Spring  
Security

short line

Your Name  
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# SHA256

**What SHA-256 Is and Its Output:**

SHA-256 is a hash function that takes an **input of any size** and produces **a fixed-size output**, which is a **256-bit string** of letters and numbers. This output is often referred to as a "fingerprint" or "digest."

**Key Properties of SHA-256 (and Hash Functions in General):**

* **Deterministic Scrambling:** For the same input, SHA-256 will always produce the exact same output. The process scrambles the data in a predictable manner.
* **Quote:** "given the same input it will always produce exactly the same output"
* **Fixed Size Output:** Regardless of the input size (a single letter or the entire Lord of the Rings series), the output will always be 256 bits long.
* **Quote:** "no matter what the size of the input the output will always be of a fixed length"
* **Irreversibility:** Given only the SHA-256 hash (the fingerprint), it should be computationally infeasible to determine the original input. Even a tiny change in the input results in a drastically different output, making reverse engineering extremely difficult.
* **Quote:** "if you only have access to the output the input should be unguessable" and "if just one letter changes in the input the output changes dramatically right it didn't just change by one character it changed like everything changed it seemingly changed in a random and complete way"

**Why SHA-256 is Special:**

1. **256-bit Output Length:** This specific length is a defining characteristic of SHA-256.
2. **Security:** SHA-256 is currently considered secure, meaning no significant exploitable vulnerabilities have been found. Unlike older hash functions like SHA-1 and MD5, no practical methods for easily creating collisions (different inputs producing the same hash) have been discovered.
3. **Speed:** SHA-256 is relatively fast, making it efficient for hashing large amounts of data quickly. However, this speed makes it less suitable for password hashing, where slower functions are preferred to hinder brute-force attacks.

**Real-World Use Cases of SHA-256:**

* **Anti-Virus Software:** When software is published (e.g., word.exe), a SHA-256 fingerprint is often provided alongside it. When a user downloads the software, their computer can calculate the SHA-256 hash of the downloaded file and compare it to the published fingerprint. If they match, it confirms the integrity of the file and assures the user it hasn't been tampered with or infected with malware.
* **Authentication (Auth):** SHA-256 plays a role in authentication processes. Websites often use it to generate authentication tokens. For example, upon successful login, a server might take a user's identifier (like a username) and append a secret key (known only to the server). This combined data is then hashed using SHA-256 to create a unique token. This token is then used to verify the user's identity in subsequent requests without needing to send the password repeatedly. The irreversibility of SHA-256 ensures that even if an attacker intercepts the token, they cannot easily derive the secret key or other sensitive information.
* **Blockchains (e.g., Bitcoin):** Bitcoin utilizes SHA-256 as its hashing algorithm. In a blockchain, each block of transactions contains a hash of its own data, as well as the hash of the previous block. This chaining of hashes ensures the integrity and immutability of the blockchain. If any data in a previous block is altered, its hash will change, which in turn will affect the hash of all subsequent blocks, making tampering easily detectable. The computational cost of generating new blocks makes it extremely difficult for malicious actors to retroactively change transaction history.

**Conclusion:**

SHA-256 is a fundamental cryptographic hash function with crucial properties like deterministic scrambling, fixed output size, and irreversibility. These properties make it invaluable for various real-world applications, including verifying file integrity, securing authentication processes, and underpinning the security of blockchain technologies like Bitcoin. While fast and efficient for many purposes, its speed makes it less suitable for password hashing, where slower, more computationally intensive functions are preferred. The continued security and widespread adoption of SHA-256 highlight its importance in modern digital security.

# Basic Web App Security

**Servlets in Java**

* A **Servlet Container** (like Tomcat or JBoss) handles HTTP requests and responses.
* When a browser sends a request (HTTP/HTTPS), the container converts it into a ServletRequest or HttpServletRequest object.
* This object is passed to a **Servlet**, which interacts with frameworks like Spring Boot and Spring Security.
* The servlet invokes your **business logic** (controllers, services).
* The response is processed similarly using a ServletResponse, which is then converted back to HTTP before sending to the client.

**Why Frameworks Help**

* Before frameworks like Spring Boot, developers had to write all web logic manually using servlets.
* Now, frameworks handle the boilerplate, letting developers focus on writing business logic with minimal configuration.

**Filters in Java**

* **Filters** intercept every HTTP request **before** it reaches the servlet.
* They're used to inspect, modify, or block requests and responses.
* In Spring Security, filters handle **authentication, authorization, and redirection** to login pages.

**Role of Filters in Spring Security**

* Spring Security uses a **chain of filters** to process every request.
* These filters check if the user is authenticated, authorized, or should be redirected.
* This mechanism ensures **security logic runs before** any business logic.

# Spring Security internal flow

## Filter Interface

**What is a Servlet Filter?** A Servlet Filter is part of the Java EE Servlet specification. It allows preprocessing and postprocessing of HTTP requests and responses in a web application.

*public interface* Filter {  
 *void* init(FilterConfig filterConfig) *throws* ServletException;  
 *void* doFilter(ServletRequest request, ServletResponse response, FilterChain chain)  
 *throws* IOException, ServletException;  
 *void* destroy();  
}

**Lifecycle Methods:**

* **init(FilterConfig config)**
  + Called once when the web application starts.
  + Used for initializing resources, configs, logging, etc.
* **doFilter(request, response, chain)**
  + Called for each matching HTTP request.
  + Core logic goes here.
  + Filters can:
    - Modify the request/response.
    - Pass control to the next filter using chain.doFilter().
    - Short-circuit the chain (e.g., by sending a response directly).
* **destroy()**
  + Called once during app shutdown.
  + Used to release resources initialized in init().

**How the Servlet Container Uses Filters**

Filter Registration

1. Via web.xml:

<filter>  
 <filter-name>authFilter</filter-name>  
 <filter-class>com.example.AuthFilter</filter-class>  
</filter>  
<filter-mapping>  
 <filter-name>authFilter</filter-name>  
 <url-pattern>/\*</url-pattern>  
</filter-mapping>

1. Via Annotation:

@WebFilter("/\*")  
*public class* AuthFilter *implements* Filter { ... }

**Execution Flow:**

1. Container starts → Instantiates all filters.
2. Calls init() on each filter.
3. For every incoming HTTP request:
   * Executes filters **in the order** defined.
   * Each filter decides whether to:
     + Pass the request to the next filter (chain.doFilter()).
     + Or handle it and stop the chain.

**How Spring Security Uses Filters**

Spring Security integrates into the servlet container’s filter system using two key components:

**A. DelegatingFilterProxy**

* A standard javax.servlet.Filter registered with the servlet container.
* Delegates filtering logic to a **Spring-managed bean**.
* Acts as a bridge between the servlet world and the Spring application context.

@Bean  
*public* FilterRegistrationBean<DelegatingFilterProxy> securityFilterChain() {  
 FilterRegistrationBean<DelegatingFilterProxy> registration = *new* FilterRegistrationBean<>();  
 registration.setFilter(*new* DelegatingFilterProxy("springSecurityFilterChain"));  
 registration.addUrlPatterns("/\*");  
 *return* registration;  
}

* It delegates to the bean named springSecurityFilterChain, which is typically an instance of FilterChainProxy.

**FilterChainProxy (Spring Security’s Filter Chain Manager)**

* + The **main filter** that manages multiple security filter chains.
  + Each SecurityFilterChain contains filters like:
    - SecurityContextPersistenceFilter
    - UsernamePasswordAuthenticationFilter
    - ExceptionTranslationFilter
    - CsrfFilter
    - And others...

**Execution:** When FilterChainProxy#doFilter() is called, it:

1. **Matches the incoming request** with an appropriate SecurityFilterChain.
2. **Creates a VirtualFilterChain** containing matched Spring Security filters.
3. Executes each filter in order.

**What is VirtualFilterChain?**

* A Spring-internal class that simulates the Servlet's FilterChain.
* Manages Spring Security’s internal filter sequence and invokes them one by one.

Example Flow : Assume: filters = [FilterA, FilterB, FilterC]

The flow:

* FilterChainProxy#doFilter() → Creates VirtualFilterChain
* FilterA#doFilter() is called → calls chain.doFilter() (i.e., VirtualFilterChain)
* VirtualFilterChain → Calls FilterB#doFilter()
* And so on…
* After the last filter, control returns to the servlet (e.g., your controller).

*@Override  
public void* doFilter(ServletRequest request, ServletResponse response) *throws* IOException, ServletException {  
 *if* (*this*.currentPosition == *this*.size) {  
 *this*.originalChain.doFilter(request, response);  
 *return*;  
 }  
 *this*.currentPosition++;  
 Filter nextFilter = *this*.additionalFilters.get(*this*.currentPosition - 1);  
 *if* (logger.isTraceEnabled()) {  
 String name = nextFilter.getClass().getSimpleName();  
 logger.trace(LogMessage.format("Invoking %s (%d/%d)", name, *this*.currentPosition, *this*.size));  
 }  
 nextFilter.doFilter(request, response, *this*);  
}

**Filters vs. Interceptors**:

* Filters: Servlet-level, sit outside Spring MVC, work on all requests.
* Interceptors: Spring MVC-specific, can access handler/controller info.

| **Order** | **Filter** | **Purpose** |
| --- | --- | --- |
| 1 | WebAsyncManagerIntegrationFilter | Integrates SecurityContext with async web requests. |
| 2 | SecurityContextPersistenceFilter | Loads/Saves the SecurityContext (e.g., from session). |
| 3 | HeaderWriterFilter | Writes HTTP security headers (HSTS, CSP, etc.). |
| 4 | CorsFilter *(if defined)* | Handles CORS preflight and headers. |
| 5 | CsrfFilter | Validates CSRF tokens on state-changing HTTP methods. |
| 6 | LogoutFilter | Processes logout URLs. |
| 7 | OAuth2AuthorizationRequestRedirectFilter | Redirects to OAuth2 provider login (if configured). |
| 8 | Saml2WebSsoAuthenticationRequestFilter | Starts SAML 2.0 login flow (if configured). |
| 9 | X509AuthenticationFilter | Authenticates based on client certificates. |
| 10 | AbstractPreAuthenticatedProcessingFilter | Handles requests already authenticated by an external system. |
| 11 | CasAuthenticationFilter | CAS login filter (if CAS is used). |
| 12 | UsernamePasswordAuthenticationFilter | Authenticates login form credentials. |
| 13 | OpenIDAuthenticationFilter | Legacy OpenID login (rarely used now). |
| 14 | DefaultLoginPageGeneratingFilter | Generates login page if none provided. |
| 15 | DefaultLogoutPageGeneratingFilter | Generates logout page if none provided. |
| 16 | BearerTokenAuthenticationFilter | Authenticates using Bearer (JWT) token in header. |
| 17 | BasicAuthenticationFilter | Authenticates using HTTP Basic Auth header. |
| 18 | RequestCacheAwareFilter | Saves the original request and restores it post-login. |
| 19 | SecurityContextHolderAwareRequestFilter | Adds security-specific methods to the request (e.g., isUserInRole). |
| 20 | AnonymousAuthenticationFilter | Provides anonymous auth when no user is authenticated. |
| 21 | SessionManagementFilter | Handles invalid or expired sessions. |
| 22 | ExceptionTranslationFilter | Handles exceptions (like 403 or redirect to login). |
| 23 | FilterSecurityInterceptor | Performs authorization (access control check). |

## Spring Security flow

A diagram of a security management system

AI-generated content may be incorrect.

**Spring Security components flow:**

1. **Client Request**: A browser, mobile app, or Postman sends a request to access a protected REST API or MVC path.
2. **Spring Security Filters**:
3. Intercepts every request (over 20 filters exist). Checks if the user is authenticated.
4. If user is unauthenticated i.e no *Anthentication* object is present in request and if it is trying to access a protected resource, spring redirects to the login. By default, *DefaultLoginPageGeneratingFilter* is used to generate the page
5. In Spring Security, the filter that checks if a request trying to access a protected resource is authenticated or not is the *FilterSecurityInterceptor*.
6. The *FilterSecurityInterceptor* is positioned at the end of the filter chain and is responsible for the final authorization decision. It verifies whether the current user (represented by the Authentication object in the SecurityContext) has the necessary permissions to access the requested resource based on the configured access control rules.
7. **Authentication Object Creation**:
   1. Filters extract credentials from the request and creates an *Authentication* object (with username, password, isAuthenticated=false).
   2. By default, it uses *UsernamePasswordAuthenticationFilter*
      1. This is a concrete implementation of *AbstractAuthenticationProcessingFilter*.
      2. It reads the username and password from the HttpServletRequest in the *attemptAuthentication* method and returns *Authentication* object.

*public* Authentication attemptAuthentication(HttpServletRequest request, HttpServletResponse response)

* + 1. It creates a *UsernamePasswordAuthenticationToken*(implementation of *Authentication*) Token with these credentials.
    2. This token is unauthenticated at this point (setAuthenticated(false)).
  1. Inside *attemptAuthentication* method this object is passed to Authentication manager via authenticate() method of Authentication manager

*return this*.getAuthenticationManager().authenticate(authRequest);

1. **Authentication Manager**: Once received request from filter, it delegates the validating of the user details to the authentication providers available. Since there can be multiple providers inside an app, it is the responsibility of the AuthenticationManager to manage all the authentication providers available
   1. Receives the *Authentication* object and delegates actual authentication to available AuthenticationProviders.
   2. The default implementation is *ProviderManager*.
   3. The *ProviderManager* iterates through a list of AuthenticationProviders and selects the appropriate one in the *authenticate* method.
   4. For username/password-based login, this is typically the *DaoAuthenticationProvider*.
2. **Authentication Providers**:
   1. *DaoAuthenticationProvider* calls *retrieveUser()*, which delegates to a UserDetailsService/UserDetailsManager (like *InMemoryUserDetailsManager* or *JdbcUserDetailsManager*) to fetch user details.

*protected final* UserDetails retrieveUser(String username, UsernamePasswordAuthenticationToken authentication)

* 1. *loadUserByUsername* present inside UserDetailsService/UserDetailsManager classes like *InMemoryUserDetailsManager* or *JdbcUserDetailsManager*
     1. UserDetailsManager has more API like create user, change password etc.
     2. UserDetailsService only has *loadUserByUsername* method
  2. User details are returned in a class called *User* which implements *UserDetails.* This class can be thought of as a counterpart of *Authentication* object cretaed in Filters. While the *Authentication* object stores the credentials provided by client. *User* class has details from database or in memory. Both are eventually matched to authentiacate client. Construtor below

*public* User(String username, String password, Collection<? *extends* GrantedAuthority> authorities) {  
 *this*(username, password, *true*, *true*, *true*, *true*, authorities);  
}

1. *DaoAuthenticationProvider* uses **PasswordEncoder** to compare user-provided and stored passwords securely.
   1. Password matching is performed using a PasswordEncoder (like BCryptPasswordEncoder).
   2. It compares the raw password entered with the hashed password stored.
2. **Authentication Success/Failure**:
   1. On success: isAuthenticated=true is set in the *Authentication* object by *DaoAuthenticationProvider* and returned to*ProviderManager*
3. Updated object is returned to filters
4. **Security Context**: Once the request has been authenticated, the Authentication will usually be stored in a thread-local SecurityContext managed by the SecurityContextHolder
   1. Stores the authenticated object against a session ID.
   2. For future requests with the same session, authentication isn’t re-processed data is reused from the context.
5. **Response to Client**:
   1. If authenticated, the client gets the API response.
   2. If authentication fails, a 401 or 403 error is returned.

Below will set the security logging level to Trace by default. It can be overwritten using the environment variable also

logging.level.org.springframework.security=${SPRING\_SECURITY\_LOG\_LEVEL:TRACE}

A diagram of a diagram

AI-generated content may be incorrect.

Detail of **DaoAuthenticationProvider** Workflow

The DaoAuthenticationProvider class in Spring Security follows this specific workflow when authenticating a user:

1. **authenticate(Authentication authentication)** - This is the main method that orchestrates the authentication process, inherited from AbstractUserDetailsAuthenticationProvider.
2. **retrieveUser(String username, UsernamePasswordAuthenticationToken authentication)** - Retrieves the UserDetails object using the configured UserDetailsService.
3. **additionalAuthenticationChecks(UserDetails userDetails, UsernamePasswordAuthenticationToken authentication)** - Performs the password comparison using the configured PasswordEncoder.
4. **preAuthenticationChecks.check(user)** - Validates pre-authentication conditions like whether the account is enabled, expired, or locked.
5. **postAuthenticationChecks.check(user)** - Validates post-authentication conditions like password expiration.
6. **createSuccessAuthentication(Object principal, Authentication authentication, UserDetails user)** - Creates a fully authenticated object with granted authorities from the UserDetails.

During this process, several important internal checks happen:

* DefaultPreAuthenticationChecks calls:
  + userDetails.isAccountNonLocked()
  + userDetails.isEnabled()
  + userDetails.isAccountNonExpired()
* DefaultPostAuthenticationChecks calls:
  + userDetails.isCredentialsNonExpired()
* The password comparison happens in additionalAuthenticationChecks using:
  + passwordEncoder.matches(presentedPassword, userDetails.getPassword())
* The DaoAuthenticationProvider throws specific exceptions based on validation failures:
* DisabledException - if the account is disabled
* LockedException - if the account is locked
* BadCredentialsException - if the password doesn't match
* AccountExpiredException - if the account is expired
* CredentialsExpiredException - if the credentials are expired

**DaoAuthenticationProvider vs Other AuthenticationProvider Usage Scenarios**

DaoAuthenticationProvider is used when authentication needs to be performed against user credentials stored in a data source (typically a database) that can be accessed through a UserDetailsService implementation. It's the default and most commonly used provider in Spring Security.

**Usage scenarios:**

* Username/password authentication with credentials stored in a database
* Custom user stores where you implement your own UserDetailsService
* Form-based authentication workflows
* Basic authentication scenarios

**Example implementations:**

@Bean

public DaoAuthenticationProvider authenticationProvider() {

DaoAuthenticationProvider provider = new DaoAuthenticationProvider();

provider.setUserDetailsService(userDetailsService);

provider.setPasswordEncoder(passwordEncoder());

return provider;

}

**Other AuthenticationProviders**

**1. LdapAuthenticationProvider**

**Scenarios:**

* Enterprise applications integrating with LDAP/Active Directory
* Single sign-on with directory services
* Corporate environments with centralized user management

**Example:**

@Bean

public LdapAuthenticationProvider ldapAuthProvider() {

BindAuthenticator authenticator = new BindAuthenticator(contextSource());

authenticator.setUserDnPatterns(new String[] { "uid={0},ou=people" });

return new LdapAuthenticationProvider(authenticator, authoritiesPopulator());

}

**2. JwtAuthenticationProvider**

**Scenarios:**

* Microservices architecture
* RESTful APIs
* Mobile applications
* Stateless authentication requirements

**Example:**

@Bean

public JwtAuthenticationProvider jwtAuthenticationProvider() {

return new JwtAuthenticationProvider(jwtTokenValidator);

}

**3. CasAuthenticationProvider**

**Scenarios:**

* Enterprise single sign-on solutions
* University/educational institution systems
* Multi-application environments with central authentication

**Example:**

@Bean

public CasAuthenticationProvider casAuthenticationProvider() {

CasAuthenticationProvider provider = new CasAuthenticationProvider();

provider.setServiceProperties(serviceProperties());

provider.setTicketValidator(ticketValidator());

provider.setUserDetailsService(userDetailsService);

provider.setKey("CAS\_PROVIDER\_KEY");

return provider;

}

**4. OAuth2LoginAuthenticationProvider**

**Scenarios:**

* Social login integration (Google, Facebook, GitHub)
* B2B applications using OAuth 2.0
* Applications delegating authentication to third-party providers

Example

// Typically configured through Spring Security OAuth2 support

@Bean

public SecurityFilterChain filterChain(HttpSecurity http) throws Exception {

http

.oauth2Login(oauth2 -> oauth2

.clientRegistrationRepository(clientRegistrationRepository())

.authorizedClientService(authorizedClientService())

);

return http.build();

}

# Overriding Security Configuration

Default Security Configuration:

Spring Security uses a class internally (e.g., *SpringBootWebSecurityConfiguration*) to apply default security settings.

