



Securing Microservices with OpenID Connect and Spring Security 5

Workshop

Andreas Falk



Agenda

1. Intro:
 - OAuth 2.0
 - Intro-Lab: OAuth2 in Action
 - OpenID Connect 1.0
2. Hands-On Part
 - Resource Server
 - Client (Auth Code Flow)
3. More Demos (as time allows)
 - Testing Support
 - ...

Workshop Code

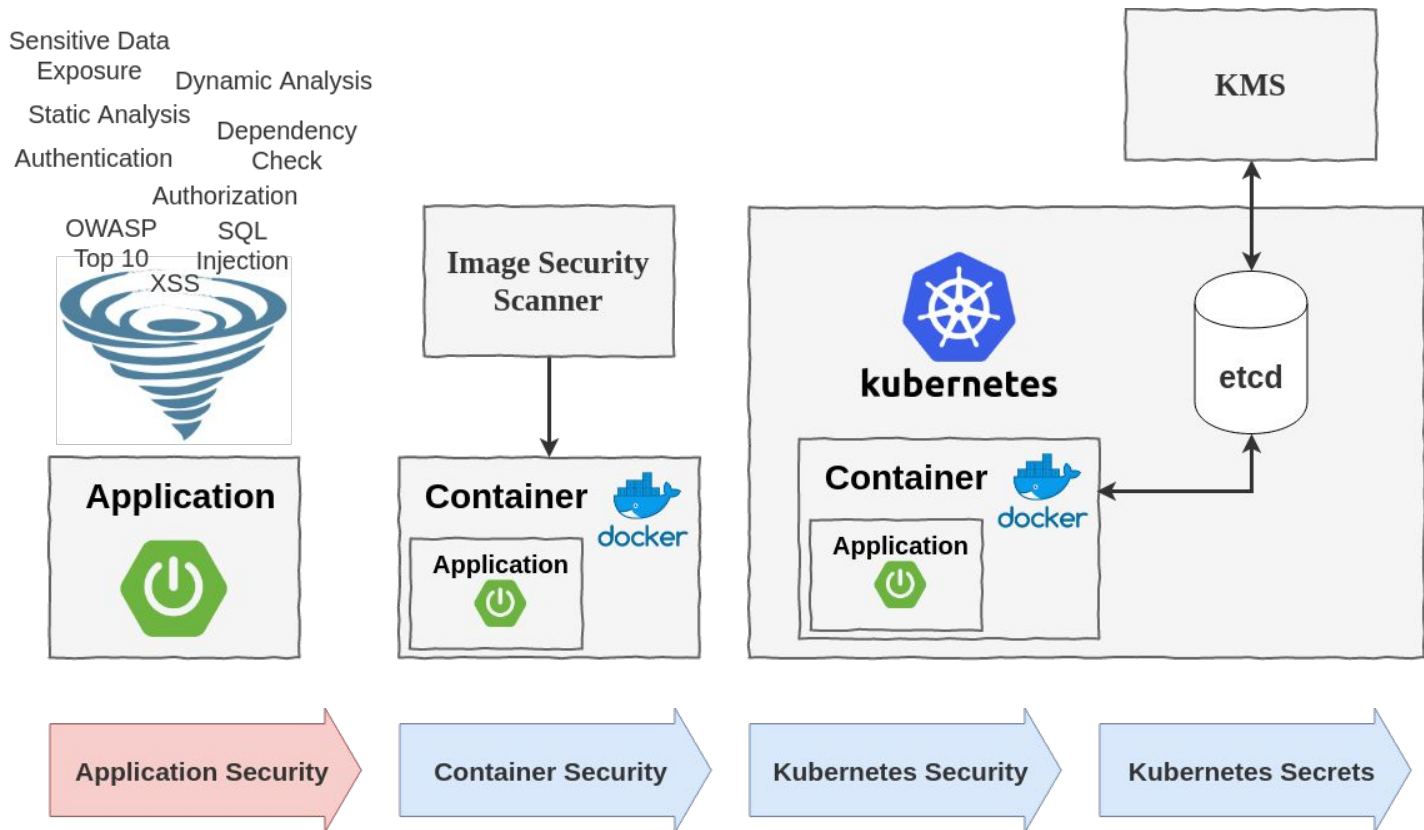
Workshop-Tutorial:

<https://andifalk.gitbook.io/openid-connect-workshop>

Workshop Source-Code:

<https://github.com/andifalk/secure-oauth2-oidc-workshop>

Authentication & Authorization: Only ONE part of Security!



Authentication



Knowledge Factor (something the user knows):
Password, PIN, security question,...

Ownership Factor (something the user has):
ID card, security token, cell phone holding a software token,...

Inherence Factor (something the user is):
Fingerprint, retinal pattern,...

Authentication

- **Single-Factor Authentication**
- **Multi-Factor Authentication**

Common Authentication Mechanisms

- Basic Authentication / Digest Access Authentication
- Form-based Authentication (i.e. using Session Cookies)
- Client-Certificates (Mutual TLS)
- Kerberos Tickets
- Proprietary mechanisms like API-Tokens, Siteminder etc.
- SAML Assertion Tokens
- JSON Web Tokens
- OAuth 2.0 & OpenID Connect 1.0
- WebAuthn / FIDO2



OAuth 2.0 & OpenID Connect



Introduction



OAuth 2.0

[RFC 6749: OAuth 2.0 Authorization Framework](#)

OAuth 2.0

“The OAuth 2.0 authorization framework enables a **third-party application** to obtain **limited access to an HTTP service**, either **on behalf of a resource owner** by orchestrating an approval interaction between the resource owner and the HTTP service, or by allowing the third-party application to obtain access on **its own behalf**”

(RFC 6749)

OAuth 2.0 - A bunch of RFC's (Request for Comments)

OAuth 2.0

NEW

RFC 8628: Device Grant

RFC 7591: Client Registration

RFC 8693: Token Exchange

RFC 6750: Bearer Token

RFC 7636: PKCE

RFC 8252: Native Apps

RFC 6819: Threat Model

RFC 7662: Token Introspection

RFC 7009: Token Revocation

RFC 6749: OAuth 2.0 Authorization Framework

“OAuth 2.1” - Even more Draft Specifications...

“OAuth 2.1”

