
- a means to authenticate presented password

2.6. DaoAuthenticationProvider

Spring provides a concrete `DaoAuthenticationProvider` extension of the `AbstractUserDetailsAuthenticationProvider` class that works directly with:

- `UserDetailService` to obtain the `UserDetails`
- `PasswordEncoder` to perform password matching



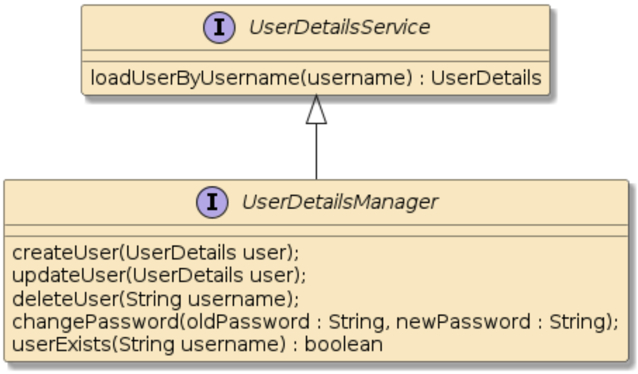
retrieveUser()
obtains UserDetails from UserDetailsService
or throws UsernameNotFoundException
C
«AuthenticationProvider»
AbstractUserDetailsAuthenticationProvider
userCache : UserCache
supports(Authentication authentication) : boolean
authenticate(Authentication authentication) : Authentication
retrieveUser(String username, ...) : UserDetails «abstract»
preAuthenticationChecks()
additionalAuthenticationChecks(UserDetails,)
postAuthenticationChecks()
additionalAuthenticationChecks()
checks presented password against stored value
throws BadCredentialsException if not a match
C
DaoAuthenticationProvider
retrieveUser(String username, ...) : UserDetails
additionalAuthenticationChecks()
I
PasswordEncoder
encode(pwd : String) : String
matches(rawPwd, encodedPwd) : boolean
I
UserDetailsService
loadUserByUsername(username) : UserDetails

Now all we need is a `PasswordEncoder` and `UserDetailsService` to get all this rolling.

2.7. UserDetailsManager

Before we get too much further into the details of the `UserDetailsService`, it will be good to be reminded that the interface supplies only a single `loadUserByUsername()` method.

There is an extension of that interface to address full lifecycle `UserDetails` management and some of the implementations I will reference implement one or both of those interfaces. We will, however, focus only on the authentication portion and ignore most of the other lifecycle aspects for now.



I
UserDetailsService
loadUserByUsername(username) : UserDetails
I
UserDetailsManager
createUser(UserDetails user);
updateUser(UserDetails user);
deleteUser(String username);
changePassword(oldPassword : String, newPassword : String);
userExists(String username) : boolean

Chapter 3. AuthenticationManagerBuilder Configuration

At this point we know the framework of objects that need to be in place for authentication to complete and how to build a toy `InMemoryUserDetailsManager` using builder methods within the `AuthenticationManagerBuilder` class.

In this section we will learn how we can configure additional sources with less assistance from the `AuthenticationManagerBuilder`.

3.1. Fully-Assembled AuthenticationManager

We can directly assign a fully-assembled `AuthenticationManager` to other `SecurityFilterChains` by first exporting it as a `@Bean`.

- The legacy `WebSecurityConfigurerAdapter` approach provides a `authenticationManagerBean()` helper method that can be exposed as a `@Bean` by the derived class.

  @Bean AuthenticationManager — legacy WebSecurityConfigurerAdapter approach

  ```
  @Configuration
  public class APIConfiguration extends legacy WebSecurityConfigurerAdapter {
      @Bean
      @Override
      public AuthenticationManager authenticationManagerBean() throws Exception {
          return super.authenticationManagerBean();
      }
  ```

- The modern Component-based approach builds an `AuthenticationManager` in a `@Bean` factory method using a builder accessible from the injected `HttpSecurity`.

  @Bean AuthenticationManager — modern Component-based approach

  ```
  @Bean
  public AuthenticationManager authnManager(HttpSecurity http,...) throws Exception {
      AuthenticationManagerBuilder builder =
                          http.getSharedObject(AuthenticationManagerBuilder.class);
      ...
      builder.parentAuthenticationManager(null); //prevent from being recursive
      return builder.build();
  }
  ```

With the fully-configured `AuthenticationManager` exposed as a `@Bean`, we can look to directly wire it into the other `SecurityFilterChains`.

3.2. Directly Wire-up AuthenticationManager

We can directly set the `AuthenticationManager` to one created elsewhere. The following examples shows setting the `AuthenticationManager` during the building of the `SecurityFilterChain`.

- legacy `WebSecurityConfigurerAdapter` approach

  Assigning Parent AuthenticationManager — legacy WebSecurityConfigurerAdapter Approach

```
@Configuration
@Order(500)
@RequiredArgsConstructor
public static class H2Configuration extends WebSecurityConfigurerAdapter {
    private final AuthenticationManager authenticationManager; ①

    @Override
    protected void configure(HttpSecurity http) throws Exception {
        http.requestMatchers(m->m.antMatchers(...));
        ...
        http.authenticationManager(authenticationManager); ②
    }
}
```

  ① `AuthenticationManager` assembled elsewhere and injected in this `@Configuration` class

  ② injected `AuthenticationManager` to be the `AuthenticationManager` for what this builder builds

- modern Component-based approach

  Assigning AuthenticationManager — modern Component-based Approach

```
@Order(500)
@Bean
public SecurityFilterChain h2SecurityFilters(HttpSecurity http,①
                                        AuthenticationManager authMgr) throws
Exception {
    http.securityMatchers(cfg->cfg.requestMatchers(...));
    ...
    http.authenticationManager(authMgr); ②
    return http.build();
}
```

  ① `AuthenticationManager` assembled elsewhere and injected in this `@Bean` factory method

  ② injected `AuthenticationManager` to be the `AuthenticationManager` for what this builder builds

3.3. Directly Wire-up Parent AuthenticationManager

We can instead set the parent `AuthenticationManager` using the `SecurityAuthenticationManagerBuilder`.

- The following example shows setting the parent `AuthenticationManager` during a `WebSecurityConfigurerAdapter.configure()` callback in the legacy WebSecurityConfigurerAdapter approach.

  Assigning Parent AuthenticationManager — legacy WebSecurityConfigurerAdapter Approach

  ```
  @Configuration
  @Order(500)
  @RequiredArgsConstructor
  public static class H2Configuration extends WebSecurityConfigurerAdapter {
      private final AuthenticationManager authenticationManager;

      @Override
      protected void configure(AuthenticationManagerBuilder auth)
          throws Exception {
          auth.parentAuthenticationManager(authenticationManager); ①
      }
  }
  ```

  ① injected `AuthenticationManager` to be the parent `AuthenticationManager` of what this builder builds

- The following example shows setting the parent `AuthenticationManager` during the build of the `SecurityFilterChain` using `http.getSharedObject()`.