*@Configuration*(proxyBeanMethods = *false*)  
*@ConditionalOnDefaultWebSecurity  
static class* SecurityFilterChainConfiguration {  
  
 *@Bean  
 @Order*(SecurityProperties.BASIC\_AUTH\_ORDER)  
 SecurityFilterChain defaultSecurityFilterChain(HttpSecurity http) *throws* Exception {  
 http.authorizeHttpRequests((requests) -> requests.anyRequest().authenticated());  
 http.formLogin(withDefaults());  
 http.httpBasic(withDefaults());  
 *return* http.build();  
 }

This includes a method defaultSecurityFilterChain(HttpSecurity http) with below configurations

* **@Order(SecurityProperties.BASIC\_AUTH\_ORDER)** - This sets the priority of this security filter chain. SecurityProperties.BASIC\_AUTH\_ORDER is a predefined constant in Spring Security (typically with value 100) that determines when this filter chain should be applied relative to other security configurations.
* **SecurityFilterChain defaultSecurityFilterChain(HttpSecurity http) throws Exception** - This method declares a security filter chain with the HttpSecurity object injected by Spring.
* **http.authorizeHttpRequests((requests) -> requests.anyRequest().authenticated())** - any HTTP request to any endpoint requires authentication
* **http.formLogin(withDefaults())** - This enables form-based authentication with default settings. It creates a login page at /login and handles login form submissions.
* **http.httpBasic(withDefaults())** - This enables HTTP Basic Authentication as a fallback authentication method, which is useful for API access or non-browser clients.
* **return http.build()** - This builds and returns the complete security filter chain with all the configurations applied.

What It Means:

* Any request must be authenticated.
* Users are redirected to a login page for UI-based apps or use HTTP Basic Auth for APIs.
* This explains the behavior we see in the browser: all endpoints are protected by default.

Comment out the @Bean on the customer SecurityFilterChain defined in SecurityConfig.java and access any endpoint like <http://localhost:8080/private/balance> or <http://localhost:8080/public/home> . As all are protected you will get Spring default login page. Since we have UserDetailsService bean configured we need to login using the credentials mentioned in the bean. Since there are a lot of Additional filters you will not get the page but login can be successful.

## Permit Deny all

* **permitAll() with anyRequest()**: Makes all endpoints publicly accessible — **no security at all**.
* **denyAll() with anyRequest()**: Blocks all endpoints — returns **403 Forbidden** even after authentication. Shows login page first, then denies access.

We can override these configurations by selectively allowing or endpoints or making them authenticated

http.authorizeHttpRequests(authorizationManagerRequestMatcherRegistry -> authorizationManagerRequestMatcherRegistry  
 .requestMatchers("/favicon.ico", "/public/style.css", "/public/main.js", "/images/\*\*","/public/home.html", "/h2-console/\*\*").permitAll()  
 .requestMatchers(HttpMethod.POST, "/v1/api/login", "/v2/api/login", "/v3/api/login").permitAll()  
 .requestMatchers("/private/balance", "/private/message", "/admin/announcement", "/admin/loan").authenticated()  
 .requestMatchers("/public/home", "/public/contact", "/error", "/public/myLogin","/public/me").permitAll()  
 )

When you configure a Spring Security filter chain with multiple rules, the order matters significantly and URL patterns are matched in the order they're defined. The first matching rule applies.

http.authorizeHttpRequests(authorize -> authorize  
 .requestMatchers("/public/\*\*").permitAll() *// This applies first for /public/\*\* paths* .requestMatchers("/\*\*").authenticated() *// This applies to everything else* );

In this example:

* Requests to /public/\*\* will be permitted without authentication
* All other requests (/\*\*) will require authentication

If we keep like below, then everything would require authentication because the /\*\* pattern (which matches everything) is evaluated first and the second rule would never be reached. Spring Security follows an "first-match-wins" approach, so properly ordering your rules is crucial for implementing the security policy you want.

http.authorizeHttpRequests(authorize -> authorize  
 .requestMatchers("/\*\*").authenticated() *// This would match everything first* .requestMatchers("/public/\*\*").permitAll() *// This would never be reached!* );

## Form Login and HTTP basic

By default, both formLogin() and httpBasic() are enabled in a Spring Boot web app.

**httpBasic()**

1. **Using a Browser**: When you access a protected endpoint, the browser will show a basic login dialog. Enter your username and password. <http://localhost:8080/private/balance>
2. **Using cURL** curl -u admin:qwerty <http://localhost:8080/private/balance>
3. **Using HTTP Headers**: Send an "Authorization" header with the value "Basic" followed by the base64-encoded string of "username

echo -n "admin:qwerty" | base64

curl -H "Authorization: Basic YWRtaW46cXdlcnR5" <http://localhost:8080/private/balance>

To access the API with Postman using HTTP Basic Authentication, follow these steps:

1. Open Postman and create a new request
2. Enter your URL: http://localhost:8080/private/balance
3. Go to the "Authorization" tab
4. From the Type dropdown, select "Basic Auth"
5. Enter your credentials:
   1. Username: admin
   2. Password: qwerty

Postman will automatically handle the base64 encoding and add the appropriate Authorization header to your request.

Alternatively, you can manually set the header:

1. Go to the "Headers" tab
2. Add a new header:
   * Key: Authorization
   * Value: Basic YWRtaW46cXdlcnR5

Note that HTTP Basic Authentication:

* **Sends credentials with every request**
* Base64 encoding is NOT encryption (it's easily decoded)
* Should be used with HTTPS to secure the credentials in transit
* Doesn't provide logout functionality (credentials are cached by the browser)
* Should be disabled if you are using UI based login

**formLogin()**

* When this is enabled and user accesses an authenticated page. Spring will generate a default login page using DefaultLoginPageGeneratingFilter
* In REST API-based applications (especially consumed by other services or mobile apps), formLogin() is unnecessary. Hence, it is **recommended to disable it**.
* To disable formLogin(), avoid using deprecated methods like .withDefaults() or .formLogin(). Instead, use a lambda with .formLogin(form -> form.disable()).
* Disabling formLogin() ensures that the login page is not shown. Authentication will then be handled by BasicAuthenticationFilter, not UsernamePasswordAuthenticationFilter.

**Internals:**

* **Form Login**: Extracts credentials using UsernamePasswordAuthenticationFilter from HttpServletRequest.
* **HTTP Basic**: Uses BasicAuthenticationFilter, which looks for the Authorization header (e.g., Basic base64(username:password)).
* The credentials are Base64-decoded and parsed into a UsernamePasswordAuthenticationToken.

**Testing Behavior:**

* After disabling formLogin(), browser triggers httpBasic() login with a popup.
* Disabling both formLogin() and httpBasic() leads to **403 Forbidden**, as no authentication method is available.

**Best Practice:**

* Enable/disable authentication mechanisms based on project needs.

## Session Management

When authentication succeeds:

1. **Session Creation**: If a session doesn't exist yet, Spring creates an HTTP session.
2. **JSESSIONID Cookie**: The server sends a JSESSIONID cookie to the client, which is the session identifier.
3. **SecurityContext Storage**: The SecurityContextHolder stores the authenticated principal in the SecurityContext.
4. **SecurityContext Persistence**: The SecurityContextPersistenceFilter saves the SecurityContext to the session.

**Subsequent Requests**

For each subsequent request:

1. **Cookie Transmission**: The browser automatically sends the JSESSIONID cookie.
2. **Session Retrieval**: The server identifies the session using the JSESSIONID.
3. **SecurityContext Restoration**: The SecurityContextPersistenceFilter retrieves the SecurityContext from the session and places it in the SecurityContextHolder.
4. **Authorization**: The FilterSecurityInterceptor uses the authenticated principal from the SecurityContext to make authorization decisions.
5. **Cleanup**: After request processing, the SecurityContextHolder is cleared.

If we tamper with JSESSIONID the request will fail

**JSESSIONID Generation and Storage**

1. **Random Generation**:
   * 1. The JSESSIONID is a cryptographically secure random value?
     2. It's typically a long string like 3A1G6E23ABC15679131415E3E28106A8
     3. The randomness is important to prevent session hijacking attacks
2. **Server-Side Storage**:
   * 1. When the server generates a JSESSIONID, it creates an entry in the session store
     2. This session store is usually an in-memory map maintained by the servlet container (Tomcat, Jetty, etc.)
     3. The structure is essentially: Map<String, HttpSession> where the key is the JSESSIONID
3. **Spring Security Context**:
   * 1. Spring Security stores the SecurityContext object in this HTTP session
     2. Specifically, it's stored as an attribute within the session with a predetermined key

In a distributed system with multiple servers, the standard JSESSIONID and SecurityContext approach faces significant challenges. Here's how session management typically works in such environments:

**Challenges in Distributed Systems**

1. **Session Affinity Problem**:
   * 1. The JSESSIONID stored in one server's memory isn't accessible to other servers
     2. If a user's request goes to Server A first and then Server B, authentication will be lost
2. **Server Failure Issues**:
   * 1. If the server holding a session fails, all users authenticated on that server lose their sessions
     2. This creates poor user experience and potential security issues

**Common Solutions for Distributed Systems**

**1. Sticky Sessions (Session Affinity)**

* Configure the load balancer to route all requests from the same user to the same server
* Uses the JSESSIONID to determine routing
* **Drawbacks**: Creates uneven load distribution and fails if the specific server goes down

User -> Load Balancer (reads JSESSIONID) -> Always routes to Server A

**2. Centralized Session Store**

* Store sessions in a shared external system accessible by all application servers
* Common implementations:
  + Redis session store
  + Database-backed sessions
  + Memcached

**3. JWT (JSON Web Tokens)**

* Stateless approach where authentication data is encoded in a signed token sent to the client
* No server-side session storage required
* Each request contains all the necessary authentication information

**4. Spring Session**

* Spring Session provides a standardized way to address distributed sessions. Spring Session transparently replaces the container's HttpSession implementation, allowing session data to be stored in:
  + Redis
  + JDBC (database)
  + MongoDB
  + Hazelcast
  + Other distributed stores

Typical Production Setup : A typical enterprise setup might look like:

Client -> Load Balancer -> Multiple App Servers -> Shared Redis Session Store

1. When a user authenticates, the session is stored in Redis
2. The JSESSIONID cookie is sent to the browser
3. On subsequent requests, any server can retrieve the session from Redis using the JSESSIONID
4. Each server can then reconstruct the SecurityContext for that user

This approach provides both high availability and scalability while maintaining session integrity.

**Additional Considerations**

* **Session Replication**: Some app servers support direct session replication between nodes
* **Serialization**: Security contexts must be serializable for distributed storage
* **Token Expiration**: Proper timeout policies must be implemented
* **Cookie Settings**: Use secure, HTTP-only cookies with appropriate domain settings
* **Session Invalidation**: Proper logout mechanisms must invalidate sessions across all servers

The JSESSIONID in Java web applications isn't inherently a cryptographically secure random value by default. What makes a random value "cryptographically secure" involves several important security properties:

1. **Unpredictability**: Cryptographically secure random values cannot be predicted based on previous values, even with knowledge of the generation algorithm. An observer shouldn't be able to guess future or past values.
2. **Uniform distribution**: The values must be uniformly distributed across the entire range, with no bias toward certain values or patterns.
3. **High entropy**: They contain sufficient randomness to resist brute force attacks.
4. **Statistical randomness**: They pass statistical tests for randomness.
5. **Non-deterministic**: Truly secure random values often incorporate entropy from physical sources (hardware events, timing of interrupts, etc.) rather than just using algorithmic methods.

For generating JSESSIONID values securely, Java applications should use Java's SecureRandom class rather than standard Random implementations. This is especially important because session identifiers can be targets for session hijacking attacks if they're predictable.

In more secure applications, session ID generation typically involves:

SecureRandom secureRandom = new SecureRandom();

byte[] randomBytes = new byte[32]; // 256 bits of randomness

secureRandom.nextBytes(randomBytes);

String sessionId = Base64.getEncoder().encodeToString(randomBytes);

The specific implementation of JSESSIONID generation depends on the application server being used (Tomcat, Jetty, etc.), and most modern servers do use secure random generation methods by default, though this wasn't always the case in older versions.

## Passwords

**Problem 1: Hardcoding Passwords in Source Code**

* The password is written directly in your Java code or application.properties
* This is risky because:
  + If the code is committed to GitHub or shared, **anyone can see your password**.
  + Even for simple demo apps, this can lead to **unauthorized access** if someone uses the password to hit your secured APIs.

**Problem 2: Password Stored in Plain Text in Memory**

* Even after hardcoding, Spring stores that password **as-is** (plain text) in memory.
* If a hacker somehow gets a **heap dump** of your app (basically a memory snapshot), they can easily extract the password.

**Solution: Use a PasswordEncoder**

Spring Security provides the PasswordEncoder interface to handle passwords **securely** using hashing.

You can create a bean using:

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

* This gives you flexibility to use **multiple encoders**.
* By default, it uses **BCryptPasswordEncoder**, which is secure and recommended for production.
* The prefix {bcrypt} is used internally or explicitly like:

**Supported Encoders & Prefixes**

Spring supports many encoders via prefixes, for example:

| **Prefix** | **Encoder** | **Secure?** | **Use Case** |
| --- | --- | --- | --- |
| {noop} | NoOpPasswordEncoder | No | Plain text (NOT secure) |
| {bcrypt} | BCryptPasswordEncoder | Yes | Recommended for production |
| {scrypt} | SCryptPasswordEncoder | Yes | Secure alternative |
| {sha256} | StandardPasswordEncoder | No(deprecated) | Legacy support |

So your user credentials might look like:

*public* UserDetailsService userDetailsService() {  
 UserDetails admin = User.withUsername("admin").password("{noop}erQu773\_\_").roles("ADMIN").build();  
 *//https://bcrypt-generator.com/* UserDetails user = User.withUsername("user").password("{bcrypt}$2a$12$HknEwKGJto6O4zTn0pSA6.L9OX2wDEa3beQpN3W5XKrbNCipR0eTm")  
 .roles("USER").build();  
 *return new* InMemoryUserDetailsManager(admin, user);  
}

**Why Does Spring Security Use Bcrypt by Default?**

* You might not have **explicitly specified** to use bcrypt, yet it is still being used.
* That’s because Spring Security provides a **default implementation** using: PasswordEncoderFactories.createDelegatingPasswordEncoder()
* This method returns a DelegatingPasswordEncoder.
* It uses bcrypt as the default encoder, with a prefix like {bcrypt}.
* This prefix is stored along with the hashed password to help Spring know which algorithm was used.
* But using createDelegatingPasswordEncoder() is future-proof. If standards change or you need to support multiple formats (e.g., legacy {MD5}), Spring handles it automatically by checking the prefix.

**Why use PasswordEncoderFactories.createDelegatingPasswordEncoder()?**

Because:

* It supports **multiple encoders** via prefix.
* You can **migrate legacy** systems (e.g., {md4}, {noop}) while still supporting modern ones.
* Future Spring Security updates may change the recommended encoder; using the factory lets you adapt without rewriting code.

**How login works with PasswordEncoder**

* User enters plain password (e.g., 54321).
* Spring fetches the hashed password from memory or DB (e.g., a {bcrypt} hash).
* It uses the appropriate PasswordEncoder (based on the prefix) to compare:
  + matches(rawPassword, hashedPassword)
* If it matches, login is successful.

### Encoding

**Encoding** is:

* A process of converting data from one form to another.
* **Not** meant for security.
* **Reversible** — anyone can decode it, without needing a password or secret key.
* Example: If you **BASE64 encode** a password like "Amit Saha”, you get QW1pdCBTYWhhCg==
* But this isn’t secure! Anyone who knows it's base64 can decode it back easily.

$ echo "Amit Saha" | base64

QW1pdCBTYWhhCg==

$ echo "QW1pdCBTYWhhCg==" | base64 --decode

Amit Saha

openssl base64 -in plain.txt -out encode.txt

openssl base64 -d -in encode.txt -out decode.txt

**Why Encoding is NOT good for password protection**

* **No secrets involved**: Anyone can reverse it with a simple tool or script.
* **Fully reversible**: The data (like passwords) can be brought back to original form.
* If a hacker gets access to your database, they can **easily decode** the passwords.

### Encryption

**Encryption: What It Is**

* Encryption is the process of transforming readable data (plaintext) into an unreadable format (ciphertext) to protect its confidentiality.
* It uses an algorithm and a key to do this.
* Decryption requires the same key (symmetric) or a corresponding key (asymmetric).

Two Types of Encryptions

**1. Symmetric Encryption**

* Uses the **same secret key** for both encryption and decryption.
* Example: AES (Advanced Encryption Standard).
* **Risk**: If someone gains access to the key, they can decrypt everything.
* **Use case**: Good for encrypting **data at rest** (e.g., files on disk, S3 buckets).

**2. Asymmetric Encryption**

* Uses a **pair of keys**: public key (for encryption) and private key (for decryption).
* Example: RSA, ECC.
* **Public key** can be shared with anyone; only the **private key** holder can decrypt.
* **Use case**: Ideal for **data in transit** (e.g., HTTPS, API calls).

Example openssl enc -aes-256-cbc -pass pass:12345 -pbkdf2 -in plain.txt -out encrypt.txt -base64

|  |  |
| --- | --- |
| openssl enc | Use OpenSSL's encryption tool |
| -aes-256-cbc | AES encryption algorithm with 256-bit key and CBC mode |
| -pass pass:12345 | Secret key (password) used for encryption is 12345 |
| -pbkdf2 | Strengthens the password-derived key using a modern key derivation function (makes it harder to brute-force) |
| -in plain.txt | Input file containing the original password |
| -out encrypt.txt | Output file to store the encrypted text |
| -base64 | Encode the encrypted binary data to base64 (makes it human-readable & safe to store/send) |

**Decryption Process:** openssl enc -aes-256-cbc -base64 -pass pass:12345 -d -pbkdf2 -in encrypt.txt -out decrypt.txt

| **Part** | **Meaning** |
| --- | --- |
| -d | This flag tells OpenSSL to **decrypt** |
| Rest of the flags | Must **match** the encryption process (same algorithm, password, etc.) |
| encrypt.txt | Input file containing encrypted data |
| decrypt.txt | Output file where decrypted data (original password) is written |

**Why Not Encryption for Passwords?**

The key reason : **Encryption can be reversed** if someone gets the key. Passwords should never be something that can be reversed.