JWT Response for OAuth
Token Introspection

JSON Web Token Best Current
Practices

OAuth 2.0 Rich Authorization
Requests

JWT Secured Authorization
Request

Resource Indicators for OAuth
2.0

OAuth 2.0 Security Best
Current Practice

OAuth 2.0 for
Browser-Based Apps

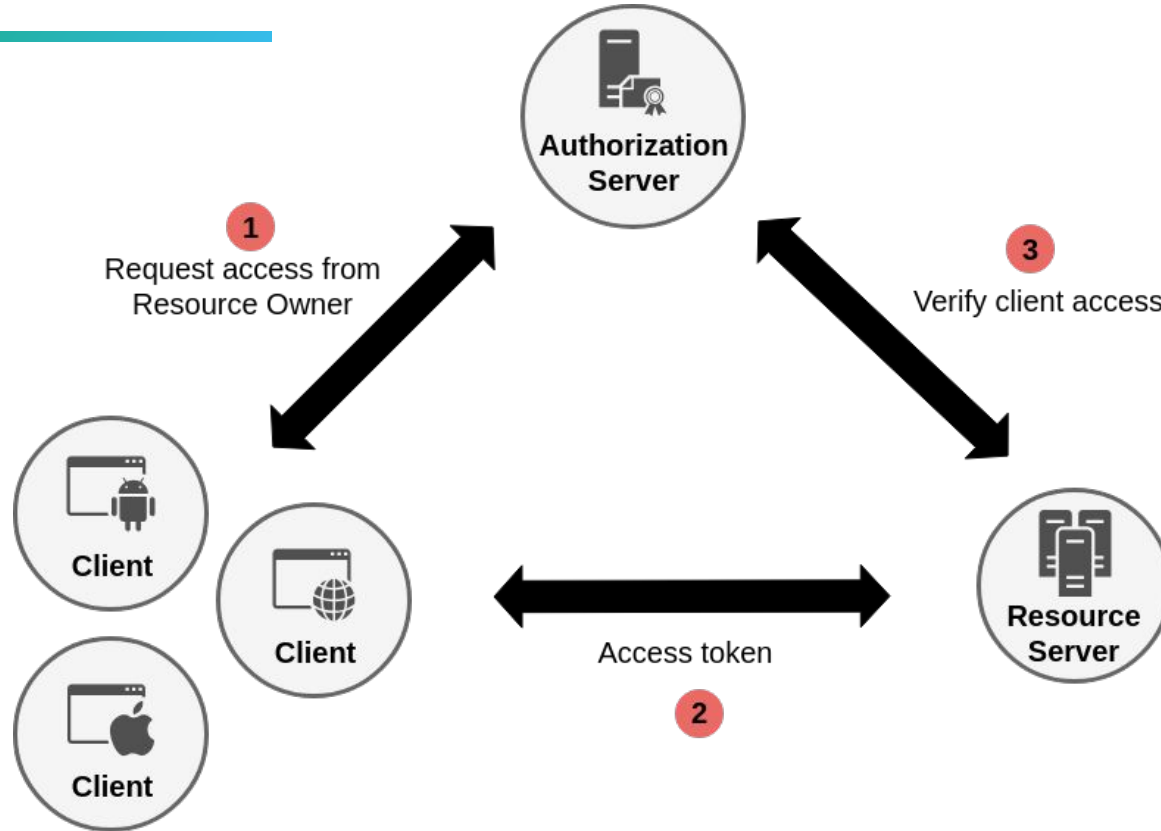
JWT Profile for OAuth 2.0
Access Tokens

OAuth 2.0 Mutual-TLS Client
Authentication

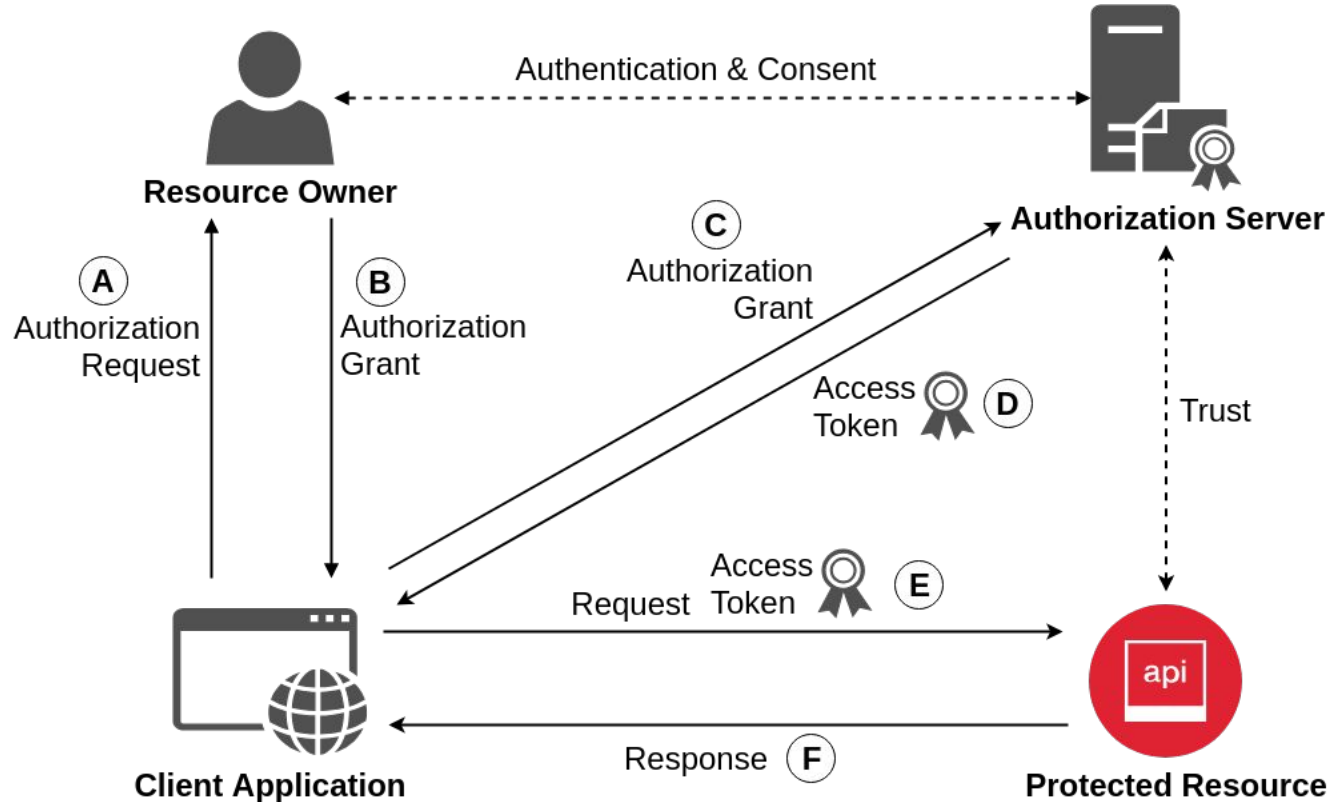
OAuth 2.0 is an authorization delegation framework



OAuth 2.0 Roles



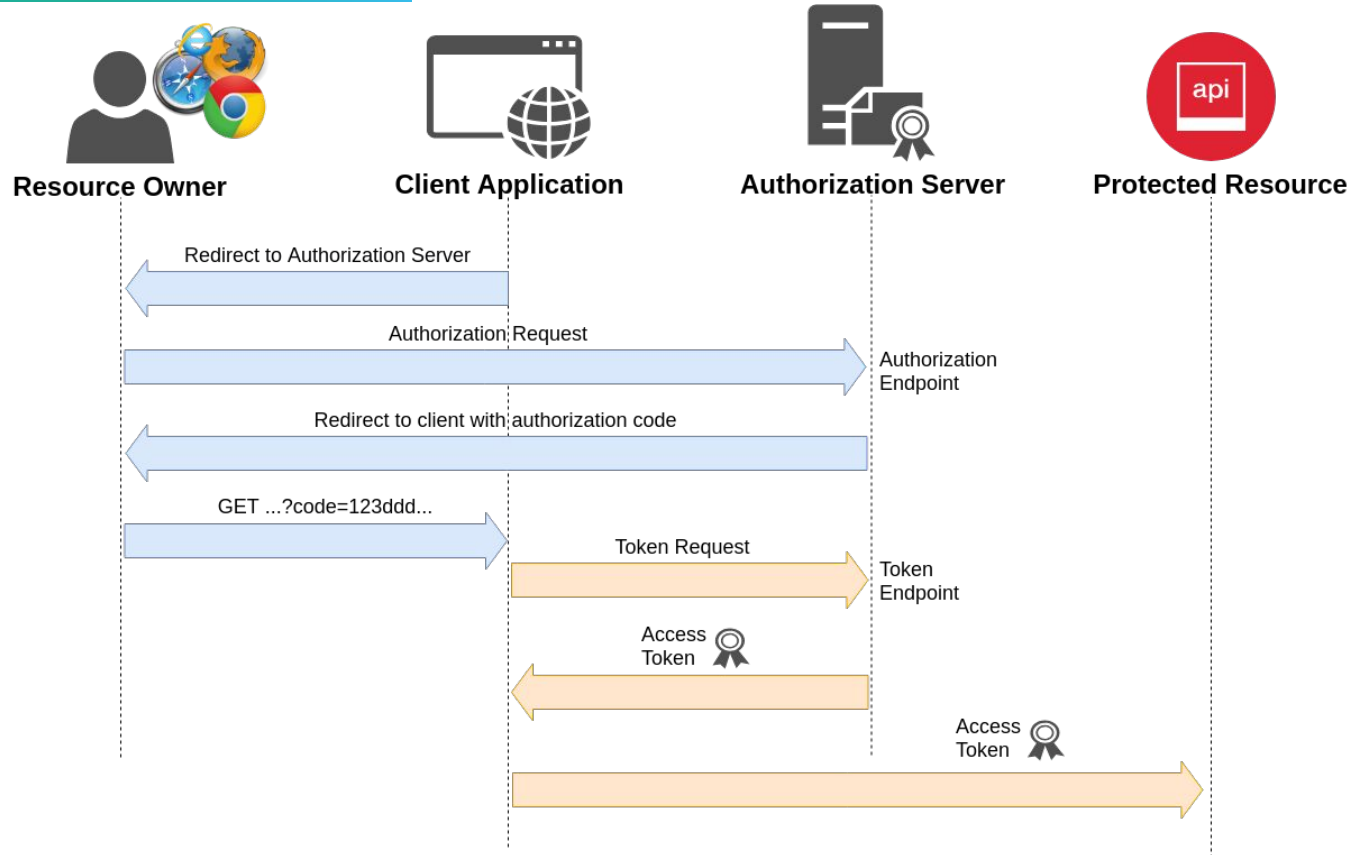
OAuth 2.0 Protocol Flow



OAuth 2.0 Grant Flows

Client Type	Flow	Refresh Tokens
Confidential	Authorization Code	X
Public (Native)	Authorization Code (PKCE)	X
Public (SPA)	Implicit	--
Trusted	RO Password Creds	X
No Resource Owner	Client Credentials	--

OAuth 2.0 Authorization Code Grant Flow





Practice Time

Intro-Lab: Authorization Code Grant Flow in Action



OpenID Connect 1.0

Identity Layer on top of the OAuth 2.0 Protocol

OAuth 2.0 is NOT an Authentication Protocol!



Jim Manico

@manicode

Follow



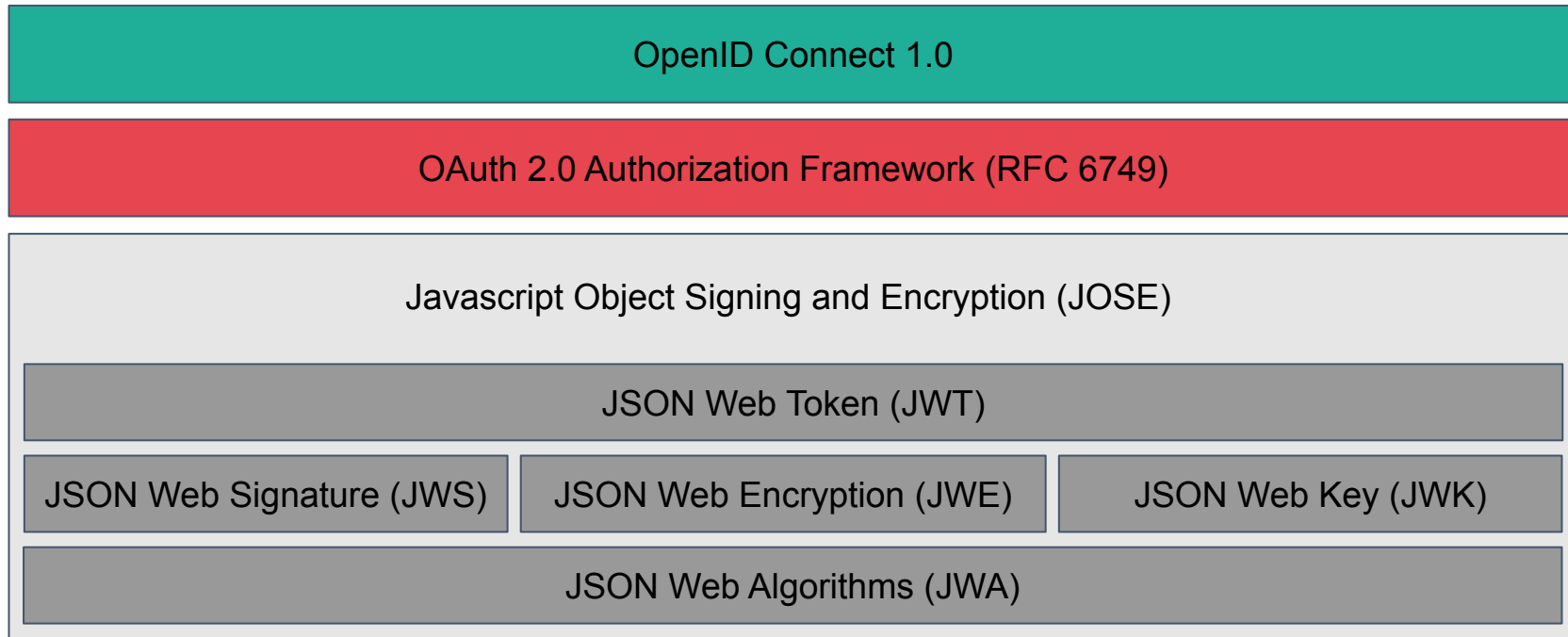
Repeat after me: OAuth 2.0 is NOT AN
AUTHENTICATION PROTOCOL.

oauth.net/articles/authenticate ...

12:22 PM - 2 Feb 2017 from [Kapaa, HI](#)

[OAuth 2.0 is not an authentication protocol](https://oauth.net/articles/authenticate)

OpenID Connect 1.0 Standards Layer



JSON Web Algorithms (JWA)

- Cryptographic algorithms and identifiers for JWS, JWE, and JWK specifications
- Digital Signatures and MACs
- Algorithms for Key Management
- Algorithms for Content Encryption
- Algorithms for Keys

<https://tools.ietf.org/html/rfc7518>

JSON Web Key (JWK)

```
{
  "keys": [
    {
      "kty": "EC",
      "crv": "P-256",
      "x": "MKBCTNIcKUSDii11ySs3526iDZ8AiTo7Tu6KPAqv7D4",
      "y": "4EtI6SRW2YiLUrN5vfvVHuhp7x8PxltmWWIbbM4IFyM",
      "use": "enc",
      "kid": "1"
    },
    {
      "kty": "RSA",
      "n": "0vx7agoebGcQSuuPiLJXZptN9nn...",
      "e": "AQAB",
      "alg": "RS256",
      "kid": "2011-04-29"
    }
  ]
}
```

<https://tools.ietf.org/html/rfc7517>

JSON Web Signature (JWS)

- JSON Web Signature (JWS) represents content secured with digital signatures or Message Authentication Codes (MACs) using JSON-based data structures
- A document using JWS can answer two questions about the JSON payload:
 - Has the JSON object been altered after creation?
 - Who created this JSON object?