  Assigning Parent AuthenticationManager — modern Component-based Approach

  ```
  @Order(500)
  @Bean
  public SecurityFilterChain h2SecurityFilters(HttpSecurity http,
                                         AuthenticationManager authMgr) throws
  Exception {
      ...
      AuthenticationManagerBuilder builder =
              http.getSharedObject(AuthenticationManagerBuilder.class);
      builder.parentAuthenticationManager(authMgr); ①
      return http.build();
  ```

  ① injected `AuthenticationManager` to be the parent `AuthenticationManager` of what this builder builds

3.4. Define Service and Encoder @Bean

Another option in supplying a `UserDetailsService` is to define a globally accessible `UserDetailsService @Bean` to inject to use with our builder. However, in order to pre-populate the `UserDetails` passwords, we must use a `PasswordEncoder` that is consistent with the `AuthenticationProvider` this `UserDetailsService` will be combined with. We can set the default `PasswordEncoder` using a `@Bean` factory.

Defining a Default PasswordEncoder for AuthenticationProvider

```
@Bean ①
public PasswordEncoder passwordEncoder() {
    return ...
}
```

① defining a `PasswordEncoder` to be injected into default `AuthenticationProvider`

Defining Injectable UserDetailsService

```
@Bean
public UserDetailsService sharedUserDetailsService(PasswordEncoder encoder) { ①
    //caution -- authorities accumulate in 3.1.0 / Spring 6.1.1, fixed in 6.2.0-M1
    //create new builder for each new user to avoid issue
    List<UserDetails> users = List.of(
        User.withUsername("user1").passwordEncoder(encoder::encode) ②
            .password("password2").roles().build(), ③
        User.withUsername("user3").passwordEncoder(encoder::encode)
            .password("password2").roles().build()
    );
    return new InMemoryUserDetailsManager(users);
}
```

① using an injected `PasswordEncoder` for consistency

② using different `UserDetails` builder than before — setting password encoding function

③ username user1 will be in both `UserDetailsService` with different passwords

`User.withUsername()` constructs new `User` builder.

3.4.1. Inject UserDetailService

We can inject the fully-assembled `UserDetailsService` into the `AuthenticationManagerBuilder` — just like before with the `inMemoryAuthentication`, except this time the builder has no knowledge of the implementation being injected. We are simply injecting a `UserDetailsService`. The builder will accept it and wrap that in an `AuthenticationProvider`

Inject Fully-Assembled UserDetails Service — legacy `WebSecurityConfigurerAdapter` *Approach*

```
@Configuration
@Order(0)
@RequiredArgsConstructor
public static class APIConfiguration extends WebSecurityConfigurerAdapter {
    private final List<UserDetailsService> userDetailsServices;①

    @Override
    protected void configure(AuthenticationManagerBuilder auth) throws Exception {
        ...
        for (UserDetailsService uds: userDetailsServices) {
            auth.userDetailsService(uds); ②
        }
    }
```

① injecting UserDetailsService into configuration class

② adding additional UserDetailsService to create additional AuthenticationProvider

The same can be done in the modern Component-based approach and during the equivalent builder configuration I demonstrated earlier with the inMemoryAuthentication. The only difference is that I found the more I custom-configured the AuthenticationManagerBuilder, I would end up in a circular configuration with the AuthenticationManager pointing to itself as its parent unless I explicitly set the parent value to null.

Inject Fully-Assembled UserDetails Service — modern Component-based Approach

```
@Bean
public AuthenticationManager authnManager(HttpSecurity http,
                List<UserDetailsService> userDetailsServices ) throws Exception { ①
    AuthenticationManagerBuilder builder = http.getSharedObject
(AuthenticationManagerBuilder.class);
    ...
    for (UserDetailsService uds : userDetailsServices) {
        builder.userDetailsService(uds); ②
    }

    builder.parentAuthenticationManager(null); //prevent from being recursive
    return builder.build();
}
```

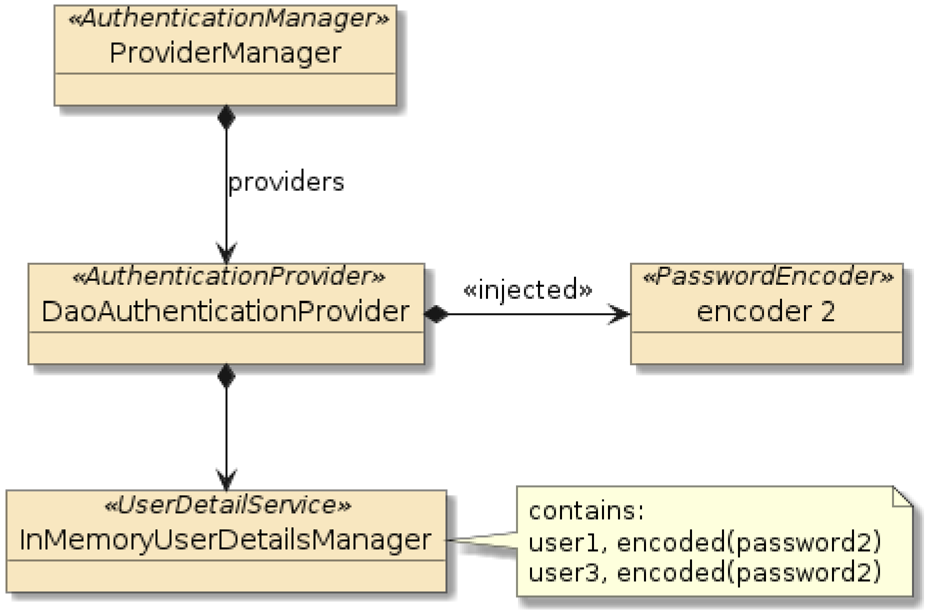
① injecting UserDetailsService into bean method

② adding additional UserDetailsService to create additional AuthenticationProvider

3.4.2. Assembled Injected UserDetailsService

The results of the builder configuration are shown below where the builder assembled an AuthenticationProvider (DaoAuthenticationProvider) based on the injected UserDetailsService (InMemoryUserDetailsManager).

The injected UserDetailsService also had two users — user1 and user3 — added with an encoded password based on the injected PasswordEncoder bean. This will be the same bean injected into the AuthenticationProvider.



3.4.3. Injected UserDetailsService Example

With that in place, we can now authenticate `user1` and `user3` using the assigned passwords using the `AuthenticationProvider` with the injected `UserDetailService`.

Injected UserDetailsService Authentication Example

```
$ curl http://localhost:8080/api/authn/hello?name=jim -u user1:password2
hello, jim :caller=user1

$ curl http://localhost:8080/api/authn/hello?name=jim -u user3:password2
hello, jim :caller=user3

$ curl http://localhost:8080/api/authn/hello?name=jim -u userX:password -v
< HTTP/1.1 403
```

3.5. Combine Approaches

As stated before — the `ProviderManager` can delegate to multiple `AuthenticationProviders` before authenticating or rejecting an authentication request. We have demonstrated how to create an `AuthenticationManager` multiple ways. In this example, I am integrating the two `AuthenticationProviders` into a single `AuthenticationManager`.