**Problems with Using Encryption for Passwords:**

* You must **store the encryption key** securely.
* If the **key is compromised**, all passwords are compromised.
* Internal threats (even within the org) can be dangerous.
* Encryption ensures **confidentiality**, but not **integrity**.

So What Should Be Used for Passwords?

The correct approach is:

### Hashing

* Hashing is a **one-way function**: once hashed, it **cannot be reversed**. Its is a one-way process that turns your password into a fixed-length "digest" using a mathematical function (like SHA-256).
* Common hashing algorithms: **bcrypt**, **PBKDF2**, **Argon2**.
* Even if someone steals the hashed passwords, **they can't convert them back** to the original passwords easily (due to salting and computational cost).
* It ensures **integrity**, **non-reversibility**, and **better security**.

echo -n "password" | openssl dgst -sha256

**Hashing Has Drawbacks Too!**

1. Same Input = Same Hash (Deterministic Nature)
   1. If two users (U1 and U2) use the same password 12345, both will have the same hash (aef) in the database.
   2. That means if a hacker knows one password's hash, they can identify all users using the same password.
2. Hashing Is Too Fast
   1. Hash functions are designed to be very fast.
   2. This is great for performance, but bad for security — because it helps hackers guess millions of passwords very quickly.

**How Hackers Exploit These Weaknesses**

1. Brute Force Attack
   1. The hacker tries every possible common password and hashes them.
   2. Example: try 123, 1234, 12345, password, etc., one by one and hash them.
   3. If the hash matches a known value (e.g., aef), they’ve cracked the password.
2. Dictionary or Rainbow Table Attack
   1. Instead of calculating hashes every time, hackers pre-compute and store them.
   2. They create a giant dictionary
   3. During a breach, they just look up the hash in their prebuilt table — no computation needed.
3. **Rainbow Tables**
   1. These are **space-efficient, optimized** versions of dictionary tables.
   2. Designed to reduce storage needs and speed up the lookup process.

**Solution 1: Add a Salt to the Password**

**What is a Salt?** A **salt** is a **random string** added to the user's password **before hashing** it.

**Why is Salt Useful?** If two users choose the **same password** (e.g., "12345"), hashing alone would give the **same hash**. That’s bad because it makes it easier for hackers to recognize reused passwords.

By adding a **unique salt** per user:

* Each hash becomes **unique**, even if the passwords are the same.
* It defeats **rainbow table** and **dictionary attacks**.

**How Does It Work?**

**During Registration:**

* User enters password → e.g., "12345".
* Backend generates a **random salt** → e.g., "aex2fdac".
* Concatenate salt + password → "aex2fdac12345".
* Hash that combination → e.g., "af4c".
* Store both:
  + Salt: "aex2fdac"
  + Hash: "af4c"

**During Login:**

* User enters password "12345".
* System fetches stored salt "aex2fdac".
* Concatenates again → "aex2fdac12345".
* Hashes it → gets "af4c".
* Compares with stored hash. If it matches → login success.

**Why Salt Helps:**

Even if a hacker steals the hashed password:

* They **can’t use precomputed hash tables** (rainbow tables) because they **don’t know the salt in advance**.
* Each user's hash is unique, so **same password ≠ same hash**.

**Solution 2: Slow Down Hashing with Specialized Algorithms**

**Why?**

* Hash functions (like SHA-256) are **very fast**, which helps hackers.
* Hackers can try **millions of guesses per second** using brute force.

**Solution: Use "slow" password hashing algorithms**

These are designed to make brute force expensive in time and resources.

Examples:

* **BCrypt**
* **Scrypt**
* **Argon2**

These:

* Take **~1 second** per hash (instead of microseconds).
* Use **CPU and memory** heavily.
* Can be **configured** to be even slower.

**Real-World Impact:**

* A user logging in waits **1 second**—not a big deal.
* But a hacker trying **millions of guesses** needs **years of compute time and a huge budget**.

**Real Implementations (a.k.a. the ones that aren’t rotting in the deprecated bin):**

1. **BCryptPasswordEncoder (Popular Kid)**
   1. Hashes password using BCrypt algorithm.
   2. Built-in salting.
   3. Very secure. Very recommended.
   4. Slows down hashing enough to make brute-force attempts painful.
2. **Argon2PasswordEncoder (New Kid on the Block)**
   1. Uses Argon2, winner of the Password Hashing Competition (yes, that’s a real thing).
   2. More tunable and future-ready than BCrypt.
   3. Slower = better defense.
   4. Requires native libs sometimes, so can be annoying to set up.
3. **Pbkdf2PasswordEncoder (Solid, Respectable)**
   1. Uses PBKDF2 with configurable:
      1. salt length (default: 16 bytes)
      2. iteration count (default: 310,000 = slow)
      3. secret (for extra cryptographic spice)
   2. Generates salt, hashes the password using it, and verifies by re-generating the same salted hash and comparing it.
   3. Good for environments where you control all the knobs.
   4. Not deprecated, but easily misconfigured. A bit of a DIY experience.
4. **SCryptPasswordEncoder (Cryptographically Buff)**
   1. Strong key derivation function.
   2. Even more secure and memory intensive.
   3. Not as commonly used as BCrypt but very solid.
5. **DelegatingPasswordEncoder (The Switchboard Operator)**
   1. Lets you support *multiple encoders* based on prefix.
   2. Like: {bcrypt}hashedPasswordHere or {noop}plaintextPassword.
   3. Essential for migrating from old schemes to new ones.

**Deprecated or Joke-Level Encoders:**

1. **NoOpPasswordEncoder (a.k.a. "Please Rob Me")**
   1. Literally just returns the plain text. Still implements PasswordEncoder so you can plug it into Spring Security… but it **doesn’t encode** anything. Only use in demos , tests etc.
2. **StandardPasswordEncoder**
   1. Used SHA-256 with 1024 iterations and 8-byte salt.
   2. Sounds decent until you realize CPUs laugh at it now.
   3. Deprecated for good reason: *too easy to brute-force* in modern times.
3. **MessageDigestPasswordEncoder, Md4PasswordEncoder, LdapShaPasswordEncoder, etc.**
   1. Cryptographically embarrassing.
   2. Only exist for *backward compatibility*.
   3. Using these in production is basically consenting to being hacked.

## Setting Custom Login

So far we have been using login provided by Spring. But we can’t use that for production Grade app we can use our own custom login page

http.authorizeHttpRequests(authorizationManagerRequestMatcherRegistry -> authorizationManagerRequestMatcherRegistry  
 .requestMatchers("/favicon.ico", "/public/style.css", "/public/main.js", "/images/\*\*","/public/home.html", "/h2-console/\*\*").permitAll()  
 .requestMatchers(HttpMethod.POST, "/v1/api/login", "/v2/api/login", "/v3/api/login").permitAll()  
 .requestMatchers("/private/balance", "/private/message", "/admin/announcement", "/admin/loan").authenticated()  
 .requestMatchers("/public/home", "/public/contact", "/error", "/public/myLogin","/public/me").permitAll()  
 )  
 .formLogin(form -> form  
 .loginPage("/public/home.html")  
 .loginProcessingUrl("/login")  
 .defaultSuccessUrl("/public/home.html", *false*)  
 .failureUrl("/public/home.html?error")  
 .permitAll()  
 )

1. **requestMatchers("/favicon.ico", "/public/style.css", "/public/main.js", "/images/\*\*","/public/home.html", "/h2-console/\*\*").permitAll()**  Allowing all the html resources
2. **loginPage("/public/home.html")** This tells Spring Security where to show the custom login page. When an unauthenticated user tries to access a protected resource, they'll be redirected to /public/home.html. You must ensure this URL is publicly accessible (which you’ve already permitted in your authorizeHttpRequests).
3. **loginProcessingUrl("/login")** This defines the endpoint that Spring Security will watch for login form submissions. Your HTML login form should POST to this URL:

        <div class="form-wrapper">

            <h3>Form Login</h3>

            <form method="POST" action="/login">

                <label>Username:</label>

                <input type="text" name="username" required><br>

                <label>Password:</label>

                <input type="password" name="password" required><br><br>

                <button type="submit">Login</button>

            </form>

        </div>

Spring intercepts this POST and performs authentication automatically (you don’t need a controller for this).

1. **defaultSuccessUrl("/public/home.html", true)** This sets the page to redirect to after a successful login.

* If false (or omitted), Spring would: Redirect back to the originally requested protected URL (if any), or fall back to this one.
* If true Spring always redirects to this URL after login URL mentioned , regardless of what page the user was trying to access.
* It is useful if we want to redirect to some other page. In our case we want to redirect to requester page /public/home.html So true false is same
* If entire configuration is removed it will redirect to localhost:8080

1. **failureUrl("/public/home.html?error")** This sets the URL to redirect to when login fails. If the user enters wrong credentials, Spring Security redirects them to this page. You can check for the presence of ?error in your page to show an appropriate message:

*// Handle error and logout messages*

    const urlParams = new URLSearchParams(window.location.search);

    if (urlParams.has('error')) {

        document.getElementById('status').innerText = '❌ Login failed. Please try again.';

        document.getElementById('status').style.color = 'red';

    }

    if (urlParams.has('logout')) {

        document.getElementById('status').innerText = '✅ You have been logged out.';

        document.getElementById('status').style.color = 'green';

    }

1. **permitAll()** This tells Spring Security that all users (even unauthenticated ones) are allowed to access the login page and submit the login form. Without this, Spring might block access to your login form itself, creating a redirect loop.

## Custom JSON Based Login

We may not want to do form post at /login in that case we have to define our own Authentication mechanism. Which will replace the Basic login. We can do this using our own filter Which will creaate the Authentication Object and pas to Spring Security filter chain. This will read the JSON posted at /v1/api/login in the form {"username": "admin", "password": "qwerty"} create Authentication object and do validation.

The JsonUsernamePasswordAuthenticationFilter provides a custom authentication mechanism that handles JSON-based login requests instead of the traditional form-based login. Here's how it works:

1. **Filter Registration in the Security Chain**

The filter is added to Spring Security's filter chain using:

.addFilterAt(jsonAuthFilter, UsernamePasswordAuthenticationFilter.*class*)

This places it at the same position as the standard form-login filter in the chain, allowing it to intercept JSON login requests while the traditional form login still remains active for form submissions.

1. **Custom Endpoint Configuration** The filter is configured to process authentication at a custom endpoint:

*public* JsonUsernamePasswordAuthenticationFilter(AuthenticationManager authenticationManager) {  
 *super*.setAuthenticationManager(authenticationManager);  
 setFilterProcessesUrl("/v1/api/login"); *// your custom login endpoint*}

Unlike the default /login endpoint used by form login, this filter triggers only when POST requests are made to /v1/api/login.

1. **JSON Request Processing**

When a login request arrives:

* It first checks if the content type is application/json:
* Then it deserializes the request body into a LoginRequest object:
* This expects a JSON payload like: {"username": "admin", "password": "qwerty"}
* Creates an Authentication token with the credentials:
* Passes the token to the authentication manager for validation:

*@Override  
public* Authentication attemptAuthentication(HttpServletRequest request, HttpServletResponse response)  
 *throws* AuthenticationException {  
  
 *if* (!MediaType.APPLICATION\_JSON\_VALUE.equals(request.getContentType())) {  
 *throw new* AuthenticationServiceException("Unsupported Content Type: " + request.getContentType());  
 }  
  
 *try* {  
 LoginRequest loginRequest = objectMapper.readValue(request.getInputStream(), LoginRequest.*class*);  
  
 UsernamePasswordAuthenticationToken authRequest =  
 *new* UsernamePasswordAuthenticationToken(loginRequest.getUsername(), loginRequest.getPassword());  
  
 *return this*.getAuthenticationManager().authenticate(authRequest);  
  
 } *catch* (IOException e) {  
 *throw new* AuthenticationServiceException("Failed to parse login request", e);  
 }  
}

1. **Authentication Success Handling**

When authentication succeeds:

* A security context is created and populated with the authenticated user:
* The security context is stored in the HTTP session (just like with form login):
* Two cookies are added to the response:
  1. A secure, HttpOnly cookie (SECURE\_TOKEN) that's not accessible to JavaScript
  2. A plain cookie (PLAIN\_SESSION\_ID) that is JavaScript-accessible
* A success response is sent with a JSON message:

*@Override  
protected void* successfulAuthentication(HttpServletRequest request, HttpServletResponse response,  
 FilterChain chain, Authentication authResult) *throws* IOException, ServletException {  
 *// Set SecurityContext and persist in session* SecurityContext context = SecurityContextHolder.createEmptyContext();  
 context.setAuthentication(authResult);  
 SecurityContextHolder.setContext(context);  
  
 request.getSession(*true*).setAttribute(  
 HttpSessionSecurityContextRepository.SPRING\_SECURITY\_CONTEXT\_KEY,  
 context  
 );  
 *// --- Add cookies ---  
 // Secure, HttpOnly cookie (server-only)* Cookie secureCookie = *new* Cookie("SECURE\_TOKEN", "secure-value-12345");  
 secureCookie.setHttpOnly(*true*); *// JS can't access* secureCookie.setSecure(*true*); *// Only sent over HTTPS* secureCookie.setPath("/"); *// Available to entire app* secureCookie.setMaxAge(3600); *// 1 hour* response.addCookie(secureCookie);  
  
 *// Plain, JS-readable cookie* Cookie plainCookie = *new* Cookie("PLAIN\_SESSION\_ID", "visible-value-abcde");  
 plainCookie.setHttpOnly(*false*); *// JS can access* plainCookie.setSecure(*false*); *// OK for HTTP (dev env)* plainCookie.setPath("/");  
 plainCookie.setMaxAge(3600);  
 response.addCookie(plainCookie);  
  
 *// Let the success handler respond (configured in SecurityConfig)* getSuccessHandler().onAuthenticationSuccess(request, response, authResult);  
}

1. **Authentication Failure Handling** When authentication fails, an error response is sent:

## HTTP/HTTPS

Spring Boot apps by default **accept both HTTP and HTTPS**. We can make it accept https only using below

.requiresChannel(rcc -> rcc.anyRequest().requiresSecure()) *// Only HTTPS*

## Session management

**What is the default session timeout?**

By **default**, the session timeout is **30 minutes**. So:

* If the user is inactive for 30 minutes (doesn’t send any request),
* The session becomes **invalid**,
* And if the user tries to interact with the app afterward, they are redirected to the **login page**.

**How to customize the session timeout**

You can set your own timeout in the application.properties file: server.servlet.session.timeout=20m

server.servlet.session.timeout=20m

* 20m = 20 minutes (you can also use s for seconds, h for hours)
* The **minimum allowed** value is **2 minutes** (Spring Boot enforces this).

**Better user experience with** invalidSessionUrl()

Instead of redirecting to the login page, we can redirect users to a **custom URL** (e.g., /invalid-session) that explains why they are being redirected:

http.sessionManagement(smc ->

smc.invalidSessionUrl("/invalid-session")

);

You also need to **permit** access to this path:

.requestMatchers("/invalid-session").permitAll()

**Other scenarios that trigger invalid sessions**

1. **Timeout (idle)** → session becomes invalid.
2. **Tampered JSESSIONID** (e.g., user manually modifies the cookie) → also treated as invalid session.

In **both cases**, Spring Security will redirect the user to the **same URL** (/invalid-session) instead of the login page, which makes your app more **user-friendly and informative**.

**Summary**

* Sessions in Spring Boot expire after 30 mins by default.
* You can customize this using server.servlet.session.timeout.
* Minimum allowed timeout is 2 minutes.
* Use invalidSessionUrl() to handle expired/tampered sessions gracefully.
* Always permitAll() access to that URL.
* Build a user-friendly page for /invalid-session.

By **default**, Spring Security **does not limit** the number of sessions a user can have.  
So the same user (smith@example.com) could:

* Login in **multiple browsers**
* Use **Postman**, **browser tabs**, or different **devices**
* Have **unlimited active sessions** concurrently

For security or business reasons (e.g., online banking, exams, subscriptions), you might want to:

* Allow **only 1 session per user**
* Or **2, 3, or 5 sessions max**, depending on the use case

Configure sessionManagement() in Security Config

http

.sessionManagement(session -> session

.invalidSessionUrl("/session-expired")

.maximumSessions(1) // Only 1 session allowed per user

);

Prevent Login if Maximum Session Reached

If you don’t want the old session to be invalidated, but instead want to **block** new logins:

.maximumSessions(1)

.maxSessionsPreventsLogin(true)

You can configure Spring Security like:

http

.csrf().disable()

.authorizeHttpRequests(auth -> auth

.requestMatchers("/login", "/session-expired").permitAll()

.anyRequest().authenticated()

)

.sessionManagement(session -> session

.invalidSessionUrl("/session-expired")

.maximumSessions(1)

.maxSessionsPreventsLogin(true)

.expiredUrl("/session-expired")

)

.formLogin()

.httpBasic()

.exceptionHandling();

return http.build();

## Session Hijacking

**Session Hijacking** is a security attack where an attacker **steals a valid session ID** and uses it to impersonate a user.

How it happens:

* The session ID can be found in:
  + **URLs** (e.g., example.com/page?sessionId=xyz)
  + **Cookies** stored in the browser.
* A hacker can steal this session ID by:
  + Looking at **browser history** (e.g., public computers).
  + **Intercepting traffic** if the app doesn’t use HTTPS.

Prevention Techniques:

1. Use HTTPS → Encrypts data in transit.
2. Short session timeouts → e.g., 10-15 minutes.
3. Public computer mode → Websites may avoid storing session cookies.
4. Avoid putting session IDs in URLs.

Spring Security doesn't directly prevent Session Hijacking. It's mostly up to the developers and infrastructure to apply safe practices.

## Session Fixation

**Session Fixation** is a type of attack where the attacker fixes (sets) a known session ID for a user before the user logs in, and later uses it to hijack their session.

Example scenario:

1. Eva (hacker) logs into fashionmart.com → gets session ID abc123.
2. Eva sends Emily (victim) a fake promo email with a link containing session ID abc123.
3. Emily clicks and logs in → Now her account is associated with the same session ID abc123.
4. Eva reuses abc123 → Now she sees Emily’s data and payment info.

Prevention:

The solution lies in ensuring that once the user logs in, the application **changes the session ID**, making the one the hacker fixed invalid.