<https://tools.ietf.org/html/rfc7515>

JSON Web Encryption (JWE)

- Data structure representing an encrypted and integrity-protected message
- As of July 2019 only identity server of PingIdentity supports JWE
- NOT supported by Spring Security 5.x (See github issue 4435) !

<https://tools.ietf.org/html/rfc7516>

<https://github.com/spring-projects/spring-security/issues/4435>

JSON Web Token (JWT)

- JSON Web Tokens consist of three parts separated by dots ("."), which are:
 - Header
 - Payload
 - Signature
- Each part is Base64Url encoded
- Signature supports symmetric or asymmetric algorithms (e.g. HMAC or RSA)
- Signature = HMACSHA256(
base64UrlEncode(header) + "." + base64UrlEncode(payload), secret)

<https://tools.ietf.org/html/rfc7519>

<https://tools.ietf.org/html/draft-ietf-oauth-jwt-bcp>

<https://tools.ietf.org/html/draft-ietf-oauth-proof-of-possession>

JSON Web Token (JWT) - Decoded Form

```
{  
  "alg": "RS256",  
  "typ": "JWT",  
  "kid": "lp_FcMZ8D7U6EEUCiZyWAF21NcwjX_ddwJ5a3eCPMwQ"  
}
```

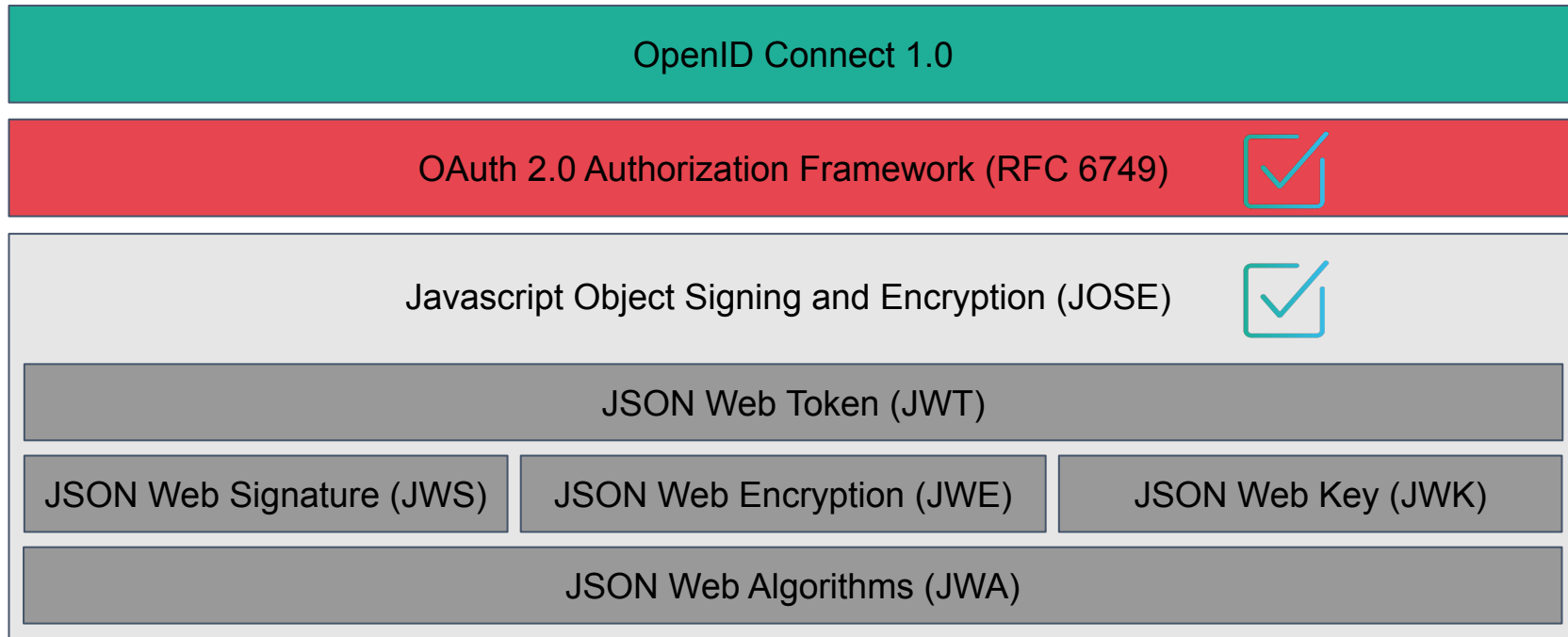
HEADER

```
{  
  "exp": 1571745342,  
  "iat": 1571745042,  
  "iss": "http://localhost:8080/auth/realms/workshop",  
  "aud": ["library-service","account"],  
  "sub": "08d3bcaa-5ffd-4b8d-909e-bb567881384b"  
}
```

PAYLOAD

[illegible]

OpenID Connect 1.0 Standards Layer



OpenID Connect 1.0 (OIDC)

- Based on OAuth 2.0
- Additions:
 - ID Token (JWT format is mandatory)
 - User Info Endpoint (Mandatory)
 - Hybrid Grant Flow (Mandatory)
 - OpenID Provider Configuration Information (Discovery, Optional)

https://openid.net/specs/openid-connect-core-1_0.html

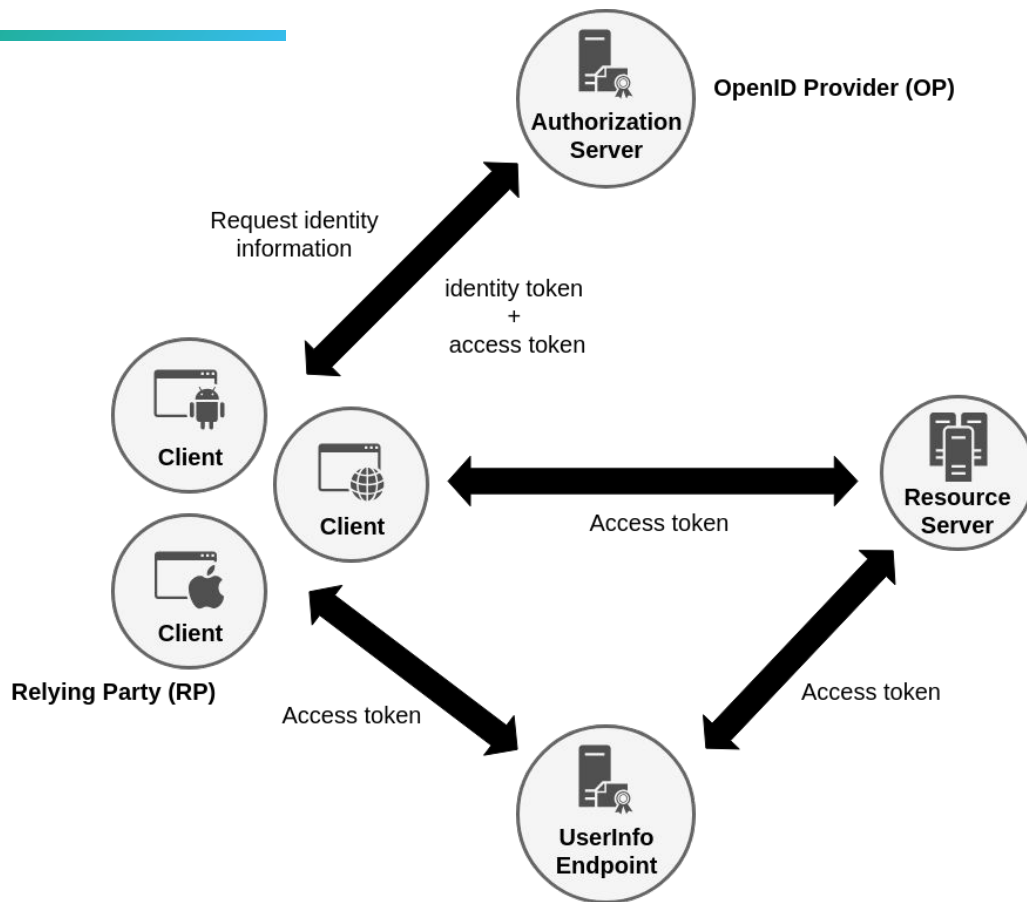
https://openid.net/specs/openid-connect-registration-1_0.html

https://openid.net/specs/openid-connect-discovery-1_0.html

OpenID Connect 1.0 Claims

Claim	Required	Description
iss	<input checked="" type="checkbox"/>	Issuer Identifier
sub	<input checked="" type="checkbox"/>	Unique Subject Identifier
aud	<input checked="" type="checkbox"/>	Target audience(s) of an ID Token
exp	<input checked="" type="checkbox"/>	Expiration time
iat	<input checked="" type="checkbox"/>	Time at which the JWT was issued
auth_time	<input checked="" type="checkbox"/>	Time of End-User authentication
nonce		Used to associate a client with an ID Token

OpenID Connect 1.0 Roles



OpenID Connect 1.0 User Info Endpoint

```
GET /userinfo HTTP/1.1  
Host: identityserver.example.com  
Authorization: Bearer SlAV32hkKG
```

```
HTTP/1.1 200 OK  
Content-Type: application/json
```









```
{  
  "sub": "248289761001",  
  "name": "Jane Doe",  
  "given_name": "Jane",  
  "family_name": "Doe",  
  "preferred_username": "j.doe",  
  "email": "janedoe@example.com",  
  "picture": "http://example.com/janedoe/me.jpg"  
}
```