Defining Multiple AuthenticationProviders

```
//AuthenticationManagerBuilder auth
PasswordEncoder encoder = ... ①
auth.inMemoryAuthentication().passwordEncoder(encoder)
    .withUser("user1").password(encoder.encode("password1")).roles()
    .and()
    .withUser("user2").password(encoder.encode("password1")).roles();
for (UserDetailsService uds : userDetailsServices) { ②
    builder.userDetailsService(uds);
}
```

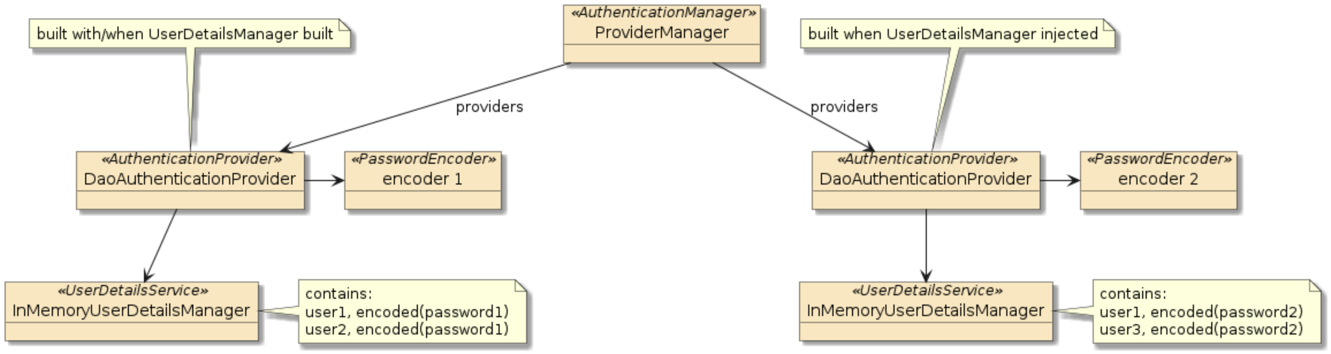
① locally built AuthenticationProvider will use its own encoder

② @Bean-built UserDetailsService injected and used to form second AuthenticationProvider

3.5.1. Assembled Combined AuthenticationProviders

The resulting AuthenticationManager ends up with two custom-configured AuthenticationProviders. Each AuthenticationProviders are

- implemented with the DaoAuthenticationProvider class
- make use of a PasswordEncoder and UserDetailsService


«AuthenticationManager»
ProviderManager
built with/when UserDetailsManager built
built when UserDetailsManager injected
providers
providers
«AuthenticationProvider»
DaoAuthenticationProvider
«PasswordEncoder»
encoder 1
«AuthenticationProvider»
DaoAuthenticationProvider
«PasswordEncoder»
encoder 2
«UserDetailsService»
InMemoryUserDetailsManager
contains:
user1, encoded(password1)
user2, encoded(password1)
«UserDetailsService»
InMemoryUserDetailsManager
contains:
user1, encoded(password2)
user3, encoded(password2)

The left UserDetailsService was instantiated locally as an InMemoryUserDetailsManager, using builder methods from the AuthenticationManagerBuilder. Since it was locally built, it was building the AuthenticationProvider at the same time and could define its own choice of PasswordEncoder

The right UserDetailsService was injected from a @Bean factory that instantiated the InMemoryUserDetailsManager directly. Since it was shared as a @Bean, the factory method used an injected PasswordEncoder to assemble.

The two were brought together by one of our configuration approaches and now we have two sources of credentials to authenticate against.

3.5.2. Multiple Provider Authentication Example

With the two AuthenticationProvider objects defined, we can now login as user2 and user3, and user1 using both passwords. The user1 example shows that an authentication failure from one provider still allows it to be inspected by follow-on providers.

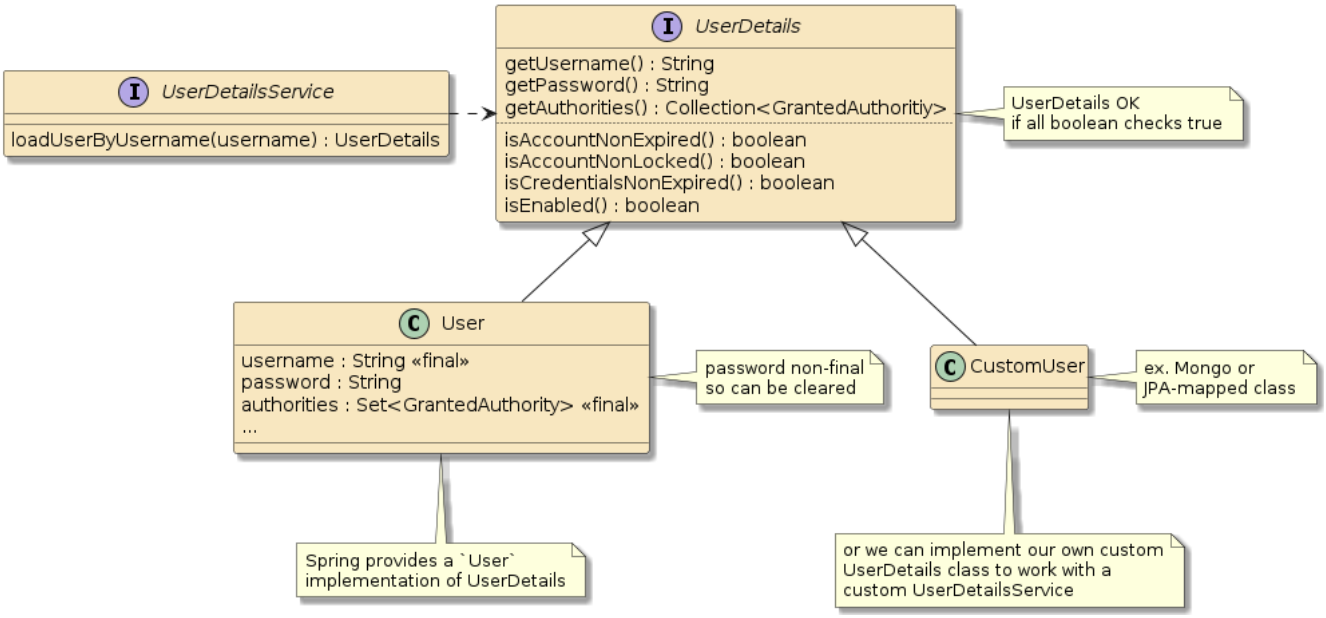
Multiple Provider Authenticate Example

```
$ curl http://localhost:8080/api/authn/hello?name=jim -u user1:password1
hello, jim :caller=user1

$ curl http://localhost:8080/api/authn/hello?name=jim -u user1:password2
hello, jim :caller=user1

$ curl http://localhost:8080/api/authn/hello?name=jim -u user2:password1
```

```
hello, jim :caller=user2

$ curl http://localhost:8080/api/authn/hello?name=jim -u user3:password2
hello, jim :caller=user3
```

Chapter 4. UserDetails

So now we know that all we need is to provide a `UserDetailsService` instance and Spring will take care of most of the rest. `UserDetails` is an interface that we can implement any way we want. For example — if we manage our credentials in MongoDB or use Java Persistence API (JPA), we can create the proper classes for that mapping. We won't need to do that just yet because Spring provides a `User` class that can work for most POJO-based storage solutions.



I UserDetailsService
loadUserByUsername(username) : UserDetails
I UserDetails
getUsername() : String
getPassword() : String
getAuthorities() : Collection<GrantedAuthoritiy>
isAccountNonExpired() : boolean
isAccountNonLocked() : boolean
isCredentialsNonExpired() : boolean
isEnabled() : boolean
UserDetails OK
if all boolean checks true
C User
username : String «final»
password : String
authorities : Set<GrantedAuthority> «final»
...
password non-final
so can be cleared
C CustomUser
ex. Mongo or
JPA-mapped class
Spring provides a `User`
implementation of UserDetails
or we can implement our own custom
UserDetails class to work with a
custom UserDetailsService

Figure 5. UserDetailsService

Chapter 5. PasswordEncoder

I have made mention several times about the `PasswordEncoder` and earlier covered how it is used to create a cryptographic hash. Whenever we configured a `PasswordEncoder` for our `AuthenticationProvider` we have the choice of many encoders. I will highlight three of them.