How Spring Security Prevents Session Fixation

By default, Spring Security protects against Session Fixation using one of these strategies:

1. changeSessionId() (Default)
2. Keeps session data, but generates a new session ID after login.
3. Hacker doesn’t know this new ID → attack fails.
4. newSession()
5. Creates a brand-new session and does NOT copy any old data except for Spring Security data (like auth info).
6. migrateSession()
7. Creates a new session, but copies all data (like user attributes) from the old session.
8. none()
9. Disables protection. Not recommended unless you implement custom protection.

http

.sessionManagement(session -> session

.sessionFixation(sfc -> sfc

.migrateSession() // or .newSession(), .none()

)

);

## Handling authentication events

Spring Security automatically **publishes events** when authentication happens:

* **AuthenticationSuccessEvent** — when login is successful.
* **AuthenticationFailureEvent** — when login fails (wrong password, etc).

These are published by a class called:

* DefaultAuthenticationEventPublisher

**What should you do as a developer?**

You can **listen** for these events using standard Spring mechanisms:

1. Create a Spring **bean** (a normal @Component class).
2. Inside it, create **methods** like onSuccess() or onFailure() to handle events.
3. Annotate those methods with **@EventListener**.

*@Component  
@Slf4j  
public class* AuthorizationEvents {  
  
 *@EventListener  
 public void* onFailure(AuthorizationDeniedEvent deniedEvent) {  
 log.error("Authorization failed for the user : {} due to : {}", deniedEvent.getAuthentication().get().getName(),  
 deniedEvent.getAuthorizationDecision().toString());  
 }  
  
}

*@Component  
@Slf4j  
public class* AuthenticationEvents {  
  
 *@EventListener  
 public void* onSuccess(AuthenticationSuccessEvent successEvent) {  
 log.info("Login successful for the user : {}", successEvent.getAuthentication().getName());  
 }  
  
 *@EventListener  
 public void* onFailure(AbstractAuthenticationFailureEvent failureEvent) {  
 log.error("Login failed for the user : {} due to : {}", failureEvent.getAuthentication().getName(),  
 failureEvent.getException().getMessage());  
 }  
  
}

## CORS

For testing CORS put the html files in an Apache server and check from http://localhost/home.html . Also disable below as CSRF will cause issue for as CSRF cookie won’t be able to read from different domain implemented in next section

*// .csrf(csrfConfig -> csrfConfig.csrfTokenRequestHandler(new CsrfTokenRequestAttributeHandler())  
// .ignoringRequestMatchers("/h2-console/\*\*", "/api/login", "/login")  
// .csrfTokenRepository(CookieCsrfTokenRepository.withHttpOnlyFalse()))* .csrf(csrf -> csrf.disable()) *// ✅ for H2 POSTs and for CORS requests*

*//.addFilterAfter(new CsrfCookieFilter(), BasicAuthenticationFilter.class)*

What is CORS?

CORS stands for Cross-Origin Resource Sharing. It’s a security feature implemented by browsers to control how resources are shared across different origins.

**What is an "Origin"?**

An **origin** is defined by three components:

1. **Protocol** (HTTP or HTTPS)
2. **Domain/Hostname** (like google.com)
3. **Port** (like :8080)

Two URLs are of different origin if **any of these differ**.

Examples:

* http://example.com:8080 vs http://example.com:8081 → **different origin**
* https://google.com vs https://amazon.com → **different origin**

Why CORS Exists

Browsers block requests from different origins by default to prevent malicious sites from stealing data from your app/server (a form of attack called Cross-Site Request Forgery or data theft via unauthorized scripts).

So CORS is not a bug or a security threat, but rather a security measure implemented by browsers.

In Spring Boot, this is typically done by:

* Adding a **CORS configuration** using @CrossOrigin on controllers or globally via a WebMvcConfigurer bean.

*@CrossOrigin*(origins = "http://localhost:4200")  
*@RestController  
public class* NoticeController {  
 *// your endpoints*}

* Or configure CORS globally like:

.cors(corsConfig -> corsConfig.configurationSource(*new* CorsConfigurationSource() {  
 *@Override  
 public* CorsConfiguration getCorsConfiguration(HttpServletRequest request) {  
 CorsConfiguration config = *new* CorsConfiguration();  
 config.setAllowedOriginPatterns(Arrays.asList("http://localhost:80", "http://localhost"));  
 config.setAllowedMethods(Arrays.asList("GET", "POST", "PUT", "DELETE", "OPTIONS"));  
 config.setAllowCredentials(*true*);  
 config.setExposedHeaders(Arrays.asList("Authorization", "Set-Cookie"));  
 config.setAllowedHeaders(Collections.singletonList("\*"));  
 config.setMaxAge(3600L);  
 *return* config;  
 }  
}))

One another issue with CORS is that cookie doesn’t get send automatically so when we are using JSESSIONID it will not be automatically set in subsequent request as setting cookie for other domain is not allowed. So we have to set in in request body and readit manually and send back in subsequent requests.

*private void* setCORSHeader(HttpServletRequest request, HttpServletResponse response) *throws* IOException {  
 *// Get the current session ID* HttpSession session = request.getSession();  
 String sessionId = session.getId();  
  
 *// Set response parameters* response.setStatus(HttpServletResponse.SC\_OK);  
 response.setContentType("application/json");  
  
 *// Create JSON response with session ID* Map<String, Object> responseMap = *new* HashMap<>();  
 responseMap.put("message", "Login successful JsonUsernamePasswordAuthenticationFilter");  
 responseMap.put("sessionId", sessionId);  
  
 *// Use Jackson or Gson to convert map to JSON* ObjectMapper mapper = *new* ObjectMapper();  
 String jsonResponse = mapper.writeValueAsString(responseMap);  
  
 response.getWriter().write(jsonResponse);  
}

*// Dropdown change handler*

    document.getElementById('apiDropdown').addEventListener('change', function () {

        const selectedPath = this.value;

        const jwt = localStorage.getItem('jwt');

*// Read the session ID from localStorage*

        const sessionId = localStorage.getItem('sessionId');

        if (sessionId) {

*// Before making the request, set the cookie manually*

            document.cookie = `JSESSIONID=${sessionId}; path=/`;

        }

        if (selectedPath) {

            fetch(domain + selectedPath,

                {

                    credentials: "include",

                    headers: {

                        'Authorization': 'Bearer ' + jwt,

                        'Content-Type': 'application/json'

                    }

                })

                .then(*res* => *res*.text())

                .then(*data* => {

                    document.getElementById('apiResponse').innerText = *data*;

                })

                .catch(*err* => {

                    document.getElementById('apiResponse').innerText = '❌ Error fetching API.';

                });

        } else {

            document.getElementById('apiResponse').innerText = '';

        }

    });

## CSRF

**What is CSRF?**

CSRF (Cross-Site Request Forgery) is a **legitimate security attack**—unlike CORS, which is a browser-enforced policy. In a CSRF attack, a malicious site tricks a logged-in user’s browser into sending **unauthorized requests** to a vulnerable web application on behalf of the user. If the app doesn't verify the legitimacy of these requests, sensitive operations (like money transfers, account changes, etc.) may be performed **without the user's consent**.

Technical Flow of a CSRF Attack

Let’s use the Netflix + badDomain.com analogy again, with a clearer structure:

**Step 1: User logs in to Netflix**

* The user logs in to netflix.com using valid credentials.
* The server authenticates and sets a **cookie** (JSESSIONID=abc123) for the domain netflix.com.
* The browser stores this cookie and will send it **automatically** with any future requests to netflix.com.

**Step 2: User visits a malicious site (evil.com)**

* In the **same browser session**, the user opens badDomain.com.
* badDomain.com is controlled by a hacker and renders a page with hidden malicious form or JavaScript.
* For example, a fake "90% off iPhone" ad tempts the user to click.

**Step 3: Hidden form submits a request to Netflix**

<form action="https://netflix.com/change-email" method="POST">

<input type="hidden" name="email" value="hacker@evil.com" />

</form>

<script>

document.forms[0].submit();

</script>

* When the form is submitted:
  + The request goes to netflix.com
  + The browser automatically attaches the Netflix cookie (abc123)
* Result: The Netflix server thinks this is a legitimate request from the user, because the cookie is valid.
* The user's email gets changed without their knowledge.

Disabling CSRF is fine in:

* Stateless APIs (e.g., using tokens or JWT)
* Non-browser clients (e.g., Postman)
* Internal microservices talking over trusted networks

But it is not recommended in production for web applications that use cookie-based authentication, because that’s exactly where CSRF thrives.

What happens when CSRF protection is enabled?

If you remove .csrf().disable() or explicitly enable CSRF, Spring Security expects every modifying HTTP request (POST/PUT/DELETE) to include a valid CSRF token. If the token is missing, invalid, or null, Spring will respond with 403 Forbidden – Invalid CSRF Token. For GET requests CSRF doesn’t have any impact.

**How Does Spring Security Help?**

By default, Spring Security enables CSRF protection for state-changing HTTP methods (POST, PUT, DELETE, PATCH).

When enabled:

1. Spring expects a CSRF token to be present on every modifying request.
2. This token is:
   * Sent by the server to the frontend (via form or meta tag)
   * Then sent back with the request (via header or hidden field)
3. If the token is missing or invalid → Spring throws **403 Forbidden**.

The server expects the CSRF token to appear in two places:

1. In the cookie (automatically sent by browser)
2. In the request header or body, manually added by JavaScript code

Now here’s the key:

1. badDomain.com can’t read the CSRF token from the cookie.
2. Why? Because JavaScript on evil.com can’t access cookies from netflix.com (same-origin policy).
3. So badDomain.com can’t include the CSRF token in the header or body.

**1. CSRF Token Basics in Spring Security**

* **CsrfToken interface**
  + The implementation of this interface holds CSRF token
  + Located in org.springframework.security.web.csrf.
  + It defines what a CSRF token looks like.
  + Important methods:
    - getToken(): actual token value.
    - getHeaderName(): header name expected in requests.
    - getParameterName(): name used in request parameters.
* **DefaultCsrfToken class**
  + A common implementation of the CsrfToken interface.
  + Typically used by Spring internally.

**2. Token Generation**

* **CsrfTokenRepository interface**
  + Responsible for generating and saving tokens.
  + Has multiple implementations:
    - HttpSessionCsrfTokenRepository: stores token in HTTP session (**not recommended**).
    - CookieCsrfTokenRepository: stores token in a cookie (**preferred**, especially for SPAs).
* **Using CookieCsrfTokenRepository**
  + Recommended when you want frontend JavaScript (Angular/React) to access the token.
  + Important method:
    - withHttpOnlyFalse(): Makes the cookie **readable by JavaScript** (needed so JS can attach the token in headers like X-XSRF-TOKEN).

**3. Sending and Validating CSRF Token**

* CSRF token is sent by backend as a **cookie (XSRF-TOKEN)**.
* JS framework (like Angular) reads the cookie and sends it in a **header (X-XSRF-TOKEN)** on POST/PUT/DELETE requests.
* **CsrfFilter**
  + A Spring Security filter that validates incoming CSRF tokens.
  + If the token is invalid or missing → AccessDeniedException is thrown.

Our Solution

1. Create CSRF configuration

.csrf(csrfConfig -> csrfConfig.csrfTokenRequestHandler(*new* CsrfTokenRequestAttributeHandler())  
 .ignoringRequestMatchers("/h2-console/\*\*", "/api/login")  
 .csrfTokenRepository(CookieCsrfTokenRepository.withHttpOnlyFalse()))

First, we are pass an instance of ***CsrfTokenRequestAttributeHandler*** which tell spring to make the CSRF token available in the request and contains logic to extract the token from headers like X-XSRF-TOKEN.

Next, we are preventing H2 data base and our Login URLs to be checking against CSRF check

Then we are allowing UI applications to access CSRF token using **CookieCsrfTokenRepository.withHttpOnlyFalse()**

1. Token Generation

When we are generating token using **CookieCsrfTokenRepository** the token is going to be generated lazily, which means until unless someone is trying to read the token value manually, the token is never going to be generated, and the cookie also is never going to be generated. This has been done intentionally by the Spring Security framework, just to achieve some performance improvement. Since not all requests like GET will need CSRF, that's why the token is going to be generated lazily.

Hence, we need to write a piece of logic to read the token manually. So we will write a filter will trigger token generation with **getToken** method.

*@Slf4j  
public class* CsrfCookieFilter *extends* OncePerRequestFilter {  
  
  
 *@Override  
 protected void* doFilterInternal(HttpServletRequest request, HttpServletResponse response, FilterChain filterChain)  
 *throws* ServletException, IOException {  
 CsrfToken csrfToken = (CsrfToken) request.getAttribute(CsrfToken.*class*.getName());  
 csrfToken.getToken(); *// This will trigger token generation* filterChain.doFilter(request, response);  
 }  
}

Register the filter

.addFilterAfter(*new* CsrfCookieFilter(), BasicAuthenticationFilter.*class*)

1. Send Token

On UI side on page load we fire an API call which checks login status it checks for XSRF-TOKEN cookie as well. This check is done for all login and update call

*// Check login status after form post login*

    function checkLoginStatus() {

        fetch(domain + '/public/me')

            .then(*res* => *res*.ok ? *res*.json() : Promise.reject())

            .then(*data* => {

                document.getElementById('loginStatus').innerText = `✅ Logged in with username: ${*data*.username}`;

                document.getElementById('formLoginStatus').innerText = '✅ Login successful';

            })

            .catch(() => {

                document.getElementById('loginStatus').innerText = '❌ Not logged in';

                document.getElementById('formLoginStatus').innerText = '❌ Login failed';

            }).finally(() => {

*// This section will always execute regardless of success or failure to load XSRF-TOKEN*

                XSRFTOKEN = getCookie("XSRF-TOKEN");

            });;

    }

And we send the token in headers for subsequent requests when needed

        fetch(domain + *uri*, {

            method: 'POST',

            credentials: "include",

            headers: {

                'Content-Type': 'application/json',

                'X-XSRF-TOKEN': XSRFTOKEN

            }

        })

Now as soon as the page is loaded is called and XSRF-TOKEN gets generated. If we clear the page data and remove token when we

1. Validation Token. This is managed by Spring using *class org.springframework.security.web.csrf.CsrfFilter*

How to test?

* 1. When page loads XSRF token will be loaded by API public/me
  2. Even if we delete it /public/home and /public/contact will be called as these are GET API
  3. But /public/publicUpdate will not be successful even if it is public as it is POST
  4. When we generate XSRF token from button it will be successful
  5. Also, after all login and update operation we are checking if XSRF token is present or not. So after first failure token will be generated and added so that next API is success.

For JWT CSRF protection is not needed because CSRF attacks exploit **browser-based cookies**, but JWTs in headers are **not automatically sent** by the browser like cookies are. Hence, CSRF attacks don’t work in this case.

# JWT

In general, there are two types of tokens

1. **Opaque Tokens** are typically random strings with no inherent meaning. Used to reference authentication information stored on the server-side.
2. **JSON Web Tokens (JWT)** are self-contained tokens that consist of three parts: a header, a payload, and a signature, encoded in Base64 URL. Requires a call to the authorization server to validate and obtain user information.
   1. JWT means JSON Web Token. It is a token implementation which will be in the JSON format and designed to use for the web requests.
   2. JWT tokens can be used both in the scenarios of Authorization/Authentication along with Information exchange which means you can share certain user related data in the token itself which will reduce the burden of maintaining such details in the sessions on the client/server side.

|  |  |  |
| --- | --- | --- |
| Client will receive the token after successful login in a header/query string etc.  Client system must make sure to send the same token value on all the further request to the backend | A screenshot of a computer  AI-generated content may be incorrect. | Server will send token and send to client and stores client details and token in memory  Sever will validate the token and return result |

**Key Advantages of Token-Based Authentication**

1. **Security**
   1. Limited exposure of user credentials within the network
   2. Tokens can be revoked during suspicious activities without invalidating the user credentials
2. **Reusability**
   1. Tokens can be used across different domains and services, making them suitable for single sign-on (SSO) systems
3. **Cross-Platform Compatibility**
   1. Tokens can be used across various platforms and devices, including web applications, mobile apps, and IoT devices
4. **Expiration**
   1. Tokens can have specific expiration times set, ensuring tokens are valid only for a predefined duration
5. **Self-contained**
   1. Tokens are self-contained and carry all the necessary information about the user, roles/authorities etc.
6. **Statelessness**
   1. The token contains all the information to identify the user, eliminating the need for the session state
   2. If we use a load balancer, we can pass the user to any server, instead of being bound to the same server we logged in on

A JWT token has 3 parts each separated by a period(.) Below is a sample JWT token,

<https://jwt.io/>

eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJpZCI6IjQ3Mjg0MiIsIm5hbWUiOiJBbWl0IFNhaGEiLCJlbWFpbCI6ImFtaXQ4Ny5zQHRjcy5jb20ifQ.OWyFwQWMwXie7FNZa1mPp-BOZeRllUWwfigwmrllg8s

1. Header
2. Payload
3. Signature (Optional)

**Header** Inside the JWT header, we store metadata/info related to the token. If we chose to sign the token, the header contains the name of the algorithm that generates the signature.

{

"alg": "HS256",

"typ": "JWT"

}

**Payload** In the body, we can store details related to user, roles etc. which can be used later for Authentication and Authorization. Though there is no such limitation what we can send and how much we can send in the body, but we should put our best efforts to keep it as light as possible. 472842

{

"id": "472842",

"name": "Amit Saha",

"email": "amit87.s@tcs.com"

}

**Signature**

* To make sure that no one tampered the data on the network, we can send the signature of the content when initially the token is generated. To create the signature part, you must take the encoded header, the encoded payload, a secret, the algorithm specified in the header, and sign that.
* For example, if you want to use the HMAC SHA256 algorithm, the signature will be created in the following way

HMACSHA256(base64UrlEncode(header) + "." + base64UrlEncode(payload), secret)

* The signature is used to verify the message wasn't changed along the way, and, in the case of tokens signed with a private key, it can also verify that the sender of the JWT is who it says it is.

## User Management

Authentication Flow Context (Quick Recap)

* UsernamePasswordAuthenticationFilter
* ↓
* AuthenticationManager
* ↓
* AuthenticationProvider(s)
* ↓
* UserDetailsService.loadUserByUsername(username)
* ↓
* UserDetails

InMemoryUserDetailsManager, an implementation of UserDetailsService, to store multiple user credentials in memory.

1. **UserDetailsService** An interface used to **load user data** from some source (memory, database, etc.).
2. **UserDetailsManager** An extension of UserDetailsService that adds **create**, **update**, **delete**, and **check** methods for users.
3. **InMemoryUserDetailsManager** An **implementation** of UserDetailsManager that stores users in **memory** using a HashMap. Used here.
4. **User** A builder class from Spring Security to easily create UserDetails objects.
5. **{noop}** A password encoder prefix that tells Spring **not to encode the password**. Useful for dev/demo, but **not safe for production**.