OpenID Connect 1.0 Discovery

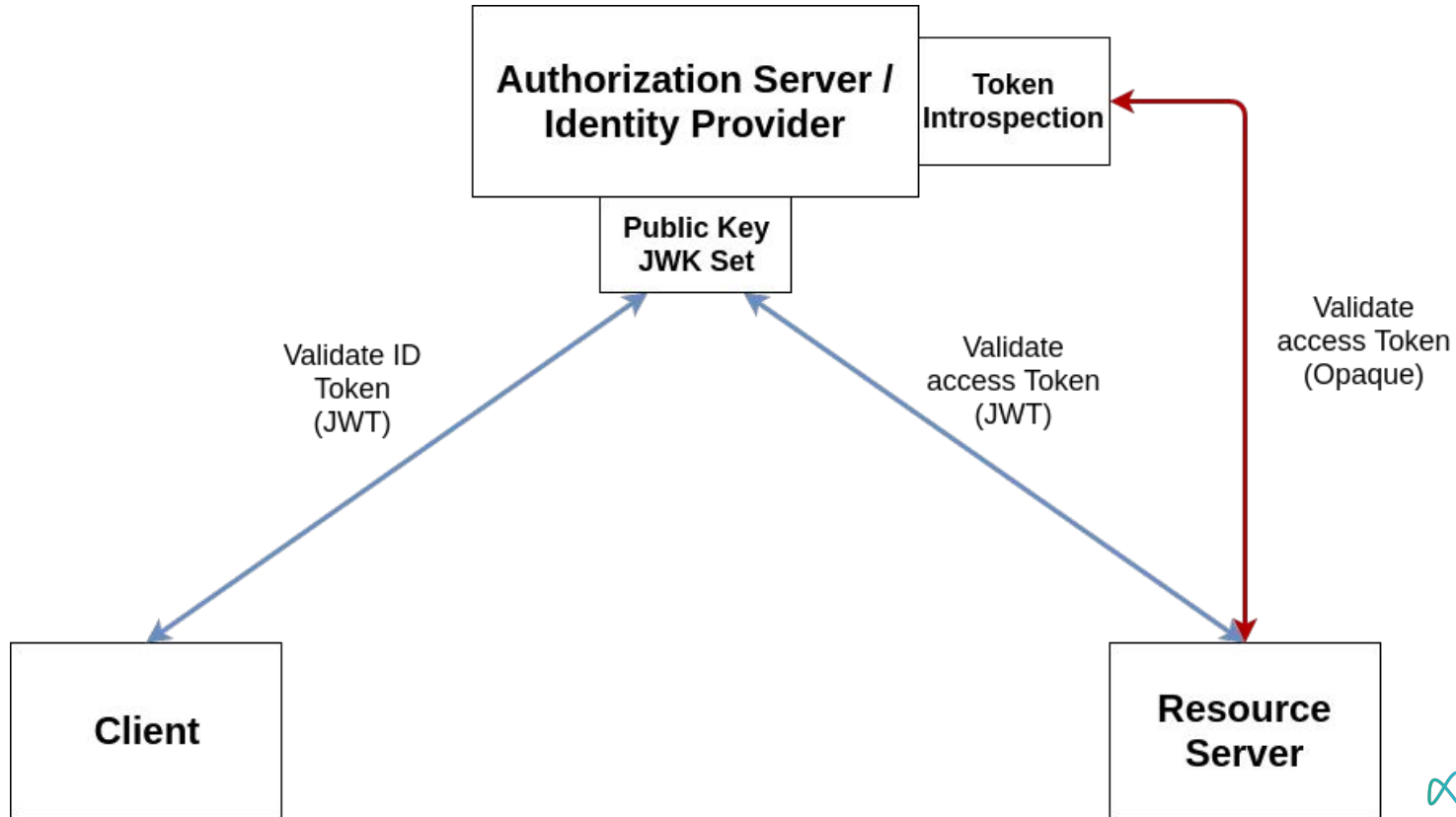
```
{
  "authorization_endpoint": "https://idp.example.com/auth",
  "grant_types_supported": [
    "authorization_code",
    "implicit",
    "refresh_token"
  ],
  "issuer": "https://idp.example.com",
  "jwks_uri": "https://idp.example.com/keys",
  "token_endpoint": "https://idp.example.com/token",
  "userinfo_endpoint": "https://idp.example.com/userinfo",
  ...
}
```

<https://example.com/.well-known/openid-configuration>

OpenID Connect 1.0: Access Token Types

JWT Token (Self-contained)	Opaque Token (Reference)
 Offline-Validation (Signature/Expiration)	 Validation call to introspection-endpoint
 Contains all required information	 Additional call to get required information
 Protocol agnostic	 Bound to Http
 Cannot be revoked	 May be revoked

Token Validation



OAuth 2.0 Access Token JWT Profile (Draft)

- Required claims: iss, exp, aud, sub, client_id
- Consider privacy restrictions for identity claims
- Authorization claims according to SCIM Core (RFC7643):
 - Groups
 - Entitlements
 - Roles

System for Cross-domain Identity Management (SCIM)
JSON Web Token (JWT) Profile for OAuth 2.0 Access Tokens

OpenID Connect Identity Providers

- RedHat/JBoss Keycloak (<https://www.keycloak.org>)
- Auth0 (<https://auth0.com>)
- Okta (<https://www.okta.com>)
- ForgeRock (<https://www.forgerock.com/platform/identity-management>)
- CloudFoundry UAA (<https://github.com/cloudfoundry/uaa>)
- PingFederate
(<https://www.pingidentity.com/en/platform/single-sign-on/sso-overview.html>)
- Azure Active Directory
(<https://azure.microsoft.com/en-us/services/active-directory>)
- ...

See: <https://openid.net/developers/certified/#OPServices>

JBoss Keycloak as OIDC Identity Provider

- Open Source identity and access management product by RedHat/JBoss
- Currently based on JBoss Wildfly Application Server
- Implements OpenID Connect 1.0, OAuth 2.0 and SAML 2.0
- Provides a centralized user management
- Keycloak-X will move away from WildFly to Quarkus (<https://quarkus.io>)