5.1. NoOpPasswordEncoder

The `NoOpPasswordEncoder` is what it sounds like. It does nothing when encoding the plaintext password. This can be used for early development and debug but should not — obviously — be used with real credentials.

5.2. BCryptPasswordEncoder

The `BCryptPasswordEncoder` uses a very strong Bcrypt algorithm and (the algorithm) likely should be considered the default in production environments.

5.3. DelegatingPasswordEncoder

The `DelegatingPasswordEncoder` is a jack-of-all-encoders. It has one default way to encode — using BCrypt — but can validate passwords of numerous algorithms. This encoder writes and relies on all passwords starting with an `{encoding-key}` that indicates the type of encoding to use.

Example DelegatingPasswordEncoder Values

```
{noop}password
{bcrypt}$2y$10$UvKwrln7xPp35c5sbj.9kuZ9jY9VYg/VylVTu88ZSCYy/YdcdP/Bq
```

Use the `PasswordEncoderFactories` class to create a `DelegatingPasswordEncoder` populated with a full compliment of encoders.

Example Fully Populated DelegatingPasswordEncoder Creation

```
import org.springframework.security.crypto.factory.PasswordEncoderFactories;

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

> *DelegatingPasswordEncoder encodes one way and matches multiple ways*
>
> `DelegatingPasswordEncoder` encodes using a single, designated encoder and matches against passwords encoded using many alternate encodings — thus relying on the password to start with a `{encoding-key}`.

Chapter 6. JDBC UserDetailsService

Spring provides two Java Database Connectivity (JDBC) implementation classes that we can easily use out of the box to begin storing `UserDetails` in a database:

- `JdbcDaoImpl` - implements just the core `UserDetailsService` `loadUserByUsername` capability
- `JdbcUserDetailManager` - implements the full `UserDetailsManager` CRUD capability

> *JDBC is a database communications interface containing no built-in mapping*
>
> JDBC is a low-level interface to access a relational database from Java. All the mapping between the database inputs/outputs and our Java business objects is done outside of JDBC. There is no mapping framework like with Java Persistence API (JPA).

`JdbcUserDetailManager` extends `JdbcDaoImpl`. We only need `JdbcDaoImpl` since we will only be performing authentication reads and not yet be implementing full CRUD (**C**reate, **R**ead, **U**pdate, and **D**elete) with databases. However, there would have been no harm in using the full `JdbcUserDetailManager` implementation in the examples below and simply ignored the additional behavior.

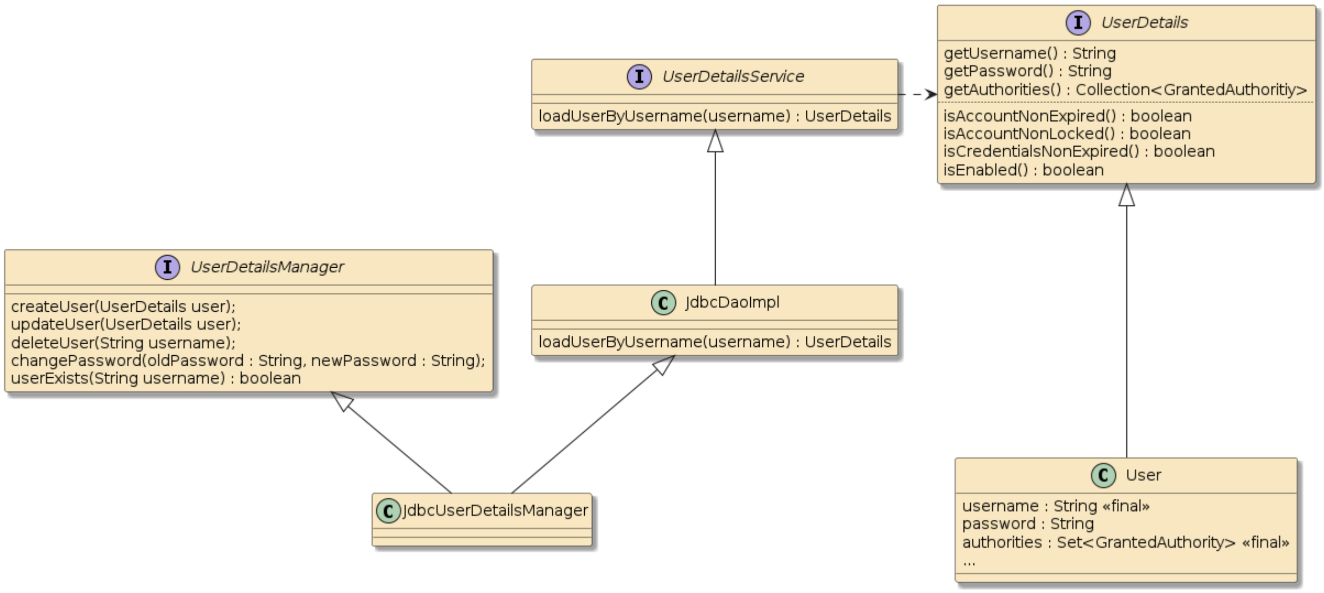

I UserDetails
getUsername() : String
getPassword() : String
getAuthorities() : Collection<GrantedAuthoritiy>
isAccountNonExpired() : boolean
isAccountNonLocked() : boolean
isCredentialsNonExpired() : boolean
isEnabled() : boolean
I UserDetailsService
loadUserByUsername(username) : UserDetails
I UserDetailsManager
createUser(UserDetails user);
updateUser(UserDetails user);
deleteUser(String username);
changePassword(oldPassword : String, newPassword : String);
userExists(String username) : boolean
C JdbcDaoImpl
loadUserByUsername(username) : UserDetails
C JdbcUserDetailsManager
C User
username : String «final»
password : String
authorities : Set<GrantedAuthority> «final»
...

Figure 6. JDBC UserDetailsService

To use the JDBC implementation, we are going to need a few things:

- A relational database - this is where we will store our users
- Database Schema - this defines the tables and columns of the database
- Database Contents - this defines our users and passwords
- `javax.sql.DataSource` - this is a JDBC wrapper around a connection to the database
- construct the `UserDetailsService` (and potentially expose as a `@Bean`)
- inject and add JDBC `UserDetailsService` to `AuthenticationManagerBuilder`

6.1. H2 Database

There are several lightweight databases that are very good for development and demonstration (e.g., h2, hsqldb, derby, SQLite). They commonly offer in-memory, file-based, and server-based instances with minimal scale capability but extremely simple to administer. In general, they supply an interface that is compatible with the more enterprise-level solutions that are more suitable for production. That makes them an ideal choice for using in demonstration and development situations like this. For this example, I will be using the `h2` database but many others could have been used as well.

6.2. DataSource: Maven Dependencies

To easily create a default DataSource, we can simply add a compile dependency on `spring-boot-starter-data-jdbc` and a runtime dependency on the `h2` database. This will cause our application to start with a default DataSource connected to the an in-memory database.

DataSource Maven Dependency