*@Bean  
//public UserDetailsManager userDetailsService() { This has additional API for create user, reset pwd etc.  
public* UserDetailsService userDetailsService() {  
 UserDetails admin = User.withUsername("admin").password("{noop}erQu773\_\_").roles("ADMIN").build();  
 *//https://bcrypt-generator.com/* UserDetails user = User.withUsername("user").password("{bcrypt}$2a$12$HknEwKGJto6O4zTn0pSA6.L9OX2wDEa3beQpN3W5XKrbNCipR0eTm")  
 .roles("USER").build();  
 *return new* InMemoryUserDetailsManager(admin, user);  
}

**UserDetailsService**

* **Purpose**: Loads user-specific data from a source (DB, memory, etc.
* Core Method: UserDetails loadUserByUsername(String username)
* Use Case:
  + Read-only scenarios (e.g., authentication only).
  + No need to allow registration, updates, or deletion.

**UserDetailsManager**

* **Extends**: UserDetailsService
* **Purpose**: Full user CRUD management.
* **Key Methods**:
  + void createUser(UserDetails user)
  + void updateUser(UserDetails user)
  + void deleteUser(String username)
  + void changePassword(String oldPassword, String newPassword)
  + boolean userExists(String username)
* Use Case:
  + Full lifecycle management (Register, Update, Delete, Change password).
* Common Implementations Provided by Spring Security

| **Class** | **Interface** | **Storage Type** | **Notes** |
| --- | --- | --- | --- |
| InMemoryUserDetailsManager | UserDetailsManager | In-memory | Ideal for testing/dev |
| JdbcUserDetailsManager | UserDetailsManager | JDBC (DB) | Works with relational DBs |
| LdapUserDetailsManager | UserDetailsManager | LDAP | Less common, used in legacy enterprise setups |

**UserDetails Interface**

* **Purpose**: Represents the authenticated user.
* Core Methods:
  + String getUsername()
  + String getPassword()
  + Collection<? extends GrantedAuthority> getAuthorities()
  + boolean isAccountNonExpired()
  + boolean isAccountNonLocked()
  + boolean isCredentialsNonExpired()
  + boolean isEnabled()

**User Implementation (User class)** The User class in Spring Security is a concrete implementation of the UserDetails interface. It's a helper class provided by Spring Security to represent the authenticated user's details like username, password, and authorities (roles/permissions).

It doesn't have setter methods, making it immutable and safe to use during authentication

When you implement a custom UserDetailsService, Spring expects a return of type UserDetails. You can either return a User object or your own class that implements UserDetails.

*@Override  
public* UserDetails loadUserByUsername(String username) *throws* UsernameNotFoundException {  
 *// usually fetched from DB  
 return new* User("john", "{noop}password", List.of(*new* SimpleGrantedAuthority("ROLE\_USER")));  
}

* **Implements**: UserDetails
* **Immutable**: No setters; use constructor or User.withUsername()...build().
* **Common Builder Method**:

User.withUsername("amit")

.password("encodedPassword")

.roles("USER")

.build();

**Internal Fields of the User class**

| **Field** | **Purpose** |
| --- | --- |
| username | Unique name to identify the user |
| password | Hashed (or raw) password |
| authorities | Roles or permissions granted |
| accountNonExpired | If false, account is expired |
| accountNonLocked | If false, account is locked |
| credentialsNonExpired | If false, credentials are expired |
| enabled | If false, account is disabled |

**Summary**

* The User class is a **ready-to-use** implementation of UserDetails.
* It’s **suitable for in-memory authentication** or quick testing.
* You can also use it in custom UserDetailsService implementations when fetching user data from a database.

**Authentication Interface**

* Represents the **authentication request and result**.
* Is the **input and output** of the AuthenticationManager.authenticate() method.
* Common implementation: UsernamePasswordAuthenticationToken

Key Methods:

| **Method** | **Purpose** |
| --- | --- |
| getPrincipal() | Usually returns the UserDetails |
| getCredentials() | Returns raw credentials (e.g., password) |
| getAuthorities() | Returns authorities after successful auth |
| isAuthenticated() | Boolean indicating success/failure |
| setAuthenticated(boolean) | Sets the status of auth |
| getDetails() | Extra details (e.g., IP, device info) |
| getName() | Returns the username (from Principal interface) |

* **UserDetails** is about **who the user is**.
* **Authentication** is about **whether the user is authenticated**.

## Custom JDBCUserDetailsManager

**The Problem Being Solved**

Spring Security, by default, loads user data from:

1. InMemoryUserDetailsManager – for in-memory users.
2. JdbcUserDetailsManager – for users stored in a predefined table structure in a database.

But in most **real-world applications**, you:

* Use **custom tables** with your own schema (like a Customer table).
* Need **full control** over how to load user data from the database.

To do that, you implement your **own class** that implements UserDetailsService.

This method is where you:

* Fetch the user from your database.
* Convert the user to a Spring Security UserDetails object.
* Throw an exception if the user isn’t found.

*@Component  
public class* CustomUserDetailsService *implements* UserDetailsService {  
  
 *private final* CustomerRepository customerRepository;  
  
 *@Autowired  
 public CustomUserDetailsService* (CustomerRepository customerRepository) {  
 *this*.customerRepository = customerRepository;  
 }  
  
 *@Override  
 public* UserDetails loadUserByUsername(String username) *throws* UsernameNotFoundException {  
 Customer customer = customerRepository.findByEmail(username).orElseThrow(() -> *new* UsernameNotFoundException("User details not found for the user: " + username));  
 List<GrantedAuthority> authorities = List.of(*new* SimpleGrantedAuthority(customer.getRole()));  
 *return new* User(customer.getEmail(), customer.getPwd(), authorities);  
 }  
}

## Authentication Provider

**What is AuthenticationProvider?**

It’s an **interface** in Spring Security that is responsible for performing authentication. This interface has **only two methods**:

**1. authenticate(Authentication authentication)**

* This is where **actual authentication logic** goes.
  + It receives an authentication object, typically with: **Username, Password,** authenticated flag set to **false**
* Your job is to:
  + Load user details (like from a DB)
  + Match credentials (e.g., passwords)
  + Do additional checks (if needed)
  + Finally return a new Authentication object with authenticated = true
* Spring’s default AuthenticationProvider is DaoAuthenticationProvider, which:
* Extracts username
* Loads user from database
* Uses PasswordEncoder to check passwords
* Returns a successful authentication if all is well

**2. supports(Class<?> authentication)**

* This method tells **what kind of Authentication tokens this provider can handle.**
* For example:
  + DaoAuthenticationProvider supports UsernamePasswordAuthenticationToken
* If the supports() method returns true for a token, Spring will **use this provider to call authenticate()**

By default, Spring Security uses:

* **DaoAuthenticationProvider**, which works with:
  + **UserDetailsService** (to load user info from DB)
  + **PasswordEncoder** (to match passwords)

This setup works well for common use-cases where users log in with **username + password**, and credentials are stored in a database. But what if your app has complex or unusual authentication requirements?

Some examples:

1. Username/password for one app
2. OAuth2 for another (e.g., login via Google/Facebook)
3. JAAS for legacy systems
4. Age-based restrictions (only allow users above 18)
5. Country-based login checks (only allow users from specific regions)

These scenarios go **beyond the default logic** of just checking username and password. So, you’ll need to write **your own AuthenticationProvider** to handle them.

**How does Spring Security decide which AuthenticationProvider to use?**

When a request comes in:

1. The **filter chain** intercepts it.
2. The request is converted into an Authentication object (like UsernamePasswordAuthenticationToken).
3. The AuthenticationManager (usually a ProviderManager) takes over.
4. Based on the **type of Authentication object**, it decides which AuthenticationProvider to call.

For example:

* If it’s UsernamePasswordAuthenticationToken → use DaoAuthenticationProvider
* If it’s a custom OAuth2Token → use your custom provider
* If it’s JaasAuthenticationToken → use JAAS provider

**How does Spring use these?**

* Spring Security has a class called **ProviderManager**, which manages multiple AuthenticationProviders.
* When an authentication request comes in:
  + It loops through all registered AuthenticationProviders.
  + For each provider, it checks: supports(authentication.getClass())
  + If true, it calls the provider’s authenticate() method.
  + It stops on the first successful result (or continues if not successful).

**TestingAuthenticationToken?**

* This is a **special token for unit testing**.
* There's a corresponding TestingAuthenticationProvider.
* It doesn’t actually check anything — just returns the input Authentication object.
* Very useful to **mock authentication** in tests without doing real logins.

| **Concept** | **Meaning** |
| --- | --- |
| **DaoAuthenticationProvider** | Default provider that checks username/password using UserDetailsService |
| **AuthenticationProvider** | Interface you implement when you want **custom login logic** |
| **ProviderManager** | Delegates to one of the available providers, based on the Authentication object type |
| **When to write custom provider?** | When you need logic like age checks, external systems, multiple login types (OAuth2, JAAS, etc.) |
| **Where to put extra logic?** | Inside your custom AuthenticationProvider, **not** in UserDetailsService |

*@Component  
public class* CustomUsernamePwdAuthenticationProvider *implements* AuthenticationProvider {  
  
 *@Autowired  
 private* CustomerRepository customerRepository;  
  
 *@Autowired  
 private* PasswordEncoder passwordEncoder;  
  
 *@Override  
 public* Authentication authenticate(Authentication authentication) *throws* AuthenticationException {  
 String username = authentication.getName();  
 String pwd = authentication.getCredentials().toString();  
 Optional<Customer> customer = customerRepository.findByEmail(username);  
 *if* (customer.isPresent()) {  
 *if* (passwordEncoder.matches(pwd, customer.get().getPwd())) {  
 List<GrantedAuthority> authorities = *new* ArrayList<>();  
 authorities.add(*new* SimpleGrantedAuthority(customer.get().getRole()));  
 *return new* UsernamePasswordAuthenticationToken(username, pwd, authorities);  
 } *else* {  
 *throw new* BadCredentialsException("Invalid password!");  
 }  
 }*else* {  
 *throw new* BadCredentialsException("No user registered with this details!");  
 }  
 }  
  
 *@Override  
 public boolean* supports(Class<?> authentication) {  
 *return* (UsernamePasswordAuthenticationToken.*class*.isAssignableFrom(authentication));  
 }  
  
}

# Authorization

Authentication is the process of confirming a user's identity using credentials like username, password, OTP, etc.

Authorization checks if the **authenticated user** has the **right permissions or roles** to access a specific resource or perform an action.

| **Feature** | **Authentication** | **Authorization** |
| --- | --- | --- |
| What it does | Verifies identity (e.g., user is John) | Verifies access rights (e.g., can John access Admin panel?) |
| When it happens | **Before** authorization | **After** authentication |
| Needs | Username/password, OTP | Roles/permissions (e.g., ROLE\_ADMIN) |
| Common error code on failure | 401 Unauthorized | 403 Forbidden |
| Real-life analogy | Checking ID & ticket at airport gate | Checking if you're allowed to enter a specific plane |

How Spring Security Stores Roles/Authorities

**Core Interface: GrantedAuthority** is the interface Spring uses to represent a single authority/role. It has **one method**:

String getAuthority();

**Most Used Implementation: SimpleGrantedAuthority**

* Spring provides ready-made implementations. The most common is:
* It has a single String field (named authority) where we store the role/authority name.

public final class SimpleGrantedAuthority implements GrantedAuthority

private final String authority;

* To use it:

new SimpleGrantedAuthority("ROLE\_USER");

**Where Are These Authorities Stored?**

**➤ Before Authentication (during user loading):**

* We use the **UserDetails** interface to represent a user from the database.
* While creating a UserDetails object (like User from Spring Security), we pass:
  + username
  + password
  + List<GrantedAuthority>
* The list of roles is stored internally as an unmodifiable set, so no changes can be made after it's created.

**After Authentication (when user is authenticated):**

* User info is wrapped into an Authentication object.
* Spring uses implementations like UsernamePasswordAuthenticationToken.

new UsernamePasswordAuthenticationToken(username, authorities).

Once authentication is successful, Spring typically sets the **credentials** (password) to null for security

* The authorities from UserDetails are passed into this object.
* Again, Spring stores them in an unmodifiable list internally.

**How Authorization Works**

* When your secure routes with something like:

@PreAuthorize("hasRole(ROLE\_ADMIN)")

* Spring will call getAuthorities() on the current Authentication object to check if the user has that role

|  |  |
| --- | --- |
| GrantedAuthority | Represents one role or authority |

|  |  |
| --- | --- |
| SimpleGrantedAuthority | Concrete class to store role as a string |

|  |  |
| --- | --- |
| UserDetails | User info before authentication |

|  |  |
| --- | --- |
| Authentication | User info after successful login |

|  |  |
| --- | --- |
| getAuthorities() | Used by Spring to check roles during authz |

|  |  |
| --- | --- |
| Internal Storage | Immutable (unmodifiable set/list) |

difference between AUTHORITY and ROLE

| **Feature** | **AUTHORITY** | **ROLE** |
| --- | --- | --- |
| **Definition** | A single, fine-grained **privilege** or **action**. | A **group** of authorities (privileges/actions). |
| **Examples** | VIEWACCOUNT, UPDATEACCOUNT, DELETECARD | ROLE\_USER, ROLE\_MANAGER, ROLE\_ADMIN |
| **Use Case** | When you want precise control over each action a user can take. | When you want to group actions and manage permissions at a higher level. |
| **Granularity** | Fine-grained (specific actions) | Coarse-grained (bundled/grouped actions) |
| **Spring Security Contract** | Both are implementations of GrantedAuthority. |  |
| **Configuration in Spring Security** | Use them as-is (e.g., hasAuthority("VIEWACCOUNT")) | Must prefix roles with ROLE\_ (e.g., hasRole("ADMIN"), which maps to ROLE\_ADMIN) |

# OAUTH2

[OAuth 2.0](https://tools.ietf.org/html/rfc6749), which stands for “Open Authorization”, is a standard designed to allow a website or application to access resources hosted by other web apps on behalf of a user.

OAuth 2.0 is an authorization protocol and NOT an authentication protocol

OAuth 2.0 uses Access Tokens. An **Access Token** is a piece of data that represents the authorization to access resources on behalf of the end-user. OAuth 2.0 doesn’t define a specific format for Access Tokens. However, in some contexts, the JSON Web Token (JWT) format is often used. This enables token issuers to include data in the token itself. Also, for security reasons, Access Tokens may have an expiration date.

**OAuth 2.0 Terminology - Standard Definitions**

**Resource Owner** The entity that can grant access to a protected resource. Typically, the end-user who owns the data (such as their email, profile, etc.). In OAuth flows, this is the person who authorizes an application to access their account.

**Client** The application requesting access to protected resources on behalf of the Resource Owner. This can be a website, mobile app, desktop application, or any other software that needs to access protected resources but cannot directly use the Resource Owner's credentials.

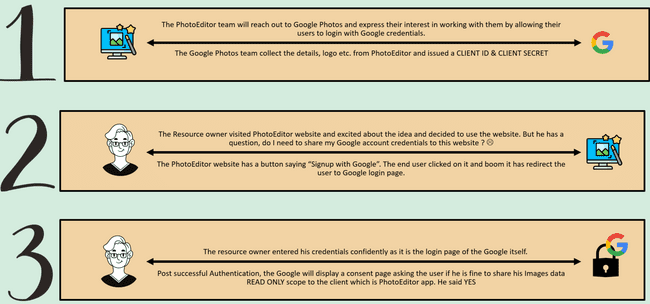
**Authorization Server** The server that authenticates the Resource Owner, obtains authorization decisions, and issues access tokens. It's responsible for validating user identity and handling the OAuth authorization process. It maintains information about clients and their allowed access scopes.

**Resource Server** The server that hosts the protected resources the Client wants to access. It accepts and validates access tokens from the Client and serves the requested resources if the token grants appropriate permissions. Often, this may be the same physical server as the Authorization Server but with a distinct logical role.

**Scopes** Granular permissions that define the extent of access granted to the Client. Scopes limit what the Client can do with the access token. Examples include read-only access to emails, write access to calendar events, or access to profile information. The Authorization Server enforces these scope limitations when issuing tokens.

These definitions establish the core components and roles within the OAuth 2.0 framework as formally specified in RFC 6749. Each plays a crucial part in enabling secure delegated access without sharing passwords across applications.

Sample OAUTH flow

A close-up of a text

AI-generated content may be incorrect.

OAuth Grant Types

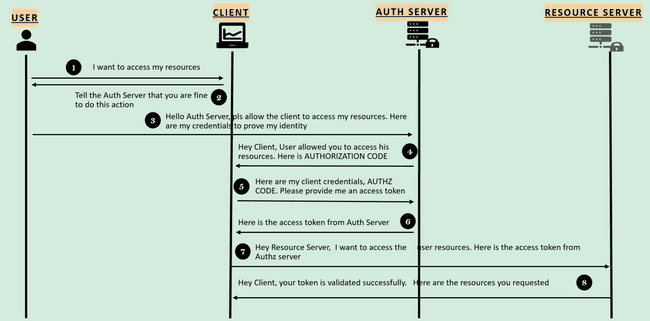
1. Authorization Code – When end user is involved
2. ~~Legacy: Implicit Flow~~
3. PKCE
4. ~~Legacy: Password Grant~~
5. Client Credentials
6. Refresh Token
7. Device Code

Authorization server examples

1. Key Cloak
2. Okta
3. Amazon Cognito
4. Forgerock
5. Fusion auth

## Authorization Code

The Authorization Code grant is the most common OAuth 2.0 flow and is designed for applications that can securely store a client secret and , specifically designed for scenarios when an end user is directly involved in the authentication process.