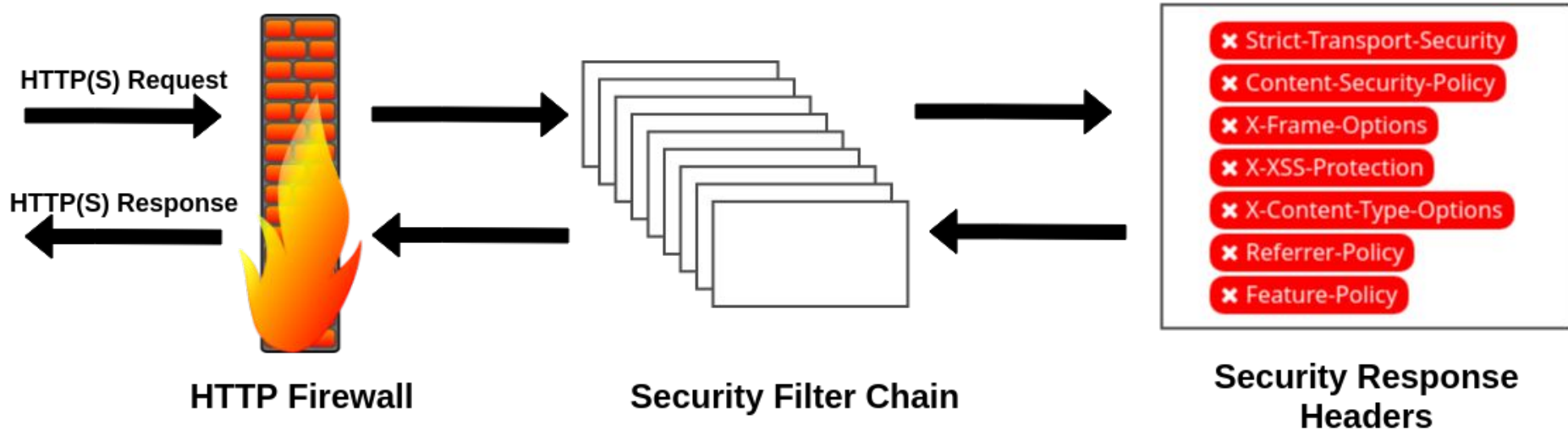
<https://www.keycloak.org/>

<https://www.keycloak.org/2019/10/keycloak-x.html>

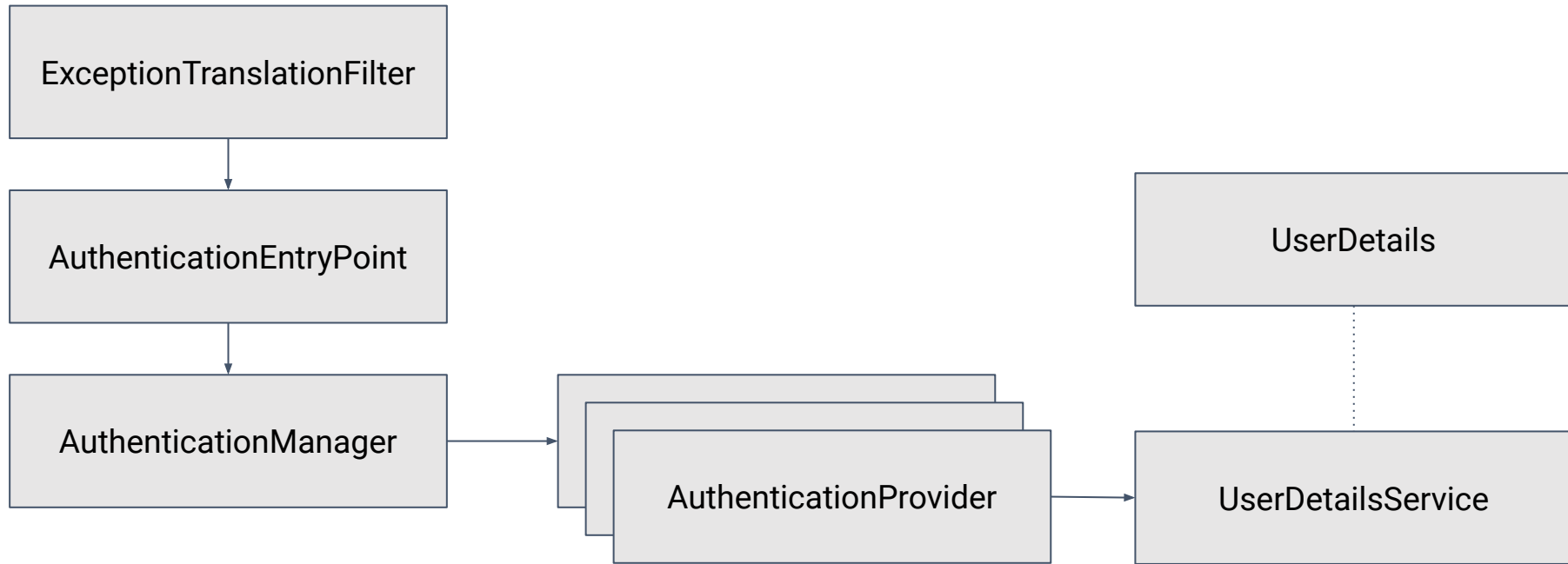


Spring Security 5 Basics

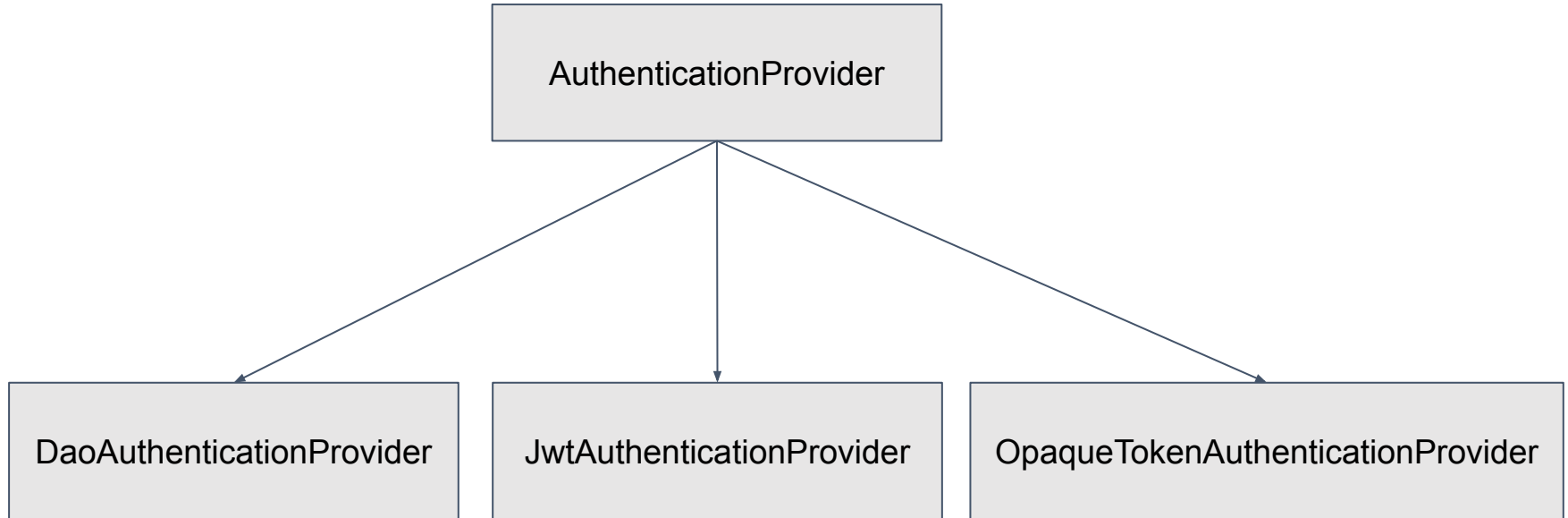
Spring Security High Level View



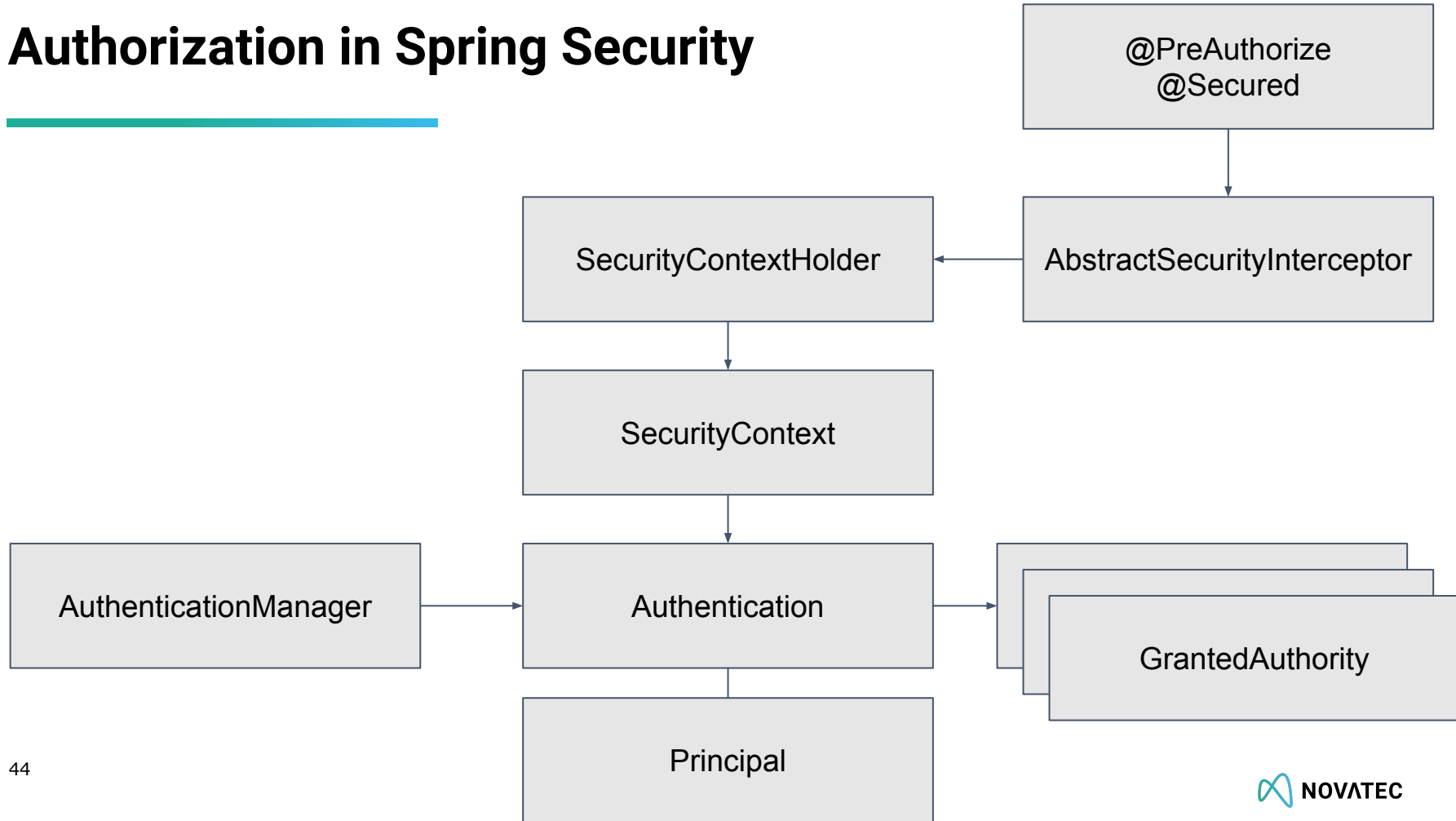
Authentication in Spring Security



Authentication in Spring Security



Authorization in Spring Security



“Legacy” Spring Security 4.x OAuth2 Technology Stack

spring-security-oauth2-autoconfigure

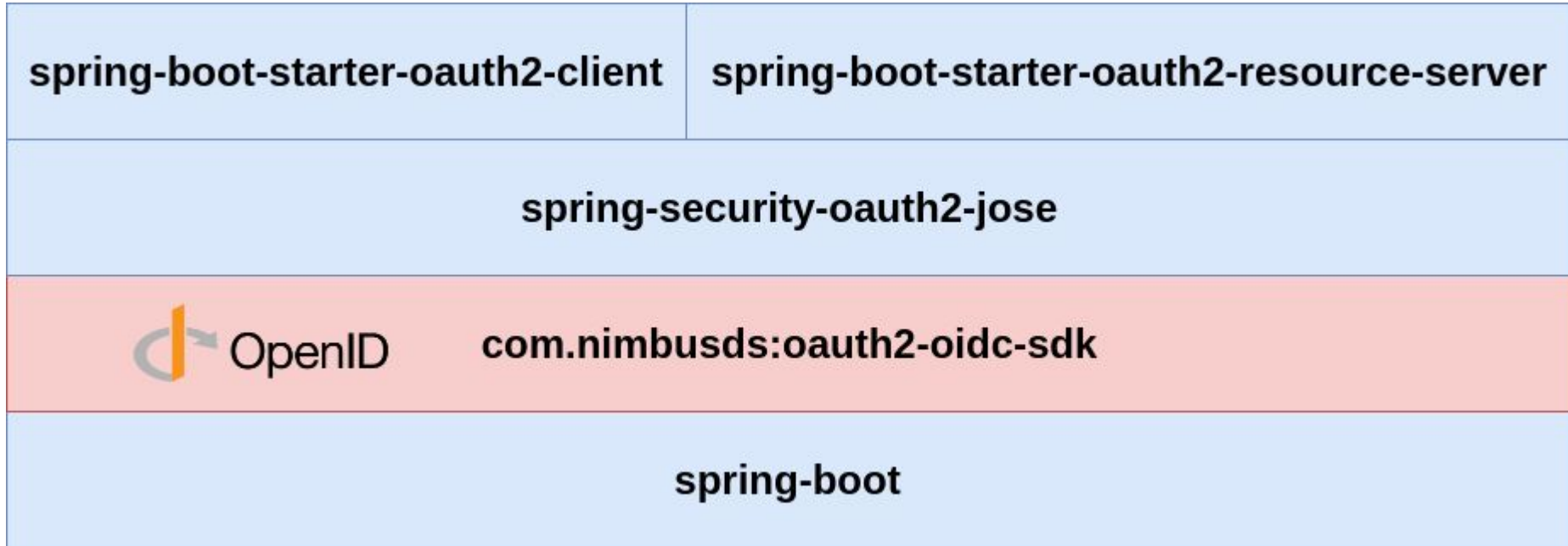
spring-security-oauth2

spring-security-jwt

spring-boot-starter-security

spring-boot

New Spring Security 5.x OIDC Technology Stack



<https://connect2id.com/products/nimbus-oauth-openid-connect-sdk>



OpenID Connect on the Server side (The Resource Server)



Authentication in a single Resource server



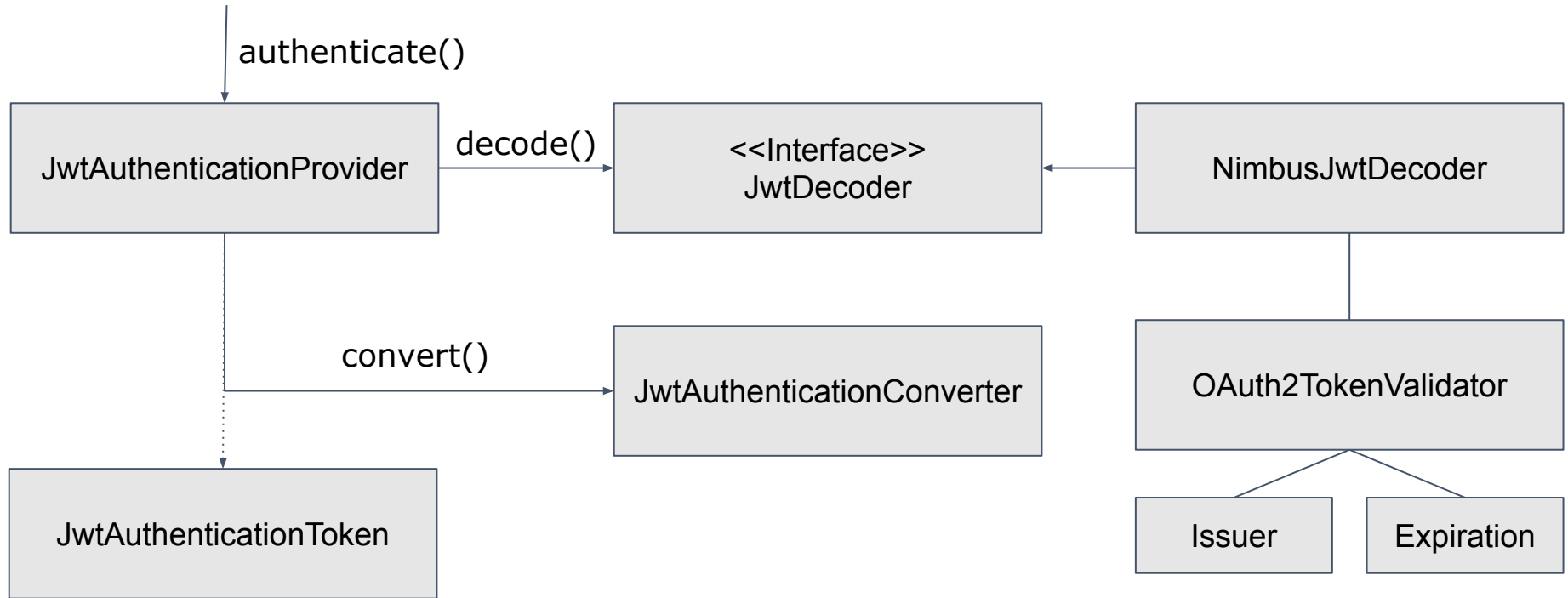
GET / HTTP/1.1

Host: localhost:8080

Authorization: Bearer

eyJ0eXAiOiJKV1QiLCJhbGciOiJSUzI1N...