```xml
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-data-jdbc</artifactId>
</dependency>
<dependency>
    <groupId>com.h2database</groupId>
    <artifactId>h2</artifactId>
    <scope>runtime</scope>
</dependency>
```

6.3. JDBC UserDetailsService

Once we have the `spring-boot-starter-data-jdbc` and database dependency in place, Spring Boot will automatically create a default `javax.sql.DataSource` that can be injected into a `@Bean` factory so that we can create a `JdbcDaoImpl` to implement the JDBC `UserDetailsService`.

JDBC UserDetailsService

```java
import javax.sql.DataSource;
...
@Bean
public UserDetailsService jdbcUserDetailsService(DataSource userDataSource) {
    JdbcDaoImpl jdbcUds = new JdbcDaoImpl();
    jdbcUds.setDataSource(userDataSource);
    return jdbcUds;
}
```

From there, we can inject the JDBC `UserDetailsService` — like the in-memory version we injected earlier and add it to the builder.

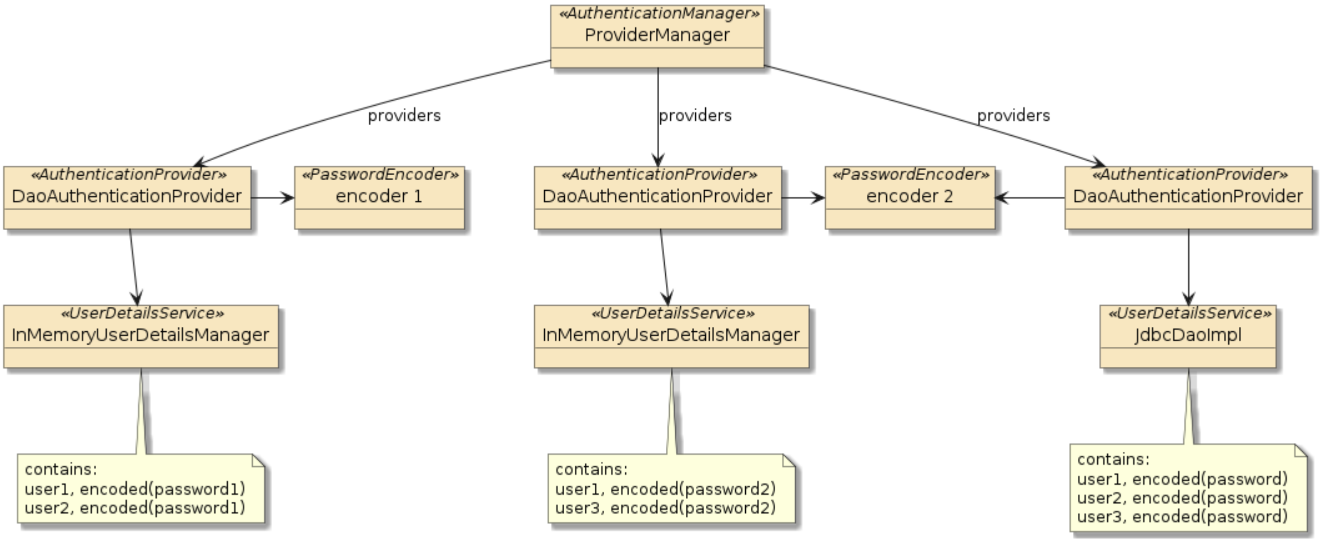


Figure 7. Aggregate Set of UserDetailsServices and AuthenticationProviders

6.4. Autogenerated Database URL

If we restart our application at this point, we will get a generated database URL using a UUID for the name.

Autogenerated Database URL Output

```
H2 console available at '/h2-console'. Database available at
                    'jdbc:h2:mem:76567045-619b-4588-ae32-9154ba9ac01c'
```

6.5. Specified Database URL

We can make the URL more stable and well-known by setting the `spring.datasource.url` property.

Setting DataSource URL

```
spring.datasource.url=jdbc:h2:mem:users
```

Specified Database URL Output

```
H2 console available at '/h2-console'. Database available at 'jdbc:h2:mem:users'
```

h2-console URI can be modified

We can also control the URI for the h2-console by setting the `spring.h2.console.path` property.

6.6. Enable H2 Console Security Settings

The h2 database can be used headless, but also comes with a convenient UI that will allow us to inspect the data in the database and manipulate it if necessary. However, with security enabled — we will not be able to access our console by default. We only addressed authentication for the API endpoints. Since this is a chapter focused on configuring authentication, it is a good exercise to go through the steps to make the h2 UI accessible but also protected. The following will:

- require users accessing the `/h2-console/**` URIs to be authenticated
- enable FORM authentication and redirect successful logins to the `/h2-console` URI
- disable frame headers that would have placed constraints on how the console could be displayed
- disable CSRF for the `/h2-console/**` URI but leave it enabled for the other URIs
- wire in the injected `AuthenticationManager` configured for the API

6.6.1. H2 Configuration - legacy WebSecurityConfigurerAdapter Approach

H2 UI Security Configuration - legacy WebSecurityConfigurerAdapter Approach

```
@Configuration
@Order(500)
@RequiredArgsConstructor
public static class H2Configuration extends WebSecurityConfigurerAdapter {
    private final AuthenticationManager authenticationManager; ①

    @Override
    protected void configure(HttpSecurity http) throws Exception {
        http.requestMatchers(m->m.antMatchers("/login","/logout", "/h2-console/**"));
        http.authorizeRequests(cfg->cfg.antMatchers("/login","/logout").permitAll())
;②
        http.authorizeRequests(cfg->cfg.antMatchers("/h2-console/**").authenticated()
);③
        http.csrf(cfg->cfg.ignoringAntMatchers("/h2-console/**")); ④
        http.headers(cfg->cfg.frameOptions().disable()); ⑤
        http.formLogin().successForwardUrl("/h2-console"); ⑥
        http.authenticationManager(authenticationManager); ⑦
    }
}
```

① injected `AuthenticationManager` bean exposed by `APIConfiguration`

② apply filter rules to H2 UI URIs as well as login/logout form

③ require authenticated users by the application to reach the console

④ turn off CSRF only for the H2 console

⑤ turn off display constraints for the H2 console

⑥ route successful logins to the H2 console

⑦ use pre-configured `AuthenticationManager` for authentication to UI

6.6.2. H2 Configuration — modern Component-based Approach

The following modern Component-based configuration addresses the URI builder changes in Spring Security 6. I needed to constrain the use of `/error` to the URI and request for `text/html` so that it did not interfere with the API errors. The use of the non-SpringMVC H2DB UI triggered the mandatory use of explicit URI builder calls to resolve ambiguous matching requirements.

H2 UI Configuration — modern Component-based Approach

```
import static
org.springframework.security.web.util.matcher.RegexRequestMatcher.regexMatcher;
import org.springframework.security.web.util.matcher.MediaTypeRequestMatcher;