**Steps**

1. The end user visits a client application and tries to access resources
2. The client redirects the user to the Auth Server's login page
3. The user enters their credentials on the Auth Server's page
4. The Auth Server validates credentials and sends an authorization code to the client
5. The client sends its credentials (client\_id and client\_secret) plus the authorization code to the Auth Server
6. The Auth Server validates everything and issues an access token to the client
7. The client uses this access token to request resources from the Resource Server
8. The Resource Server validates the token and returns the requested resources

<https://www.oauth.com/playground/index.html>

In the step 3, where client is making a request to Auth Server endpoint, must send the below important details,

* **client\_id** — the id which identifies the client application by the Auth Server. This will be granted when the client registers first time with the Auth server.
* **redirect\_uri** — the URI value which the Auth server needs to redirect post successful authentication. If a default value is provided during the registration, then this value is optional
* **scope** - like authorities. Specifies level of access that client is requesting like READ
* **state** — CSRF token value to protect from CSRF attacks
* **response\_type** — With the value token or code which indicates that we want to follow implicit grant type

In the step 5 where client after received an authorization code from Auth server, it will again make a request to Auth server for a token with the below values,

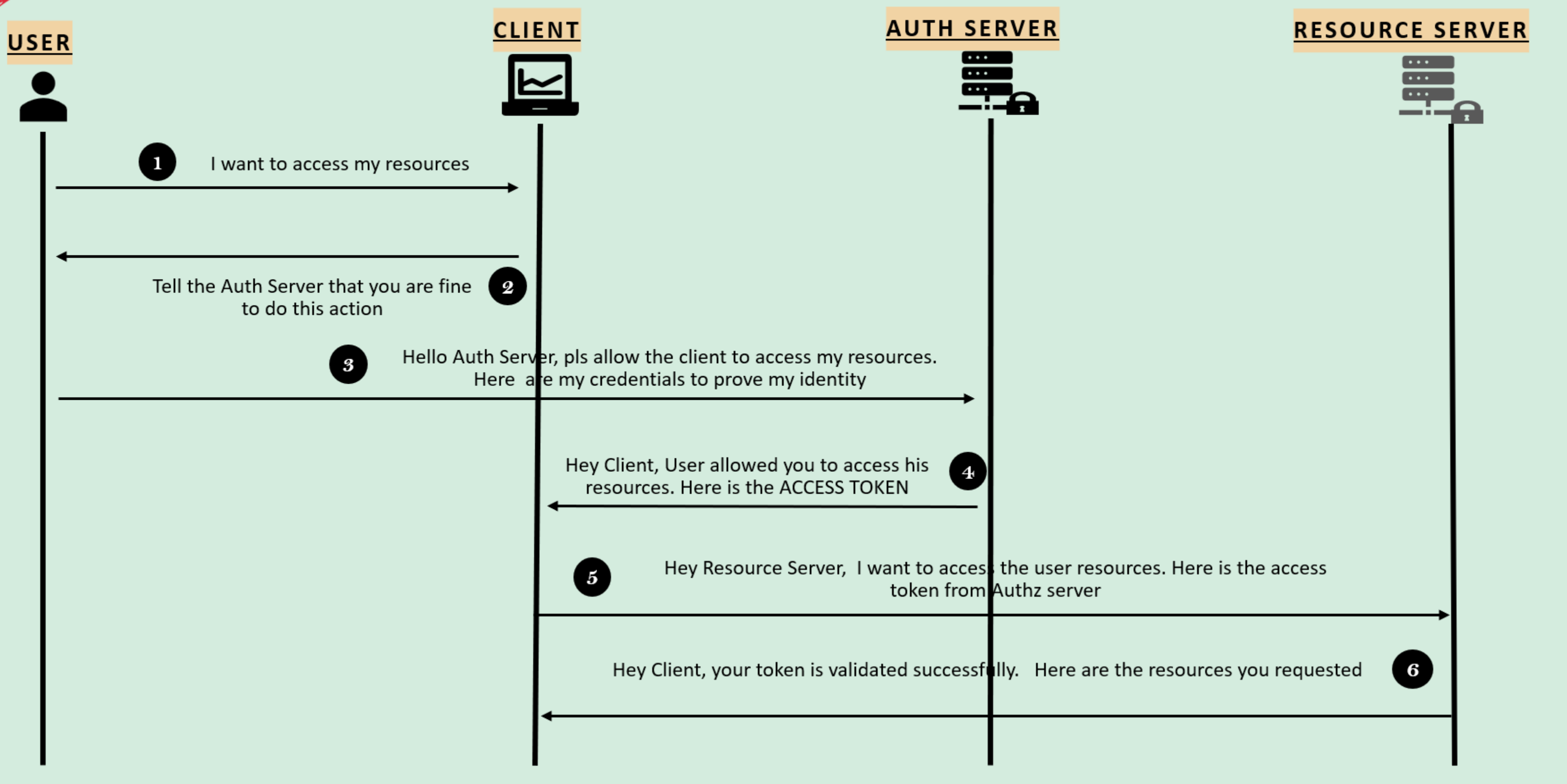
* **code** - the authorization code received from the above steps
* **client\_id & client\_secret** — the client credentials which are registered with the auth server. Please note that these are not user credentials
* **grant\_type** - With the value ‘authorization\_code’ which identifies the kind of grant type is used
* **redirect\_uri** - Must match the original redirect URI

**Security Features**

* Authorization code is short-lived and single use
* Full authentication flow happens server-to-server, not in the browser
* State parameter protects against CSRF attacks
* PKCE extension available for additional security with public clients
* Separates authentication from token issuance

## Implicit Grant Flow

it is now **deprecated** and not recommended for production use. It will be completely removed in OAuth 2.1.



1. The end user visits a client application and initiates authentication
2. The client redirects the user to the Auth Server's login page
3. The user enters their credentials on the Auth Server's page
4. The Auth Server validates credentials and issues an **access token directly** (no authorization code step)
5. The client uses this access token to request resources from the Resource Server
6. The Resource Server validates the token and returns the requested resources

When redirecting to the Auth Server (step 2-3), the client includes:

* client\_id: Identifies the application
* redirect\_uri: Where to send the access token
* scope: What permissions the client is requesting
* state: A CSRF token for security
* response\_type: Set to "token" (not "code" like in Authorization Code flow)

**Major Security Problems**

1. **No client authentication**:
   1. Only client\_id is used (no client\_secret)
   2. Anyone who knows the client\_id can impersonate the client application
2. **Token exposure in URLs**:
   1. Since this flow uses GET requests, the access token appears in the URL
   2. The token is visible in browser history, server logs, referrer headers
   3. Anyone with access to browser history could steal long-lived tokens
3. **Direct token issuance**:
   1. The Auth Server can't verify the client's identity before issuing tokens
   2. This creates more opportunities for token theft

## PKCE

PKCE (pronounced "pixy") is a security extension to the OAuth 2.0 Authorization Code grant flow, specifically designed to protect public clients that cannot securely store client secrets. In the standard Authorization Code flow, clients need to use their client\_id and client\_secret to prove their identity when exchanging the authorization code for tokens. However, public clients like:

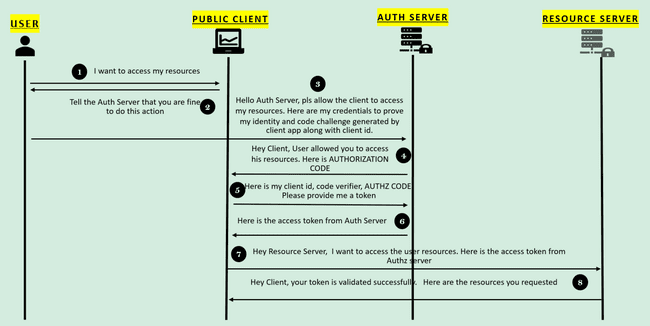
* JavaScript/single-page applications
* Mobile apps
* React/Angular applications

...cannot securely store a client secret because their code is visible to users (in browser source code or by decompiling mobile apps).

**How PKCE Works**

PKCE solves this by replacing the client secret with a dynamically generated proof:

1. **Client Generates Two Values:**
   1. code\_verifier: A random string generated for each authorization request
   2. code\_challenge: A hash of the code\_verifier (typically using SHA-256, then Base64-URL encoded)
2. **Authorization Request:**
   1. The client sends the code\_challenge (not the code\_verifier) along with normal parameters
   2. The Auth Server stores this challenge value
3. **Code Exchange:**
   1. After receiving the authorization code, the client sends both the code and the original code\_verifier (not the hashed challenge)
   2. The Auth Server hashes the received code\_verifier and compares it to the stored code\_challenge
   3. If they match, the server knows it's the same client and issues the tokens

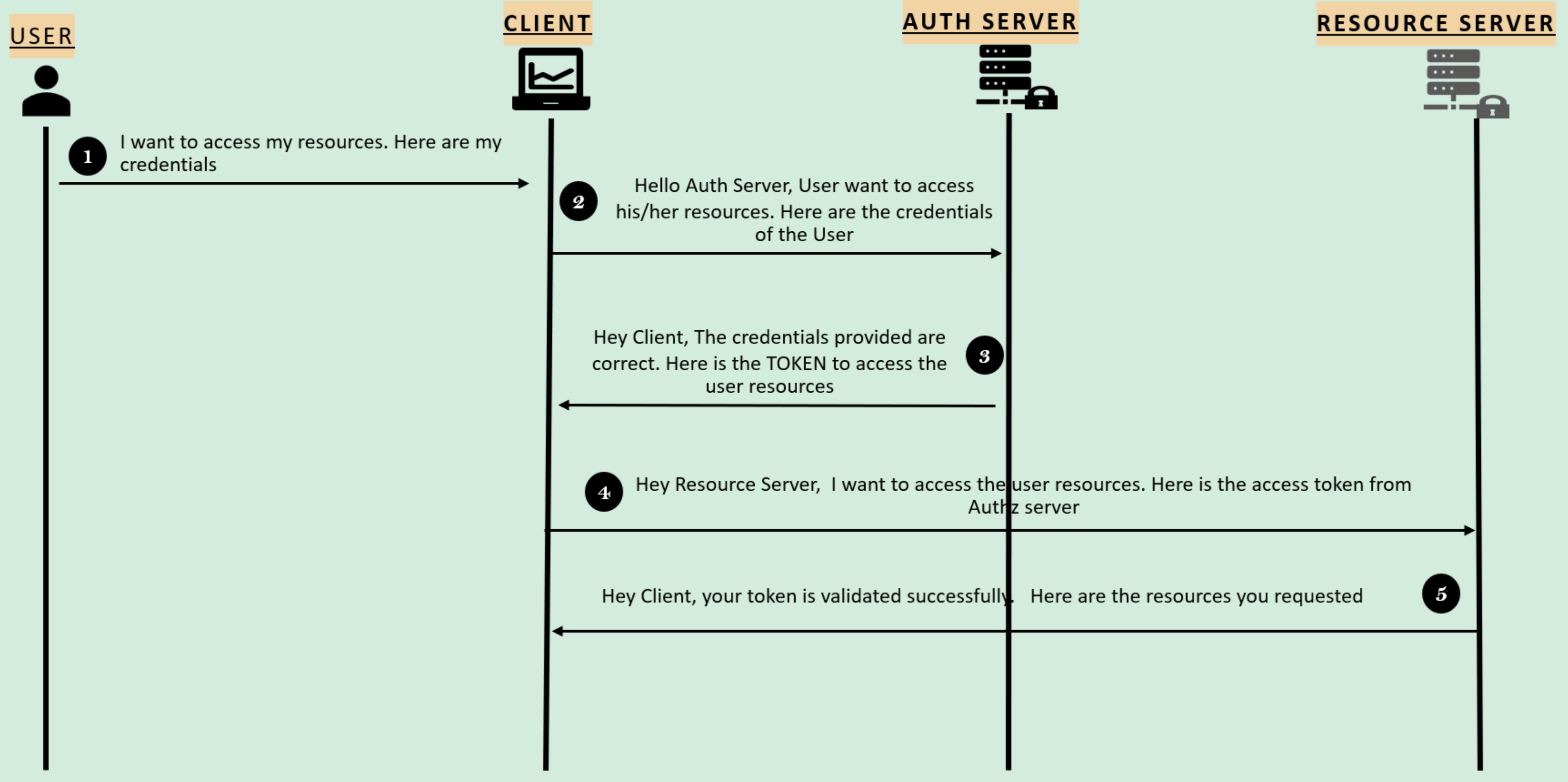


The PKCE-enhanced Authorization Code Flow follows below steps,

1. Once user clicks login, client app creates a cryptographically random code\_verifier and from this generates a code\_challenge.
2. code challenge is a Base64-URL-encoded string of the SHA256 hash of the code verifier.
3. Redirects the user to the Authorization Server along with the code\_challenge.
4. Authorization Server stores the code\_challenge and redirects the user back to the application with an authorization code, which is good for one use.
5. Client App sends the authorization code and the code\_verifier(created in step 1) to the Authorization Server.
6. Authorization Server verifies the code\_challenge and code\_verifier. If they are valid it responds with ID Token and Access Token (and optionally, a Refresh Token).

## Password/Resource Owner

This flow is deprecated and not recommended for production use



Unlike other OAuth flows (Authorization Code, Implicit, PKCE) where the user is redirected to the Auth Server's login page, in this flow:

1. The client application presents its own login form to the user
2. The user enters their credentials directly into the client application
3. The client application sends both the user's credentials AND the client credentials to the Auth Server
4. If valid, the Auth Server issues an access token directly to the client
5. The client uses this token to access resources from the Resource Server

**Request Parameters**

When requesting the token (step 2), the client includes:

* client\_id and client\_secret: Client credentials
* username and password: User credentials
* scope: Requested permissions
* grant\_type: Set to "password" for this flow

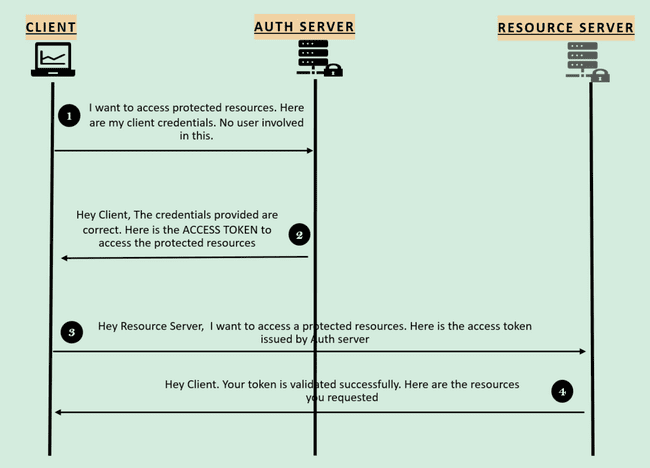
The main security issue is that **the user must give their credentials directly to the client application**. This creates several risks:

* The client could store and misuse the user's credentials
* The client has complete access to the user's account
* The user can't limit what the client can access

## Client Credentials

The Client Credentials grant flow is one of the OAuth 2.0 authorization flows specifically designed for server-to-server authentication when there's no user context involved. It's the simplest OAuth 2.0 grant type and is used when the client itself is the resource owner.

* **No End User Involvement**: This flow is used when services need to communicate directly with each other
* **Common Use Case**: Microservices communicating with other microservices or APIs
* **Most Common Flow** for backend service-to-service authentication



**Steps**

1. The client service (e.g., a microservice) sends a request to the Auth Server with:
   1. client\_id and client\_secret (acting as username/password for the service)
   2. scope (defining what access is needed)
   3. grant\_type: Set to "client\_credentials"
2. If the client credentials are valid, the Auth Server issues an access token
3. The client service uses this token when making requests to the Resource Server (e.g., another microservice)
4. The Resource Server validates the token and, if valid, fulfills the request

**Security Considerations**

* The client secret must be kept secure and never exposed to public clients
* Usually limited to confidential clients (servers that can securely store credentials)
* Scopes should be strictly limited to only what's necessary
* No refresh tokens are typically issued since the client can always request a new token

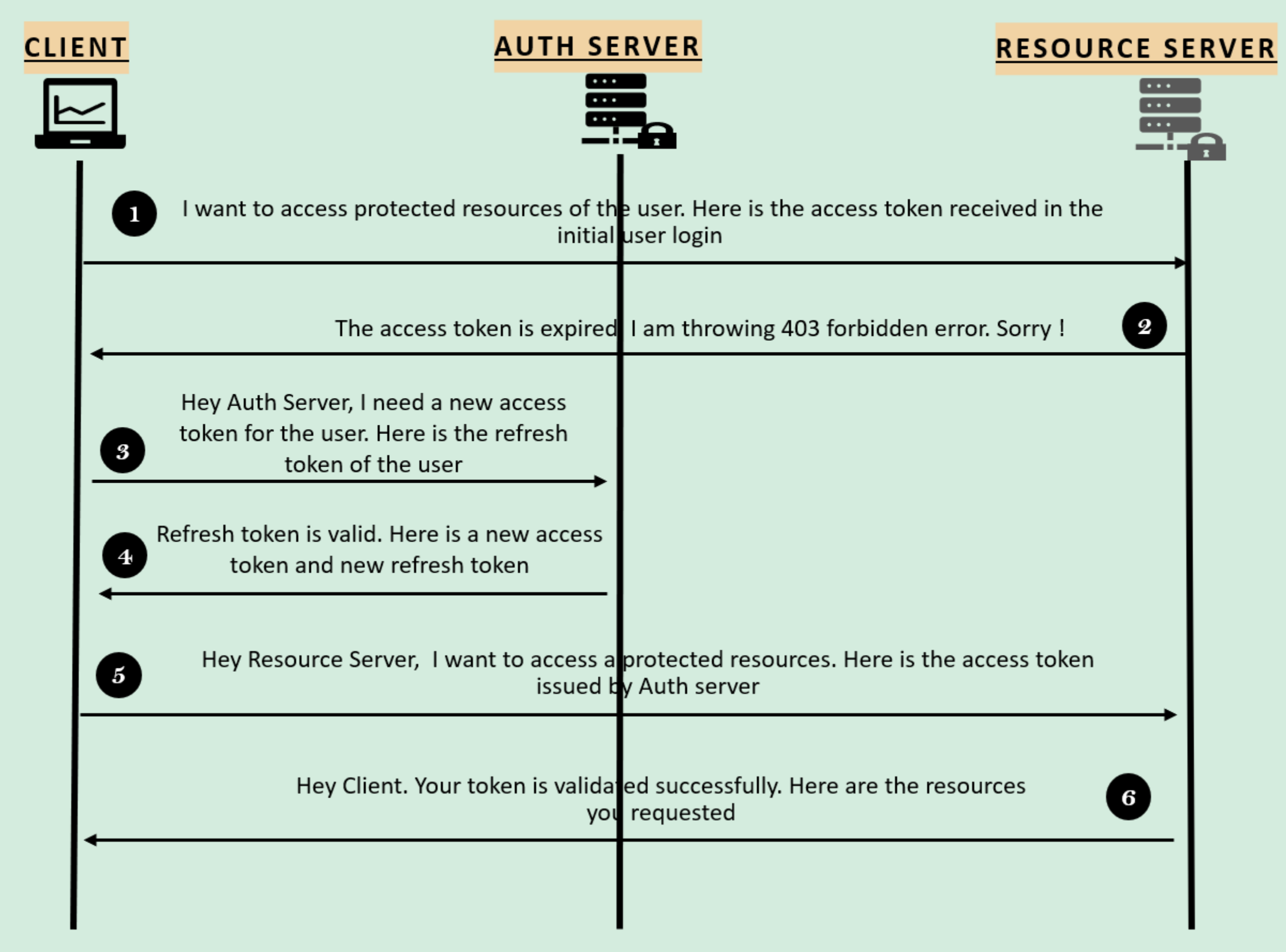
This flow is ideal for backend services that need to communicate with other APIs without user interaction, providing a secure authentication mechanism for service-to-service communication.

## Refresh Token

The Refresh Token Grant Type flow solves a critical user experience problem in OAuth 2.0: how to maintain user sessions without requiring frequent re-authentication.