JWT Authentication in Spring Security 5





Practice Time

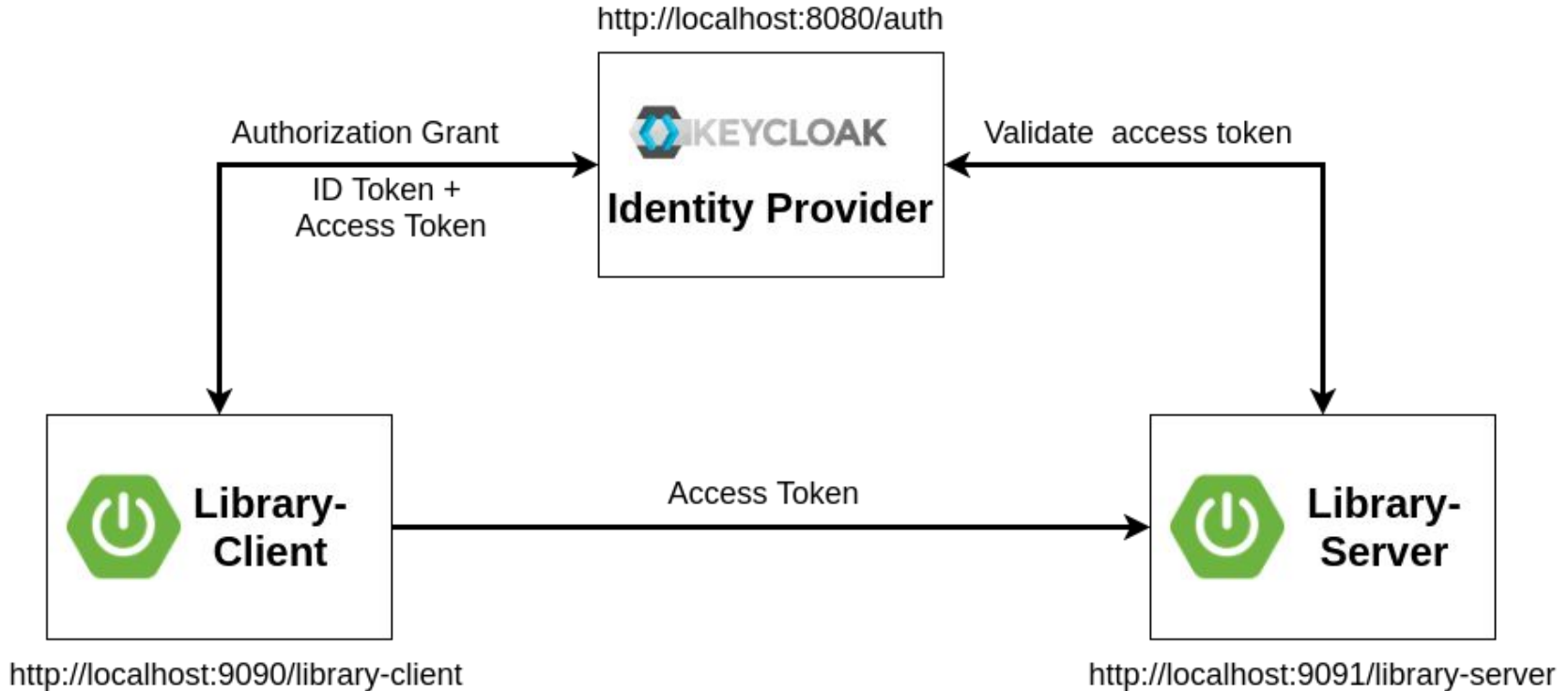
Lab 1: Implementing a Resource Server

The Hands-On Application: Use Cases

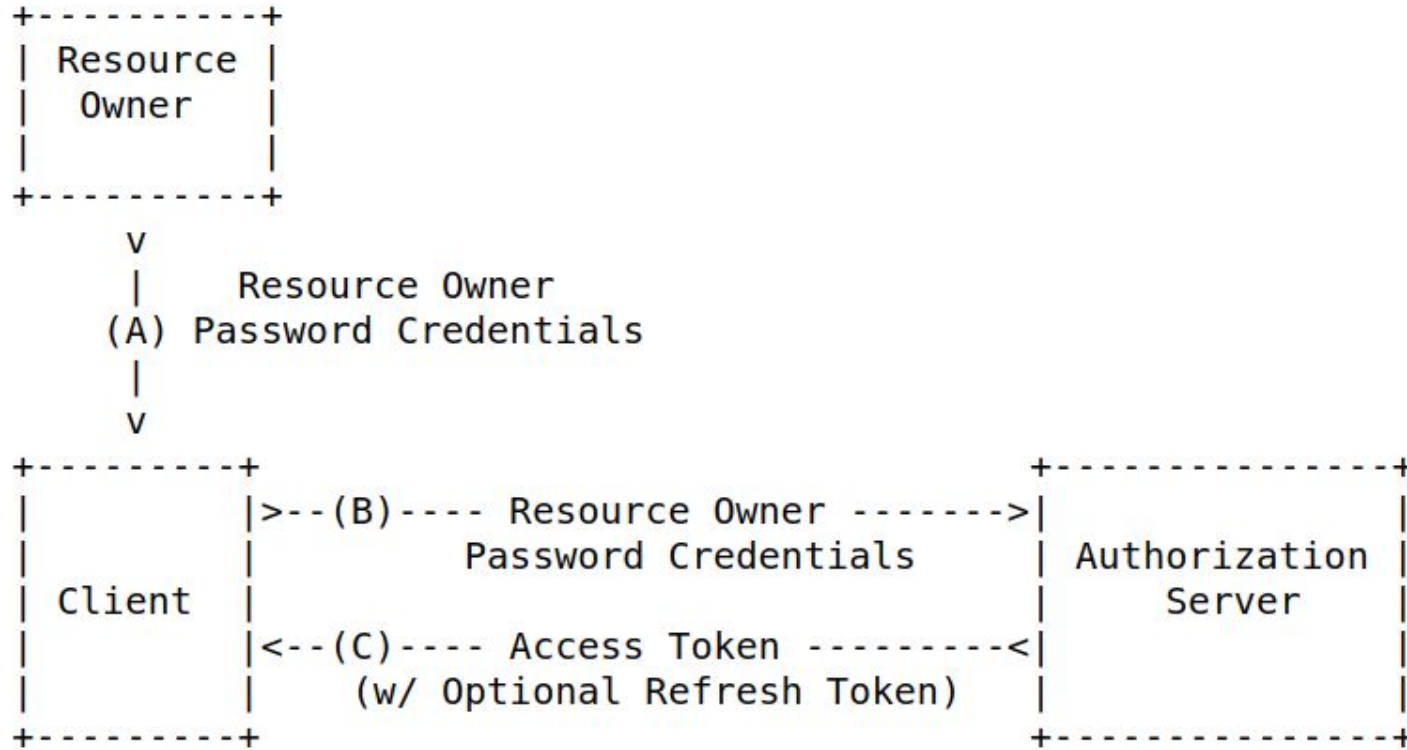
- Online Book Library
 - Administer Library Users
 - Administer Books
 - List available Books
 - Borrow a Book
 - Return a previously borrowed Book

<https://github.com/andifalk/secure-oauth2-oidc-workshop>

The Hands-On Application: Architecture



OAuth 2.0 Resource Owner Password Credentials Flow (1)



OAuth 2.0 Resource Owner Password Credentials Flow (2)

POST /token HTTP/1.1

Host: server.example.com

Authorization: Basic czZCaGRSa3F0MzpnWDFmQmF0M2JW

Content-Type: application/x-www-form-urlencoded

grant_type=password&username=johndoe&password=A3ddj3w

POST /token HTTP/1.1

Host: server.example.com

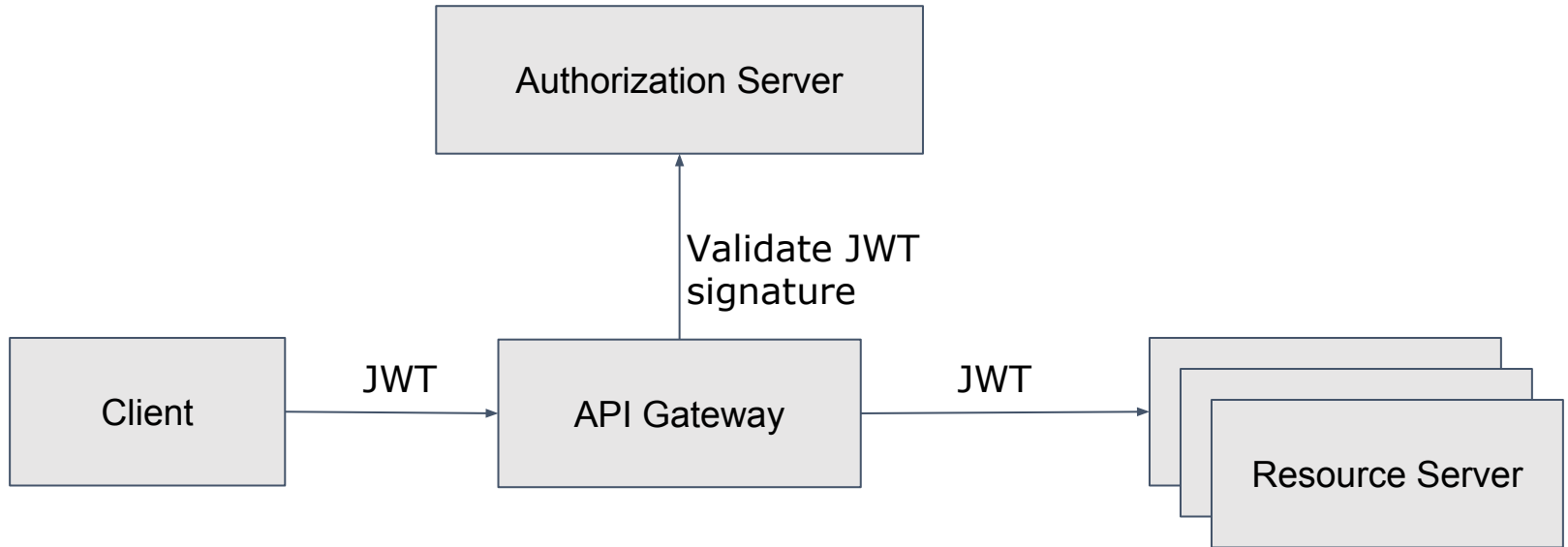
Content-Type: application/x-www-form-urlencoded

grant_type=password&username=johndoe&password=A3ddj3w
&client_id=123&client_secret=xyz