@Order(500)
@Bean
public SecurityFilterChain h2SecurityFilters(HttpSecurity http,
        AuthenticationManager authMgr) throws Exception {
    MediaTypeRequestMatcher htmlRequestMatcher =
            new MediaTypeRequestMatcher(MediaType.TEXT_HTML);
    htmlRequestMatcher.setUseEquals(true);

    http.securityMatchers(cfg->cfg
            .requestMatchers("/h2-console*","/h2-console/**")
            .requestMatchers("/login", "/logout")
            .requestMatchers(RequestMatchers.allOf(
                    htmlRequestMatcher, //only want to service HTML error pages
                    AntPathRequestMatcher.antMatcher("/error")
                ))
    );
    http.authorizeHttpRequests(cfg->cfg
            .requestMatchers(regexMatcher(HttpMethod.GET,".+(.css|.jsp|.gif)$"))
.permitAll()
            .anyRequest().authenticated() ③
    );
    http.formLogin(cfg->cfg
        .permitAll() //applies permitAll to standard login URIs
        .successForwardUrl("/h2-console") ⑥
    );
    http.csrf(cfg->cfg.ignoringRequestMatchers(antMatcher("/h2-console/**"))); ④
    http.headers(cfg-> cfg.frameOptions(fo->fo.disable())); ⑤

    http.authenticationManager(authMgr);//reuse applications authz users ⑦
    return http.build();
}
```

① injected `AuthenticationManager` bean exposed by API Configuration

② apply filter rules to H2 UI URIs as well as login/logout form

③ require authenticated users by the application to reach the console

④ turn off CSRF only for the H2 console

⑤ turn off display constraints for the H2 console

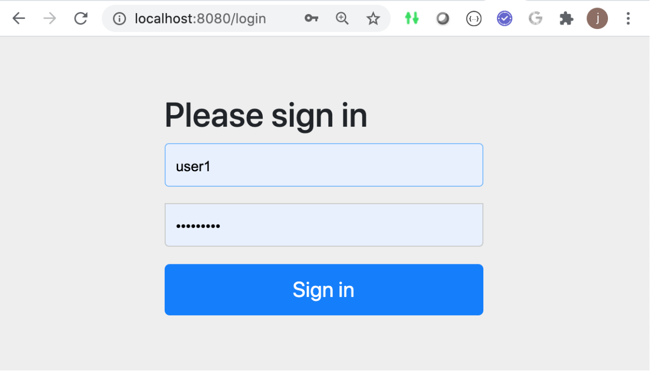
⑥ route successful logins to the H2 console

⑦ use pre-configured AuthenticationManager for authentication to UI

6.7. Form Login

When we attempt to reach a protected URI within the application with FORM authentication active — the FORM authentication form is displayed.

We should be able to enter the site using any of the username/passwords available to the AuthenticationManager. At this point in time, it should be user1/password1, user1/password2, user2/password1, user3/password2.



localhost:8080/login

Please sign in

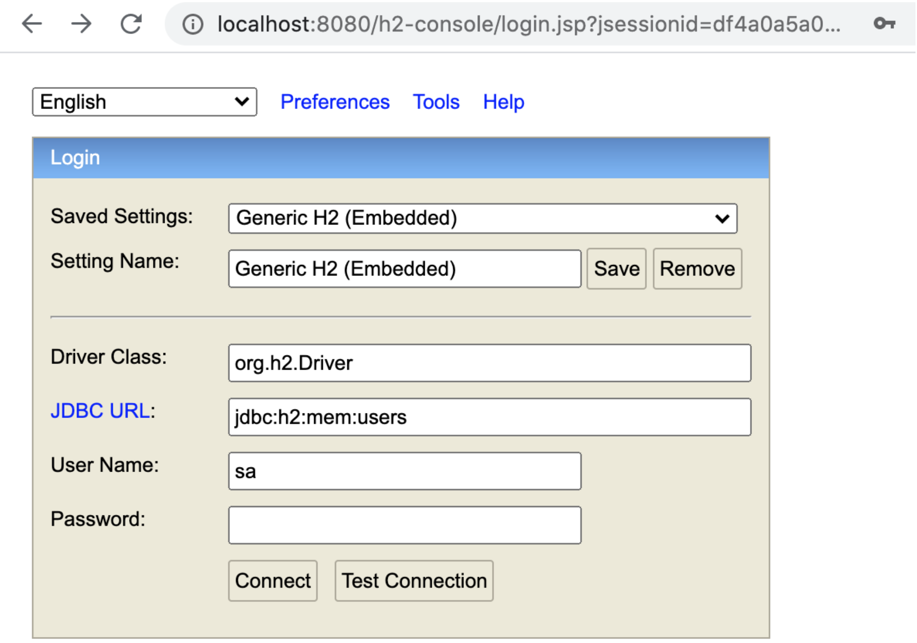
user1

•••••••••

Sign in

If you enter a bad username/password at the point in time you will receive a JDBC error since we have not yet setup the user database.

6.8. H2 Login



localhost:8080/h2-console/login.jsp?jsessionid=df4a0a5a0...

English | Preferences | Tools | Help

Login

Saved Settings: Generic H2 (Embedded)

Setting Name: Generic H2 (Embedded) | Save | Remove

Driver Class: org.h2.Driver

JDBC URL: jdbc:h2:mem:users

User Name: sa

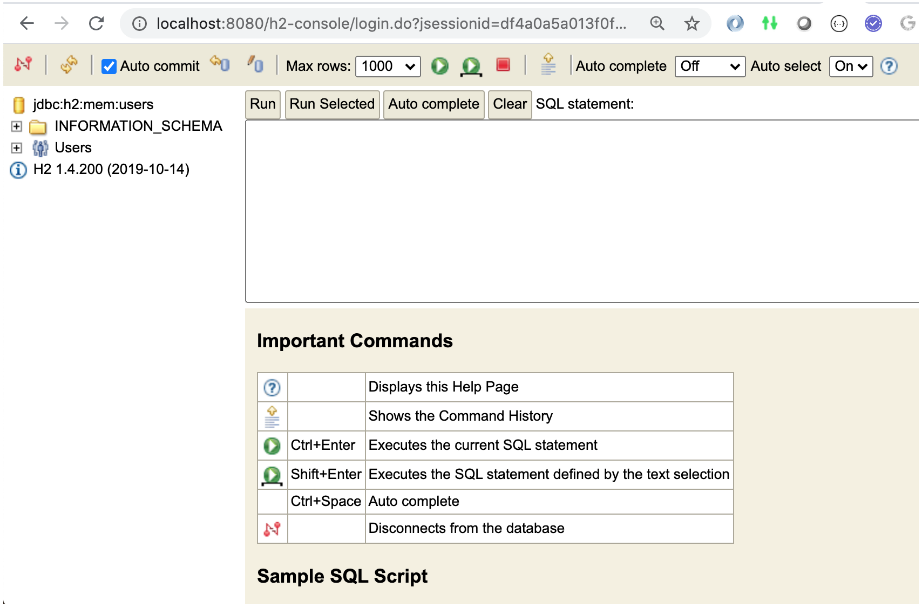
Password:

Connect | Test Connection

Once we get beyond the application FORM login, we are presented with the H2 database login. The JDBC URL should be set to the value of the spring.datasource.url property (jdbc:h2:mem:users). The default username is "sa" and has no password. These can be changed with the spring.datasource.username and spring.datasource.password properties.

6.9. H2 Console

Once successfully logged in, we are presented with a basic but functional SQL interface to the in-memory H2 database that will contain our third source of users — which we need to now setup.



jdbc:h2:mem:users
INFORMATION_SCHEMA
Users
H2 1.4.200 (2019-10-14)

Important Commands

?		Displays this Help Page
		Shows the Command History
	Ctrl+Enter	Executes the current SQL statement
	Shift+Enter	Executes the SQL statement defined by the text selection
	Ctrl+Space	Auto complete
		Disconnects from the database

Sample SQL Script

6.10. Create DB Schema Script

From the point in time when we added the `spring-boot-starter-jdbc` dependency, we were ready to add database schema — which is the definition of tables, columns, indexes, and constraints of our database. Rather than use a default filename, it is good to keep the schemas separated.

The following file is being placed in the `src/main/resources/database` directory of our source tree. It will be accessible to use within the classpath when we restart the application. The bulk of this implementation comes from the Spring Security Documentation Appendix. I have increased the size of the password column to accept longer Bcrypt encoded password hash values.

Example JDBC UserDetails Database Schema