When an Auth Server issues an access token, it typically has a limited lifespan (often 24 hours or less). This creates a dilemma:

* Short-lived tokens are more secure
* But requiring users to re-authenticate frequently creates poor user experience



1. **Initial Authentication**:
   1. During the initial Authorization Code or PKCE flow
   2. The Auth Server issues both an access\_token AND a refresh\_token
   3. The client stores both tokens
2. **When Access Token Expires**:
   1. The client tries to access the Resource Server with the expired token
   2. The Resource Server returns a 403 Forbidden error
   3. The client detects this error
3. **Refresh Flow Process**:
   1. The client sends a request to the Auth Server with:
      1. client\_id and client\_secret
      2. The refresh\_token received earlier
      3. grant\_type set to "refresh\_token"
   2. If the refresh token is valid, the Auth Server issues:
      1. A new access\_token
      2. Often a new refresh\_token (token rotation for better security)
4. **Continued Access**:
   1. The client uses the new access token to access resources
   2. The user never sees this process or has to re-authenticate

# OpenID Connect (OIDC)

* OpenID Connect (OIDC) is an authentication protocol built on top of OAuth 2.0, which is an authorization framework.
* Think of OIDC as a thin wrapper over OAuth 2.0—it doesn’t replace it but extends it with identity-related capabilities.

**Why OIDC When We Have OAuth 2.0?**

* OAuth 2.0 was designed for **authorization**—granting access to resources.
* Over time, developers started using OAuth 2.0 for **authentication** (e.g., social login via Google, Facebook, GitHub, etc.), but OAuth doesn’t clearly define **how to get or share user identity information**.
* This led to **non-standard, inconsistent workarounds** to identify users.

OIDC solves this gap by standardizing **authentication flows** on top of OAuth 2.0.

It introduces:

* A **new token** called the **ID Token** (in addition to the access token).
* Standard **scopes** like openid, profile, email, address.
* A standard **userinfo endpoint** to fetch identity data via API.

**ID Token vs Access Token**

* **Access Token**: Grants access to resources (e.g., photos API).
* **ID Token**: Contains **user identity info** (e.g., username, email) in **JWT** format.
* With OIDC, the client app gets both—so it knows **who** the user is and what they can access.

Flow

1. User clicks login with Google.
2. App sends request with scope=openid profile email.
3. User authenticates and consents.
4. App receives **authorization code**, exchanges it for:
   1. **access\_token** (for APIs),
   2. **id\_token** (for identity),
   3. (optional) **refresh\_token**.
5. App decodes id\_token (JWT) to get user info.

# Social Logins

## Set up your code

**Step 1: Define Security Configuration**

* Create a class ProjectSecurityConfig inside a config package.
* Annotate the class with @Configuration.
* Define a SecurityFilterChain bean:

*@Bean*SecurityFilterChain defaultSecurityFilterChain(HttpSecurity httpSecurity) *throws* Exception {  
 httpSecurity.authorizeHttpRequests((requests) -> requests.requestMatchers("/secure").authenticated()  
 .anyRequest().permitAll())  
 .formLogin(Customizer.withDefaults())  
 .oauth2Login(Customizer.withDefaults());  
 *return* httpSecurity.build();  
}

* This configuration:
  + Secures /secure path
  + Permits all other paths
  + Enables both form-based and OAuth 2.0 login

**Step 2: Register OAuth Clients**

* OAuth requires client registration details (like client ID and secret) to be known by Spring Security.
* Create a bean of type ClientRegistrationRepository to store these:

*@Bean*ClientRegistrationRepository clientRegistrationRepository() {  
 ClientRegistration github = githubClientRegistration();  
 ClientRegistration facebook = facebookClientRegistration();  
 *return new* InMemoryClientRegistrationRepository(github, facebook);  
}

**Step 3: Create Client Registrations**

* Use CommonOAuth2Provider (an enum provided by Spring) to simplify common provider configurations:

*private* ClientRegistration githubClientRegistration() {  
 *return* CommonOAuth2Provider.GITHUB.getBuilder("github").clientId("Ov23liCBLLUjii41pS7k")  
 .clientSecret("9da8734b56aad52d91b268fe6834a8df12447d95").build();  
}  
  
*private* ClientRegistration facebookClientRegistration() {  
 *return* CommonOAuth2Provider.FACEBOOK.getBuilder("facebook").clientId("974042741122392")  
 .clientSecret("36d48c25c1767d58b3101551513d7e1e").build();  
}

## Git hub

**Step-by-Step: Registering with GitHub**

**Log into GitHub**

1. Go to <https://github.com>
   1. Sign in with your GitHub account.
2. **Go to Developer Settings**
   1. Click on your profile picture > **Settings**
   2. Scroll down to the bottom > Click **Developer settings**
3. **Create an OAuth App**
   1. In the left panel, click **OAuth Apps**
   2. Click **"New OAuth App"**
4. **Fill in App Details**
   1. **Application Name**: some\_name
   2. **Homepage URL**: http://localhost:8080 (for local development)
   3. **Authorization callback URL**: http://localhost:8080 (same as above)
   4. Don’t check the "Device Flow" checkbox.
   5. Click **Register Application**
5. **Copy Client ID and Secret**
   1. After registering:
      1. You’ll see a **Client ID** – copy and save it.
      2. Click **"Generate a new client secret"**, re-enter your GitHub password, and then copy the **Client Secret**.
      3. Note: You won’t be able to see the secret again.
6. **(Optional) Add Logo and Description**
   1. Upload a logo (optional)
   2. Add description like: *"application to demo OAuth2."*
   3. Click **Update application**
   4. Use environment variables in real apps to store clientId and clientSecret. Don’t hardcode them in code.

## Facebook

**Go to Facebook for Developers**

1. Visit <https://developers.facebook.com>
   1. Make sure you're logged in with your Facebook account.
2. **Create a New App**
   1. Click **"My Apps"** > **"Create App"**
   2. Select **default option** (no need for special use cases)
   3. Click **Next**
3. **Choose Use Case**
   1. Choose **Authentication and account creation**
   2. Click **Next**
   3. Select **"No, I’m not building a game"**
   4. Click **Next**
4. **App Details**
   1. **App name**: some\_name
   2. **Contact email:** Valid Email
   3. Click **Create App**
5. **Enable Permissions (Scopes)**
6. Go to **Use Cases** > Click **Customize**
   1. Enable:
      1. public\_profile (default)
      2. email (required for Spring app)
   2. ⚠️ If you don’t enable email permission, login will fail due to missing scope.
7. **Get Client ID and Secret**
   1. Go to **App Settings** > **Basic**
   2. Copy:
      1. **App ID** → this is your clientId
      2. **App Secret** → click **Show**, enter password, copy it as clientSecret
8. **(Optional) Add Logo & Save**
   1. Optionally upload a logo
   2. Click **Save Changes**

# Key cloak

Local set up

docker run -d -p 8080:8080 -e KC\_BOOTSTRAP\_ADMIN\_USERNAME=admin -e KC\_BOOTSTRAP\_ADMIN\_PASSWORD=admin quay.io/keycloak/keycloak:26.1.4 start-dev

<http://192.168.0.143:8080/>

Set up on ec2

**SET UP SSL**

* **Step 1:** Install docker

*sudo yum update -y*

*sudo yum install -y docker*

*sudo service docker start*

*sudo usermod -a -G docker ec2-user*

* **Step 2:** Install OpenSSL

First, ensure OpenSSL is installed on your EC2 instance:

*sudo yum install -y openssl*

* **Step 3:** Generate a Self-Signed Certificate

1. Navigate to a directory where you want to store the certificate

*mkdir -p ~/keycloak-cert && cd ~/keycloak-cert*

1. Generate a private key:

*openssl genpkey -algorithm RSA -out keycloak.key*

1. Create a certificate signing request (CSR):

*openssl req -new -key keycloak.key -out keycloak.csr*

Fill in details as prompted (Common Name should be your EC2 public IP or domain).

1. Generate a self-signed certificate valid for 1 year:

*openssl x509 -req -days 365 -in keycloak.csr -signkey keycloak.key -out keycloak.crt*

* **Step 4:** Convert Certificate to PKCS12 Format

openssl pkcs12 -export -inkey keycloak.key -in keycloak.crt -out keycloak.p12 -name keycloak -password pass:changeit

* **Step 5:** Convert to Java Keystore (JKS)

1. Install keytool (part of OpenJDK):

*sudo yum install -y java-17-amazon-corretto*

1. Convert the PKCS12 file to a Java Keystore:

* **Step 6:** Convert Certificate to PKCS12 Format

*keytool -importkeystore -srckeystore keycloak.p12 -srcstoretype PKCS12 -destkeystore keycloak.jks -deststoretype JKS -deststorepass changeit -srcstorepass changeit -alias keycloak*

* **Step 7:** Run Keycloak with HTTPS

Run Keycloak with HTTPS enabled using your generated keystore:

*docker run -d -p 8443:8443 \*

*-e KC\_HTTPS\_CERTIFICATE\_FILE=/opt/keycloak/conf/keycloak.crt \*

*-e KC\_HTTPS\_CERTIFICATE\_KEY\_FILE=/opt/keycloak/conf/keycloak.key \*

*-e KC\_HOSTNAME=$(curl -s ifconfig.me) \*

*-e KC\_BOOTSTRAP\_ADMIN\_USERNAME=admin \*

*-e KC\_BOOTSTRAP\_ADMIN\_PASSWORD=admin \*

*-v ~/keycloak-cert:/opt/keycloak/conf \*

*quay.io/keycloak/keycloak:26.1.4 start-dev --https-port=8443 --https-key-store-file=/opt/keycloak/conf/keycloak.jks --https-key-store-password=changeit*

* **Step 8:** Set up security Group
* **Step 9:** Test

# OAUTH2 implementation

**Why Not Social Logins in Enterprise Apps?**

* **Limited Control**: With GitHub, Facebook, etc., you can't define custom roles or authorities based on your business needs.
* **Fixed User Info**: You're stuck with whatever data these social platforms give you.
* **Enterprise Needs**: Large applications might have **thousands of users**, each with specific **roles and permissions**, which social auth providers don’t support.
* **Security & Compliance**: Enterprises often need tighter control, auditing, and internal policy enforcement.

**What’s the Alternative?**

**Build or use your own Authorization Server**:

* Gives **full control** over users, roles, permissions.
* You can align it exactly with your business and security requirements

**Two Options for an Auth Server:**

1. **Use existing solutions** (e.g., [Keycloak](https://www.keycloak.org/), Okta, AWS Cognito, Azure AD):
   1. Ready-to-use
   2. Standards-compliant (OAuth 2.0, OpenID Connect)
   3. Scalable and flexible
2. **Build your own** using **Spring Authorization Server**:
   1. Maximum customization
   2. Requires more effort, time, and resources

**Application Setup Overview (OAuth 2 Flow)**

1. **Client Applications**:
   1. Angular frontend (or Postman for testing)
   2. Will **request access tokens** from the Auth Server (Keycloak)
2. **Auth Server (Keycloak)**:
   1. Issues **access tokens** after authenticating the user/client
3. **Resource Server (Spring Boot App)**:
   1. Contains protected APIs (like /accounts, /loans, /cards)
   2. Verifies the access token by communicating with the Auth Server
4. **Flow**:
   1. **Step 1**: Client → Keycloak (asks for access token)
   2. **Step 2**: Keycloak → Client (returns token)
   3. **Step 3**: Client → Spring Boot (sends request + token)
   4. **Step 4**: Spring Boot → Keycloak (validates token)
   5. **Final Step**: If valid → responds with protected resource

## Configure the Resource server

First, we must configure our APIs as a resource server to validate tokens coming from any of the authorization flows

Code change

This converter extract’s role information from a Keycloak JWT token:

1. Gets the realm\_access claim from the JWT
2. Extracts the roles list from this claim
3. Transforms each role by:
   1. Adding "ROLE\_" prefix (Spring Security convention)
   2. Converting to SimpleGrantedAuthority objects

*public class* KeycloakRoleConverter *implements* Converter<Jwt, Collection<GrantedAuthority>> {  
 */\*\*  
 \* @param source the source object to convert, which must be an instance of {@code S} (never {@code null})  
 \* @return  
 \*/  
 @Override  
 public* Collection<GrantedAuthority> convert(Jwt source) {  
 Map<String, Object> realmAccess = (Map<String, Object>) source.getClaims().get("realm\_access");  
 *if* (realmAccess == *null* || realmAccess.isEmpty()) {  
 *return new* ArrayList<>();  
 }  
 Collection<GrantedAuthority> returnValue = ((List<String>) realmAccess.get("roles"))  
 .stream().map(roleName -> "ROLE\_" + roleName)  
 .map(SimpleGrantedAuthority::*new*)  
 .collect(Collectors.toList());  
 *return* returnValue;  
 }  
}

Changes in Security Configuration

* Creates a JwtAuthenticationConverter that uses a custom KeycloakRoleConverter to extract roles from the JWT token.
* The converter transforms Keycloak roles into Spring's GrantedAuthority format (prefixed with "ROLE\_")

*/\* Creates a JwtAuthenticationConverter that uses a custom KeycloakRoleConverter to extract roles from the JWT token.  
 The converter transforms Keycloak roles into Spring's GrantedAuthority format (prefixed with "ROLE\_")\*/* JwtAuthenticationConverter jwtAuthenticationConverter = *new* JwtAuthenticationConverter();  
 jwtAuthenticationConverter.setJwtGrantedAuthoritiesConverter(*new* KeycloakRoleConverter());

Configures JWT support with the custom role converter

http.oauth2ResourceServer(rsc -> rsc.jwt(jwtConfigurer ->  
 jwtConfigurer.jwtAuthenticationConverter(jwtAuthenticationConverter)));

<http://192.168.0.143:8080/realms/master/.well-known/openid-configuration>

From there we can get the below endpoint for our application to download the certificates to validate the token

"jwks\_uri": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/certs>",

User the above certificate URL. With below configuration Spring will download the certificate during application startup

*#Public key to validate the token*spring.security.oauth2.resourceserver.jwt.jwk-set-uri=${JWK\_SET\_URI:http://192.168.0.143:8080/realms/master/protocol/openid-connect/certs}

## Opaque Token

JWT How It Works

* Keycloak issues JWT tokens (signed with a private key).
* Resource Server (Spring Boot) validates tokens locally using a public key (fetched from Keycloak’s jwk-set-uri).
* No runtime dependency on Keycloak after startup (only fetches keys once).

Key Points

* JWT tokens are self-contained (no need to call Keycloak for every request).
* Public key is cached (only fetched once at startup).
* Fast validation (no network calls after initial key fetch).

**Opaque Token Validation (Remote Introspection)**

How It Works

* **Opaque tokens** (non-JWT) require **calling Keycloak** for validation.
* **Resource Server sends token to Keycloak** (introspection endpoint).
* **Keycloak responds with token details** (active/inactive, roles, etc.).

How to set up

KeycloakOpaqueRoleConverter

* Implements OpaqueTokenAuthenticationConverter.
* Extracts **username** (preferred\_username) and **roles** (realm\_access.roles).
* Converts into a **Spring Security Authentication object**.

*public class* KeycloakOpaqueRoleConverter *implements* OpaqueTokenAuthenticationConverter {  
 */\*\*  
 \* @param introspectedToken the bearer token used to perform token introspection  
 \* @param authenticatedPrincipal the result of token introspection  
 \* @return UsernamePasswordAuthenticationToken  
 \*/  
 @Override  
 public* Authentication convert(String introspectedToken, OAuth2AuthenticatedPrincipal authenticatedPrincipal) {  
 String username = authenticatedPrincipal.getAttribute("preferred\_username");  
 Map<String, Object> realmAccess = authenticatedPrincipal.getAttribute("realm\_access");  
 Collection<GrantedAuthority> roles = ((List<String>) realmAccess.get("roles"))  
 .stream().map(roleName -> "ROLE\_" + roleName)  
 .map(SimpleGrantedAuthority::*new*)  
 .collect(Collectors.toList());  
 *return new* UsernamePasswordAuthenticationToken(authenticatedPrincipal.getName(), *null*,  
 roles);  
 }  
}

Set up security configuration for opaque token

*@Value*("${spring.security.oauth2.resourceserver.opaque.introspection-uri}")  
String introspectionUri;  
  
*@Value*("${spring.security.oauth2.resourceserver.opaque.introspection-client-id}")  
String clientId;  
  
*@Value*("${spring.security.oauth2.resourceserver.opaque.introspection-client-secret}")  
String clientSecret;

http.oauth2ResourceServer(rsc -> rsc.opaqueToken(otc -> otc.authenticationConverter(*new* KeycloakOpaqueRoleConverter())  
 .introspectionUri(*this*.introspectionUri).introspectionClientCredentials(*this*.clientId,*this*.clientSecret)));

Configuring application.properties for opaque tokens

*##Public key to validate the token  
#spring.security.oauth2.resourceserver.jwt.jwk-set-uri=${JWK\_SET\_URI:http://192.168.0.143:8080/realms/master/protocol/openid-connect/certs}  
  
#spring.profiles.active= test*spring.security.oauth2.resourceserver.opaque.introspection-uri= ${INTROSPECT\_URI:http://192.168.0.143:8080/realms/master/protocol/openid-connect/token/introspect}  
spring.security.oauth2.resourceserver.opaque.introspection-client-id=${INTROSPECT\_ID: springSecurityClientCredentials}  
spring.security.oauth2.resourceserver.opaque.introspection-client-secret=${INTROSPECT\_SECRET:HBLepoapsNJ8KeyYRuWofzDgN5pUPtaH}

"introspection\_endpoint": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/token/introspect>",

Now when I hit the same API it will try to validate access\_token with Keycloak every time. If we stop the Keycloak the token validation and API will fail. If we bring it up again API and access\_token validation will start working.

**Key Takeaways**

1. **Use JWT** for most cases (performance + simplicity).
2. **Use Opaque Tokens** only if:
   1. You need **instant token revocation**.
   2. Your auth server supports opaque tokens (e.g., Spring Authorization Server).
3. **Keycloak’s opaque token support is limited** (still issues JWTs).
4. JWT is faster but cannot revoke tokens early.
5. Opaque tokens are more secure but require Keycloak to be always online.
6. Choose based on security vs. performance needs:
   1. JWT → Microservices, internal APIs.
   2. Opaque → External clients, high-security apps.

## Client Credentials

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Create a client with name springSecurityClientCredentials

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AI-generated content may be incorrect.

Click on the OpenID Endpoint Configuration to get a list of endpoints

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Create roles in Realm roles USER and ADMIN and associate with the client springSecurityClientCredentials

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Select Filter by realm roles

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<http://192.168.0.143:8080/realms/master/.well-known/openid-configuration>

From there we can get the below endpoint to get access token

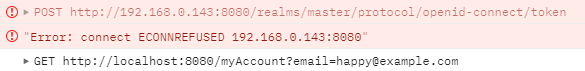
"token\_endpoint": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/token>",

First we will generate token using <http://192.168.0.143:8080/realms/master/protocol/openid-connect/token> in postman and use the token to access our API

**Steps in Postman:**

1. **Go to Authorization Tab** → Select **OAuth 2.0**.
2. **Configure Token:**
   * 1. **Token Name**: AccessToken (arbitrary name).
     2. **Grant Type**: **Client Credentials** (machine-to-machine flow).
     3. **Access Token URL**: Taken from Keycloak’s **Token Endpoint** (e.g., <http://192.168.0.143:8080/realms/master/protocol/openid-connect/token>).
     4. **Client ID**: (registered in Keycloak).
     5. **Client Secret**: Copied from Keycloak’s **Credentials** tab.
     6. **Scope**: openid email (standard OpenID scopes).
     7. **Client Authentication**: **Send client credentials in body**.
3. **Click "Get New Access Token"** → Keycloak issues a **JWT token** (valid for 5 minutes by default).