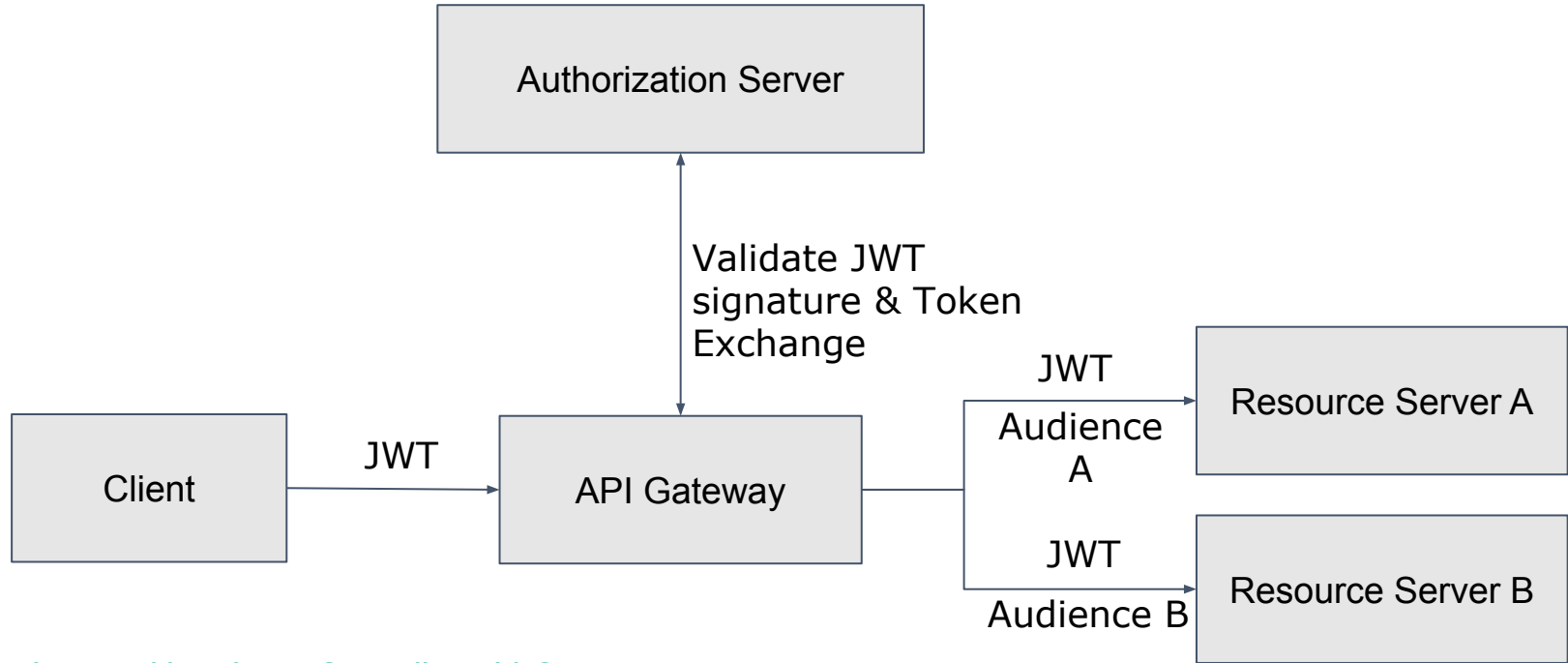


Advanced OpenID Connect Scenarios

Token-Relay with an API Gateway

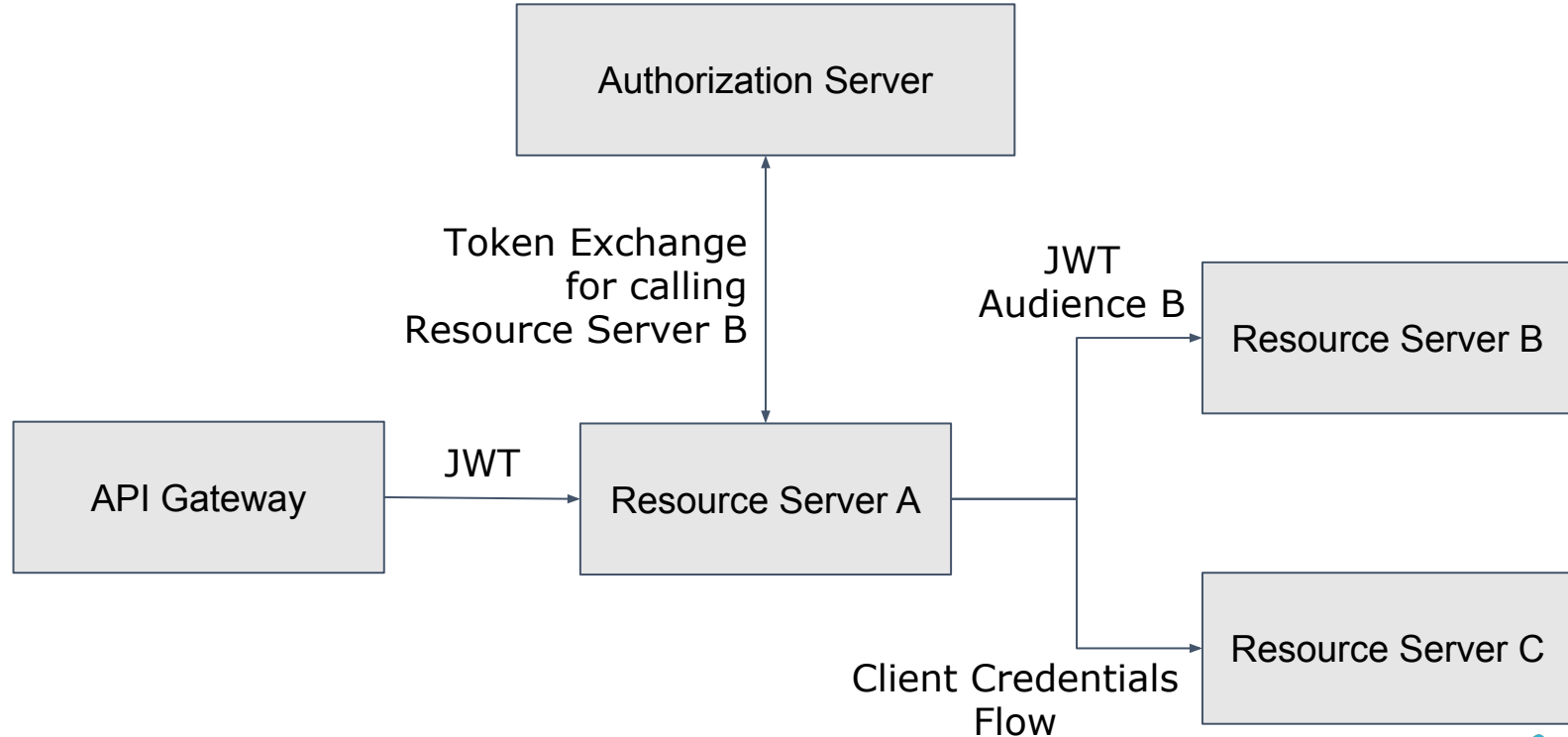


Token-Exchange with an API Gateway



<https://tools.ietf.org/html/rfc8693>

Microservice-to-Microservice calls





OpenID Connect on the Client side

OAuth 2.0 Grant Flows

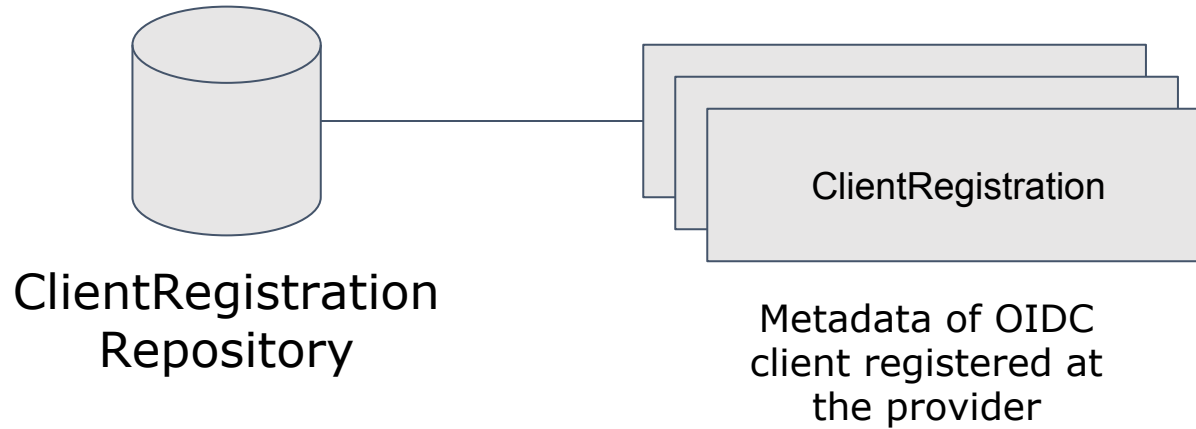
Client Type	Flow	Refresh Tokens
Confidential	Authorization Code	X
Public (Native)	Authorization Code (PKCE)	X
Public (SPA)	Implicit	--
Trusted	RO Password Creds	X
No Resource Owner	Client Credentials	--