```
--users-schema.ddl ①
drop table authorities if exists; ②
drop table users if exists;

create table users( ③
      username varchar_ignorecase(50) not null primary key,
      password varchar_ignorecase(100) not null,
      enabled boolean not null);

create table authorities ( ④
  username varchar_ignorecase(50) not null,
  authority varchar_ignorecase(50) not null,
  constraint fk_authorities_users foreign key(username) references users(username));⑤
  create unique index ix_auth_username on authorities (username,authority); ⑥
```

① file places in `src/main/resources/database/users-schema.ddl

② dropping tables that may exist before creating

③ `users` table primarily hosts username and password

④ `authorities` table will be used for authorizing accesses after successful identity authentication

⑤ ``foreign key' constraint enforces that `user`` must exist for any `authority`

⑥ `unique index` constraint enforces all authorities are unique per user and places the foreign key to the users table in an efficient index suitable for querying

The schema file can be referenced through the `spring.database.schema` property by prepending `classpath:` to the front of the path.

Example Database Schema Reference

```
spring.datasource.url=jdbc:h2:mem:users
spring.sql.init.schema-locations=classpath:database/users-schema.ddl
```

Spring Security provides a schema file with the basics of what is included here. The path is also referenced by JdbcDaoImpl.DEFAULT_USER_SCHEMA_DDL_LOCATION

6.11. Schema Creation

The following shows an example of the application log when the schema creation in action.

Example Schema Creation

```
Executing SQL script from class path resource [database/users-schema.ddl]
SQL: drop table authorities if exists
SQL: drop table users if exists
SQL: create table users( username varchar_ignorecase(50) not null primary key,
    password varchar_ignorecase(100) not null, enabled boolean not null)
SQL: create table authorities ( username varchar_ignorecase(50) not null,
    authority varchar_ignorecase(50) not null,
    constraint fk_authorities_users foreign key(username) references users(username))
SQL: create unique index ix_auth_username on authorities (username,authority)
Executed SQL script from class path resource [database/users-schema.ddl] in 48 ms.
H2 console available at '/h2-console'. Database available at 'jdbc:h2:mem:users'
```

6.12. Create User DB Populate Script

The schema file took care of defining tables, columns, relationships, and constraints. With that defined, we can add population of users. The following user passwords take advantage of knowing we are using the DelegatingPasswordEncoder and we made `{noop}plaintext` an option at first.

The JDBC UserDetailsService requires that all valid users have at least one authority so I have defined a bogus `known` authority to represent the fact the username is known.

Example User DB Populate Script

```
--users-populate.sql
insert into users(username, password, enabled) values('user1','{noop}password',true);
insert into users(username, password, enabled) values('user2','{noop}password',true);
insert into users(username, password, enabled) values('user3','{noop}password',true);

insert into authorities(username, authority) values('user1','known');
insert into authorities(username, authority) values('user2','known');
insert into authorities(username, authority) values('user3','known');
```

We reference the population script thru a property and can place that in the application.properties file.

Example Database Populate Script Reference

```
spring.datasource.url=jdbc:h2:mem:users
spring.sql.init.schema-locations=classpath:database/users-schema.ddl
spring.sql.init.data-locations=classpath:database/users-populate.sql
```

6.13. User DB Population

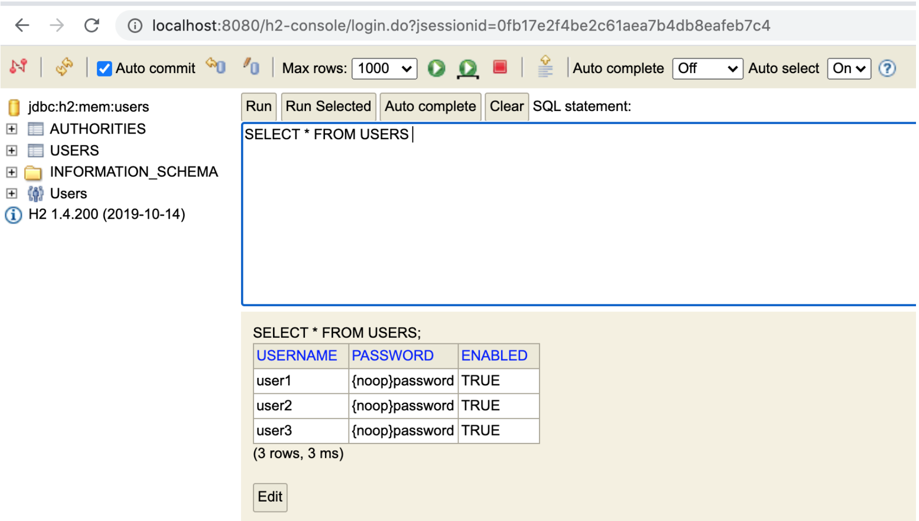
After the wave of schema commands has completed, the row population will take place filling the tables with our users, credentials, etc.

Example User DB Populate

```
Executing SQL script from class path resource [database/users-populate.sql]
SQL: insert into users(username, password, enabled)
values('user1','{noop}password',true)
SQL: insert into users(username, password, enabled)
values('user2','{noop}password',true)
SQL: insert into users(username, password, enabled)
values('user3','{noop}password',true)
SQL: insert into authorities(username, authority) values('user1','known')
SQL: insert into authorities(username, authority) values('user2','known')
SQL: insert into authorities(username, authority) values('user3','known')
Executed SQL script from class path resource [database/users-populate.sql] in 7 ms.
H2 console available at '/h2-console'. Database available at 'jdbc:h2:mem:users'
```

6.14. H2 User Access

With the schema created and users populated, we can view the results using the H2 console.



localhost:8080/h2-console/login.do?jsessionid=0fb17e2f4be2c61aea7b4db8eafeb7c4

☑ Auto commit   Max rows: 1000   Auto complete: Off   Auto select: On

jdbc:h2:mem:users
- AUTHORITIES
- USERS
- INFORMATION_SCHEMA
- Users
- H2 1.4.200 (2019-10-14)

SQL statement:

```
SELECT * FROM USERS
```

SELECT * FROM USERS;

USERNAME	PASSWORD	ENABLED
user1	{noop}password	TRUE
user2	{noop}password	TRUE
user3	{noop}password	TRUE

(3 rows, 3 ms)

6.15. Authenticate Access using JDBC UserDetailsService

We can now authenticate to access to the API using the credentials in this database.

Example Logins using JDBC UserDetailsService

```
$ curl http://localhost:8080/api/anonymous/hello?name=jim -u user1:password
hello, jim :caller=user1 ①