Since in this case we are using JWT token our spring boot application can validate the user if the token is valid. Spring boot connects with Keycloak at the start up to get the certificate with which it validates any token and if the token is active it will work. We can test this by stopping Keycloak server after we have generated the access\_token and hit the API with the token. We will see that the Spring security can validate the token. As long ad the token is not expired it will work and we can access API. In postman we will see that the postman is failing to refresh the token but the API is successful as long as the access\_token has not expired.



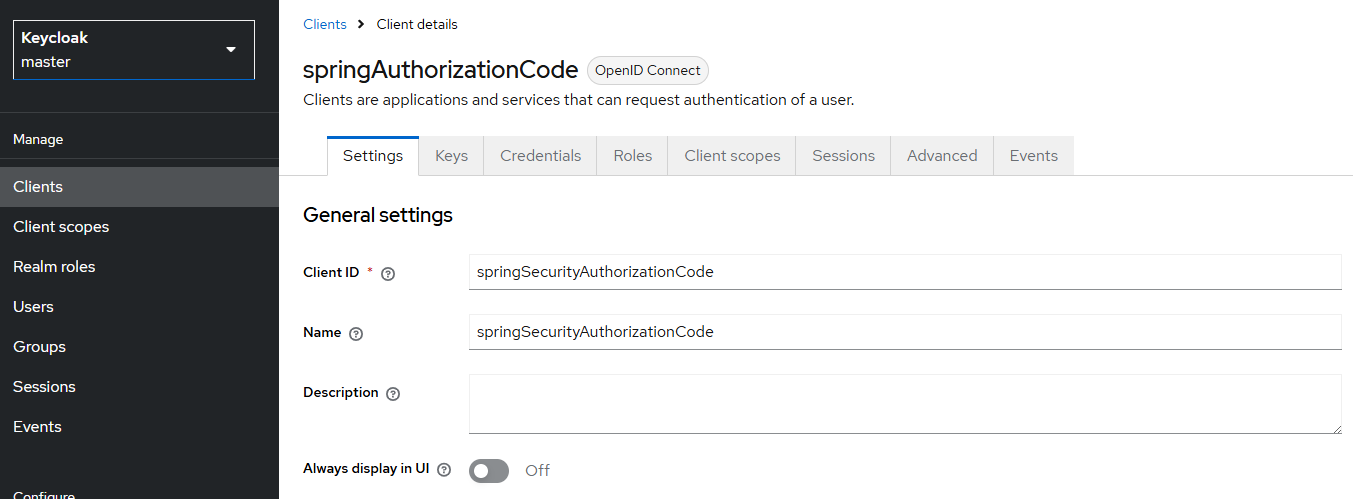
Once we bring back the Keycloak we can generate token again. We can validate token in <https://jwt.io/>

## Authorization code grant flow

Set up Keycloak

Keycloak set up for Authorization code Grant type flow

Create a client with name springSecurityAuthorizationCode



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For the next settings

1. **Valid Redirect URIs**

* This field defines where the authorization server should redirect the user after successful authentication.
* It prevents attackers from redirecting the access token to malicious sites.
* Ideally, this should be set to the actual **dashboard or profile page URL** of your client application.
* If left as \* (wildcard), it allows redirection to any URL, which is insecure in a production environment.

1. **Valid Post Logout Redirect URIs**

* This determines where the user is redirected after logging out.
* It can be left blank if no redirection is required post-logout.

1. **Web Origins**

* Defines which domains can interact with the Keycloak authentication server.
* Used to prevent **CORS (Cross-Origin Resource Sharing)** errors in browsers when different domains communicate.
* Setting \* (wildcard) allows all domains, but in production, it should be restricted to the actual client domain.

**Key Takeaways**

* **For production**, avoid using \* in **Valid Redirect URIs** and **Web Origins**.
* Configure the exact **redirect URL** of your client application for security.
* Ensure **CORS** is properly configured to prevent unauthorized access.

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Since this grant flow needs user, we need to create one

A screenshot of a browser window

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A screenshot of a computer

AI-generated content may be incorrect.

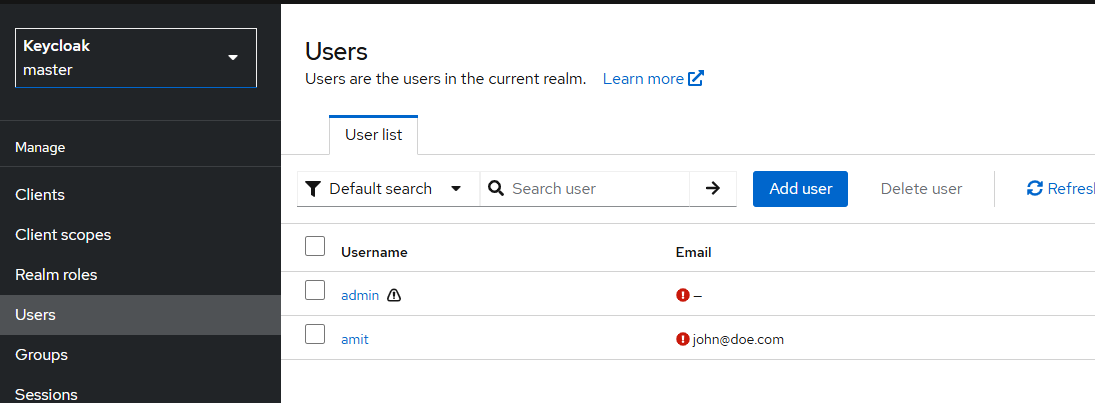
A screenshot of a computer

AI-generated content may be incorrect.

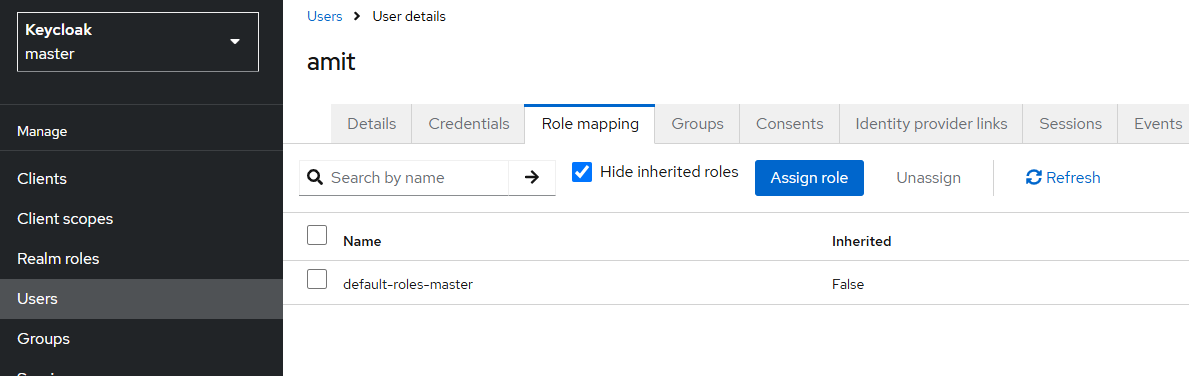
A screenshot of a login screen

AI-generated content may be incorrect.

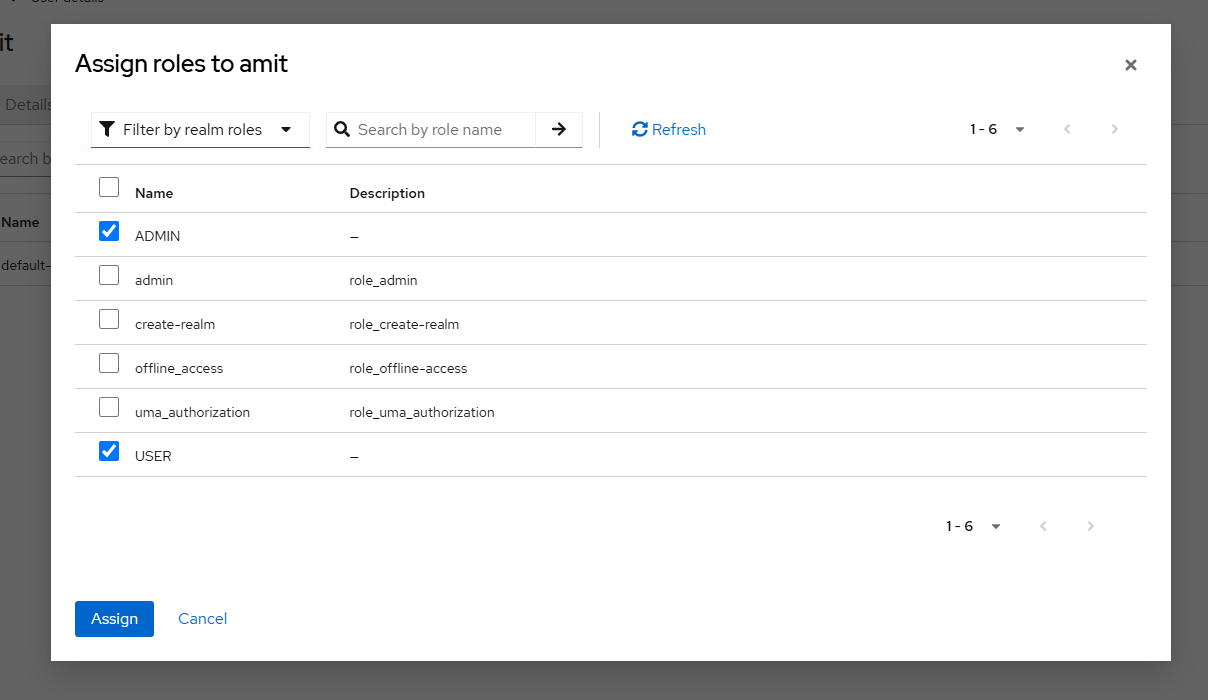
Assign roles to user



Click to see the details of user and click on assign role in Role Mapping



Select Realm roles and assign roles ADMIN and USER created during Client Credentials flow. If not created create now



Use this end point <http://192.168.0.143:8080/realms/master/.well-known/openid-configuration> to get below

Auth Url 🡪"authorization\_endpoint": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/auth>" to get Authorization code

Access Token UR 🡪 "token\_endpoint": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/token>", to get access\_token

**Configure Postman**:

* **Auth Type**: OAuth 2.0.
* **Grant Type**: Authorization Code.
* **Callback URL**: https://oauth.pstmn.io/v1/callback (Postman’s default).
* **Auth URL**: Keycloak’s authorization\_endpoint (e.g., <http://192.168.0.143:8080/realms/master/protocol/openid-connect/auth>).
* **Token URL**: Keycloak’s token\_endpoint (e.g., <http://192.168.0.143:8080/realms/master/protocol/openid-connect/token>).
* **Client ID**: springSecurityAuthorizationCode.
* **Client Secret**: Copied from Keycloak.
* **Scope**: openid email profile.

**User Authentication**:

* Postman opens Keycloak’s login page.
* User enters credentials .
* Keycloak redirects back to Postman with an **authorization code**.

**Token Exchange**:

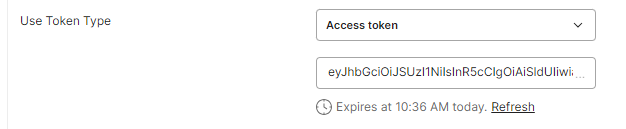
* Postman exchanges the code for an **access token** (and optionally a **refresh token**).

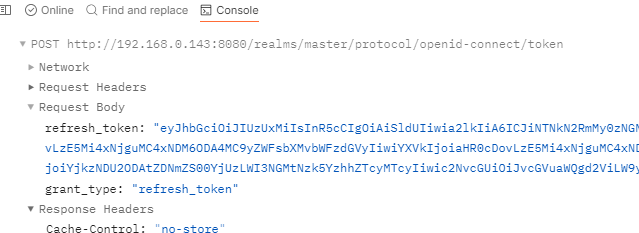
**Call Secured APIs**:

* Access token is sent to the **Resource Server** (Spring Boot).
* Server validates the token (via JWKS or introspection).

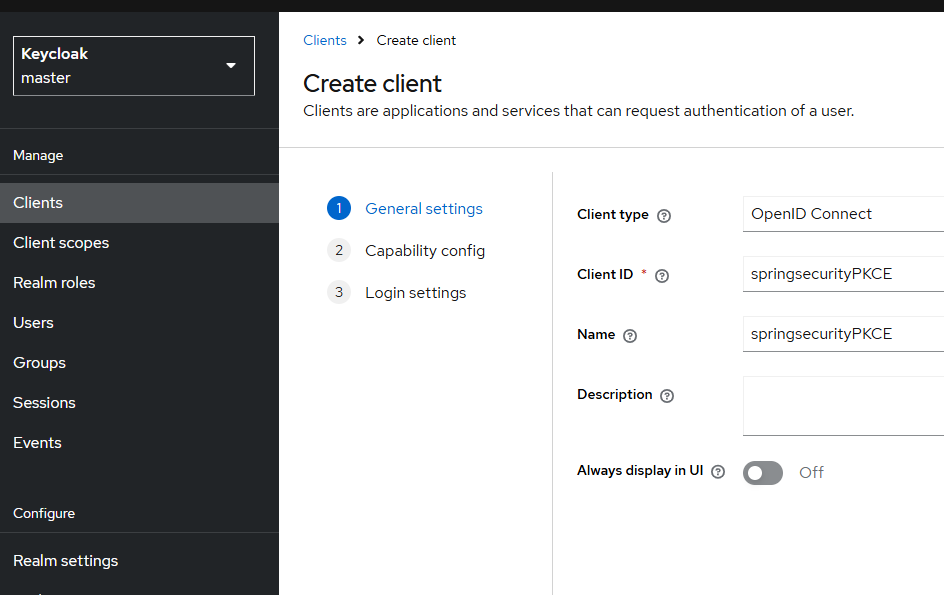
While testing Authorization code grant type flow, logout from key cloak in browser otherwise it will take the session from Admin

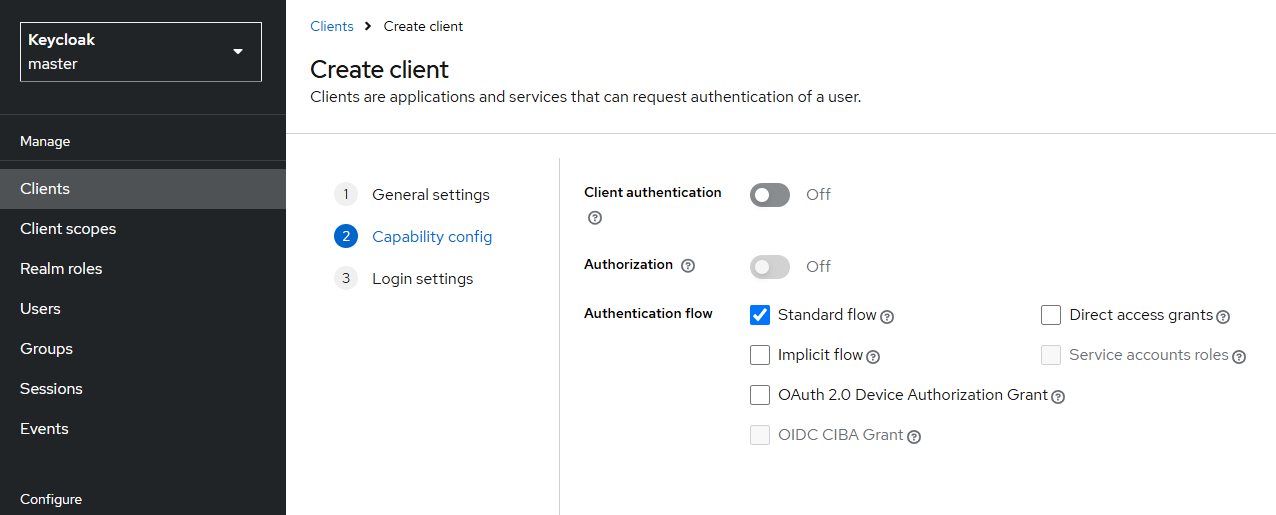
The token’s have an expiry period, which is shown in postman. If we click on this refresh, you can see I got a new token, but if I go and check the console, what happened behind the scenes, my postman made a post request to this URL to get a new access token. This time if you try to see what is there inside the RequestBody, you'll be able to see there is a refresh\_token along with the grant\_type as refresh token and as a response, we received a new access token. The same is populated by my postman inside this field. With which we can make API call





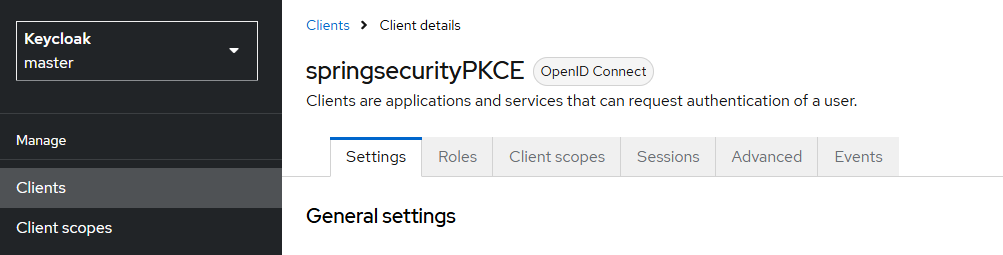
## PKCE



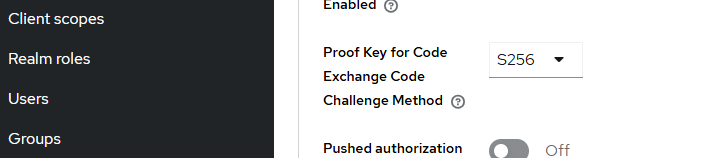




Since this is PKCE flow we won’t see any client credentials Tab



Go to advanced section and search for “Proof Key for Code Exchange Code Challenge Method” and select S265 or SHA256

****

In postman

"authorization\_endpoint": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/auth>",

"token\_endpoint": "<http://192.168.0.143:8080/realms/master/protocol/openid-connect/token>",

When we test in postman when we generate token we see

below endpoint getting called

<http://192.168.0.143:8080/realms/master/protocol/openid-connect/token>

With below request body

1. grant\_type: "authorization\_code"
2. code: "0193d26e-e9d4-45e4-9284-a114bccc3a82.27d128c4-4747-44f4-b101-09a329348366.10769ff6-1dde-46d7-80f0-485a5b0776bf"
3. redirect\_uri: "https://oauth.pstmn.io/v1/callback"
4. code\_verifier: "qPsH306-ZDDaOE8DFzVn05TkN3ZZoRvI14-8oGD7thP"
5. client\_id: "springsecurityPKCE"

No client secret is send

While testing PKCE we have to allow origin to solve cors issue