$ curl http://localhost:8080/api/anonymous/hello?name=jim -u user1:password1
hello, jim :caller=user1 ②

$ curl http://localhost:8080/api/anonymous/hello?name=jim -u user1:password2
hello, jim :caller=user1 ③
```

① authenticating using credentials from JDBC UserDetailsService

② authenticating using credentials from directly configured in-memory UserDetailsService

③ authenticating using credentials from injected in-memory UserDetailsService

However, we still have plaintext passwords in the database. Lets look to clean that up.

6.16. Encrypting Passwords

It would be bad practice to leave the user passwords in plaintext when we have the ability to store cryptographic hash values instead. We can do that through Java and the `BCryptPasswordEncoder`. The follow example shows using a shell script to obtain the encrypted password value.

Bcrypt Plaintext Passwords

```
$ htpasswd -bnBC 10 user1 password | cut -d\: -f2 ① ②
$2y$10$UvKwrln7xPp35c5sbj.9kuZ9jY9VYg/VylVTu88ZSCYy/YdcdP/Bq

$ htpasswd -bnBC 10 user2 password | cut -d\: -f2
```

```
$2y$10$9tYKBY7act5dN.2d7kumuOsHytIJW8i23Ua2Qogcm6OM638IXMmLS

$ htpasswd -bnBC 10 user3 password | cut -d\: -f2
$2y$10$AH6uepcNasVxlYeOhXX20.OX4cI3nXX.LsicoDE5G6bCP34URZZF2
```

① script outputs in format `username:encoded-password`

② `cut` command is breaking the line at the ":" character and returning second field with just the encoded value

6.16.1. Updating Database with Encrypted Values

I have updated the populate SQL script to modify the `{noop}` plaintext passwords with their `{bcrypt}` encrypted replacements.

Update Plaintext Passwords with Encrypted Passwords SQL

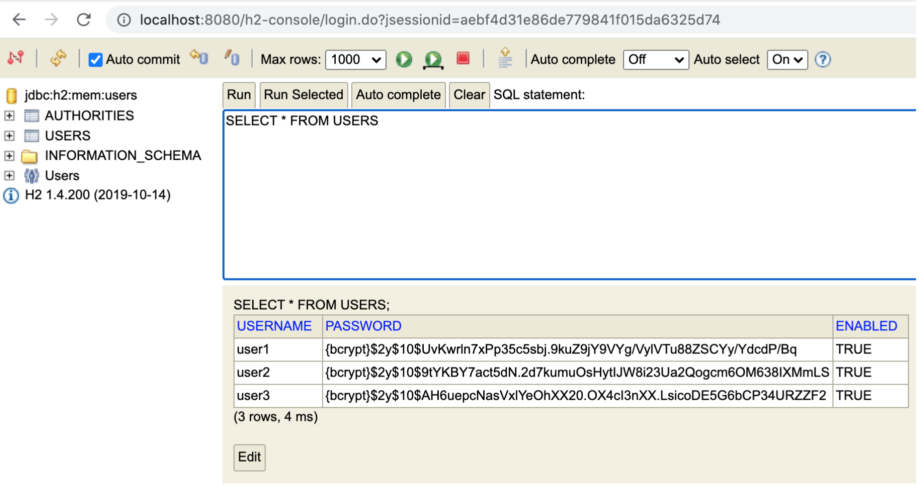
```sql
update users
set password='{bcrypt}$2y$10$UvKwrln7xPp35c5sbj.9kuZ9jY9VYg/VylVTu88ZSCYy/YdcdP/Bq'
where username='user1';
update users
set password='{bcrypt}$2y$10$9tYKBY7act5dN.2d7kumuOsHytIJW8i23Ua2Qogcm6OM638IXMmLS'
where username='user2';
update users
set password='{bcrypt}$2y$10$AH6uepcNasVxlYeOhXX20.OX4cI3nXX.LsicoDE5G6bCP34URZZF2'
where username='user3';
```

Don’t Store Plaintext or Decode-able Passwords

The choice of replacing the plaintext INSERTs versus using UPDATE is purely a choice made for incremental demonstration. Passwords should always be stored in their Cryptographic Hash form and never in plaintext in a real environment.

6.16.2. H2 View of Encrypted Passwords

Once we restart and run that portion of the SQL, the plaintext `{noop}` passwords have been replaced by `{bcrypt}` encrypted password values in the H2 console.



localhost:8080/h2-console/login.do?jsessionid=aebf4d31e86de779841f015da6325d74

☑ Auto commit | Max rows: 1000 | Auto complete: Off | Auto select: On

jdbc:h2:mem:users
⊞ AUTHORITIES
⊞ USERS
⊞ INFORMATION_SCHEMA
⊞ Users
H2 1.4.200 (2019-10-14)

```
SELECT * FROM USERS
```

SELECT * FROM USERS;

USERNAME	PASSWORD	ENABLED
user1	{bcrypt}$2y$10$UvKwrln7xPp35c5sbj.9kuZ9jY9VYg/VylVTu88ZSCYy/YdcdP/Bq	TRUE
user2	{bcrypt}$2y$10$9tYKBY7act5dN.2d7kumuOsHytIJW8i23Ua2Qogcm6OM638IXMmLS	TRUE
user3	{bcrypt}$2y$10$AH6uepcNasVxlYeOhXX20.OX4cI3nXX.LsicoDE5G6bCP34URZZF2	TRUE

(3 rows, 4 ms)

Figure 8. H2 User Access to Encrypted User Passwords

Chapter 7. Final Examples

7.1. Authenticate to All Three UserDetailsServices

With all UserDetailsServices in place, we are able to login as each user using one of the three sources.

Example Logins to All Three UserDetailsServices

```
$ curl http://localhost:8080/api/authn/hello?name=jim -u user1:password -v ②
> Authorization: Basic dXNlcjE6cGFzc3dvcmQ= ①
hello, jim :caller=user1

$ curl http://localhost:8080/api/authn/hello?name=jim -u user2:password1 ③
hello, jim :caller=user2

$ curl http://localhost:8080/api/authn/hello?name=jim -u user3:password2 ④
hello, jim :caller=user3
```

① we are still sending a base64 encoding of the plaintext password. The cryptographic hash is created server-side.

② password is from the H2 database

③ password1 is form the original in-memory user details

④ password2 is from the injected in-memory user details

7.2. Authenticate to All Three Users

With the JDBC UserDetailsService in place with encoded passwords, we are able to authenticate against all three users.

Example Logins to Encrypted UserDetails

```
$ curl http://localhost:8080/api/authn/hello?name=jim -u user1:password ①
hello, jim :caller=user1

$ curl http://localhost:8080/api/authn/hello?name=jim -u user2:password ①
hello, jim :caller=user2

$ curl http://localhost:8080/api/authn/hello?name=jim -u user3:password ①
hello, jim :caller=user3
```

① three separate user credentials stored in H2 database

Chapter 8. Summary

In this module, we learned:

- the various interfaces and object purpose that are part of the Spring authentication framework
- how to wire up an `AuthenticationManager` with `AuthenticationProviders` to implement authentication for a configured security filter chain
- how to implement `AuthenticationProviders` using only `PasswordEncoder` and `UserDetailsSource` primitives
- how to implement in-memory `UserDetailsService`
- how to implement a database-backed `UserDetailsService`
- how to encode and match encrypted password hashes
- how to configure security to display the H2 UI and allow it to be functional