OpenID Connect Libraries

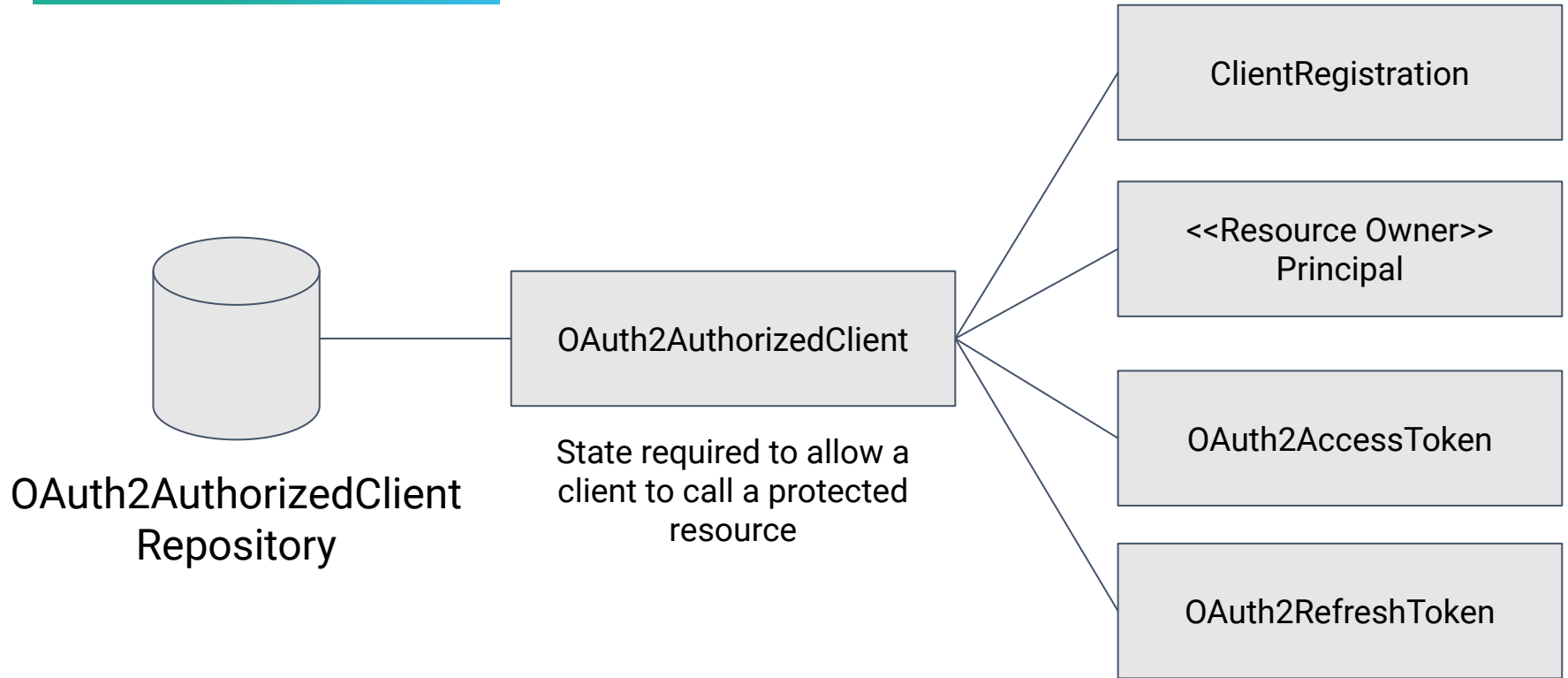
- oidc-client (Javascript) <https://github.com/IdentityModel/oidc-client-js>
- angular-oauth2-oidc (Typescript)
<https://github.com/manfredsteyer/angular-oauth2-oidc>
- angular-auth-oidc-client (Typescript)
<https://github.com/damienbod/angular-auth-oidc-client>
- IdentityModel.OidcClient (C#/.Net)
<https://github.com/IdentityModel/IdentityModel.OidcClient>
- Nimbus OAuth 2.0 SDK (Java)
<https://connect2id.com/products/nimbus-oauth-openid-connect-sdk>
- OIDC RP library (Python) <https://github.com/openid/JWTConnect-Python-OidcRP>
- ...

See: <https://openid.net/developers/certified/#OPServices>

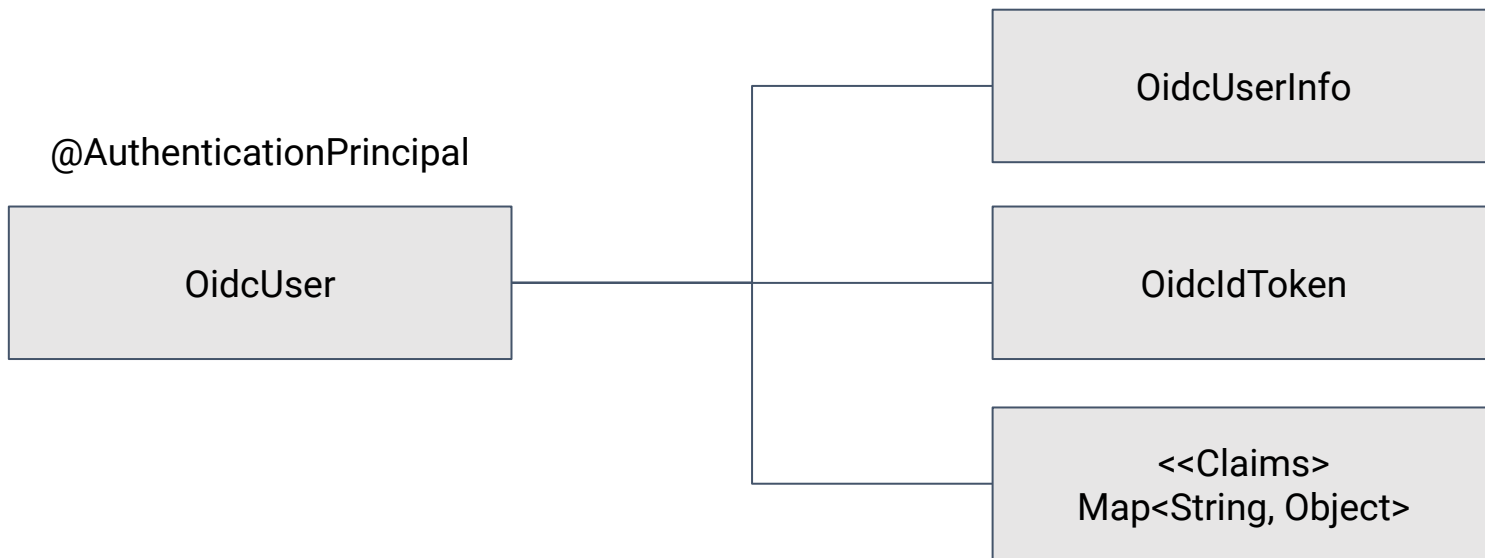
Spring Security: ClientRegistration



Spring Security: OAuth2AuthorizedClient



Spring Security: OidcUser





Practice Time

Lab 2: Implementing the client side (Authorization Code Flow)

OAuth 2.0 / OIDC Client (Spring MVC / Thymeleaf)

Library Client

A nice library to borrow books

Hello Bruce Wayne

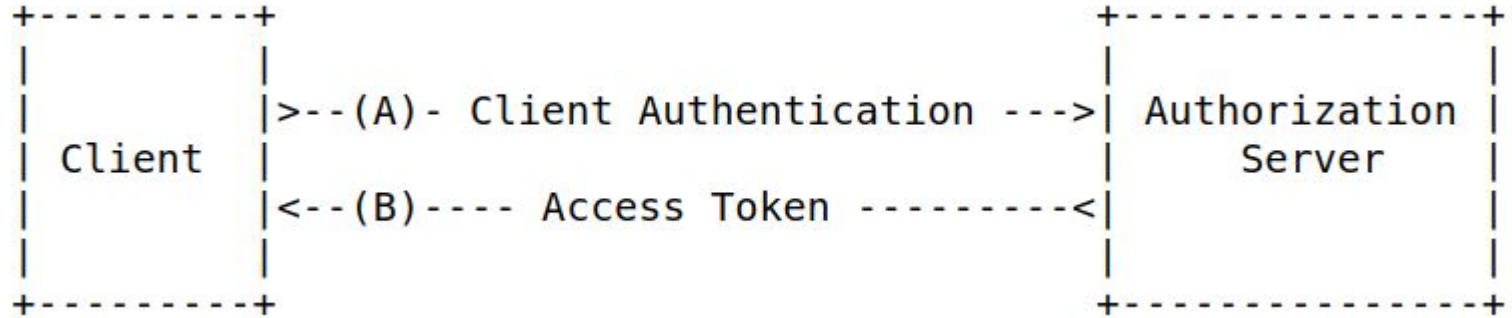
Author(s)	Title	Description	ISBN	
[Bob C. Martin]	Clean Code	Even bad code can function. But if code isn't clean, it can bring a development organization to its knees. Every year, countless hours and significant resources are lost because of poorly written code. But it doesn't have to be that way. Noted software expert Robert C. Martin presents a revolutionary paradigm with Clean Code: A Handbook of Agile Software Craftsmanship. Martin has teamed up with his colleagues from Object Mentor to distill their best agile practice of cleaning code "on the fly" into a book that will instill within you the values of a software craftsman and make you a better programmer—but only if you work at it.	9780132350884	Return
[Josh Long, Kenny Bastiani]	Cloud Native Java	What separates the traditional enterprise from the likes of Amazon, Netflix, and Etsy? Those companies have refined the art of cloud native development to maintain their competitive edge and stay well ahead of the competition. This practical guide shows Java/JVM developers how to build better software, faster, using Spring Boot, Spring Cloud, and Cloud Foundry.	9781449374648	
[Craig Walls]	Spring in Action: Covers Spring 4	Spring in Action, Fourth Edition is a hands-on guide to the Spring Framework, updated for version 4. It covers the latest features, tools, and practices including Spring MVC, REST, Security, Web Flow, and more. You'll move between short snippets and an ongoing example as you learn to build simple and efficient J2EE applications. Author Craig Walls has a special knack for crisp and entertaining examples that zoom in on the features and techniques you really need.	9781617291203	Borrow
[Gene Kim, Jez Humble, Patrick Debois]	The DevOps Handbook	Wondering if The DevOps Handbook is for you? Authors, Gene Kim, Jez Humble, Patrick Debois and John Willis developed this book for anyone looking to transform their IT organization—especially those who want to make serious changes through the DevOps methodology to increase productivity, profitability and win the marketplace.	9781942788003	Borrow



Practice Time

Lab 3: Implementing the client side (Client Credentials Flow)

OAuth 2.0 Client Credentials Grant Flow (1)



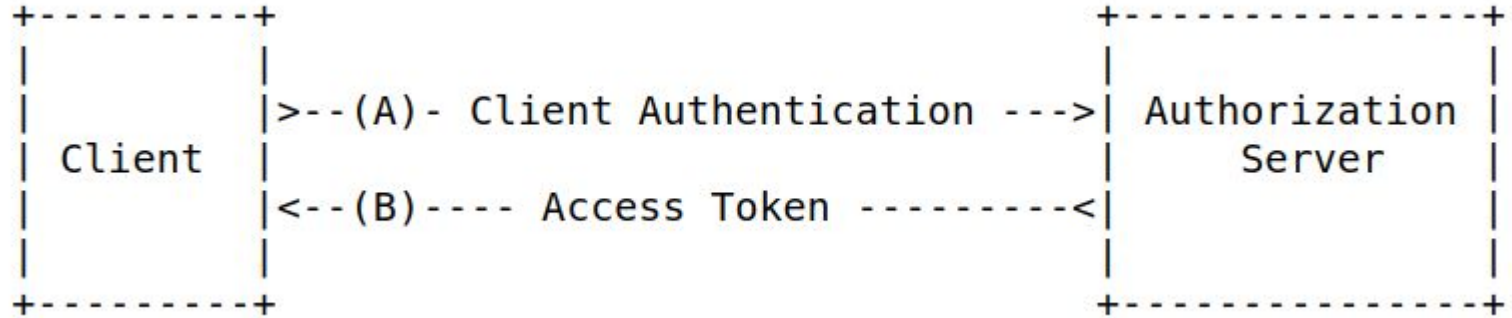
POST /token HTTP/1.1

Host: server.example.com

Authorization: Basic czZCaGRSa3F0MzpnWDFmQmF0M2JW

Content-Type: application/x-www-form-urlencoded
grant_type=client_credentials

OAuth 2.0 Client Credentials Grant Flow (2)



POST /token HTTP/1.1

Host: server.example.com

Content-Type: application/x-www-form-urlencoded

grant_type=client_credentials&client_id=123&client_secret=xyz



Practice Time

Lab 4: Testing JWT Auth+Authz

General Testing Strategies for JWT Auth+Authz

- Using Spring JWT test support (MockMvc / WebTestClient)
- Using self-signed JWT Tokens
- Using real identity provider (using Testcontainers)
- Only test the authorization layer

<https://docs.spring.io/spring-security/site/docs/current/reference/htmlsingle/#testing-bearer-authentication>

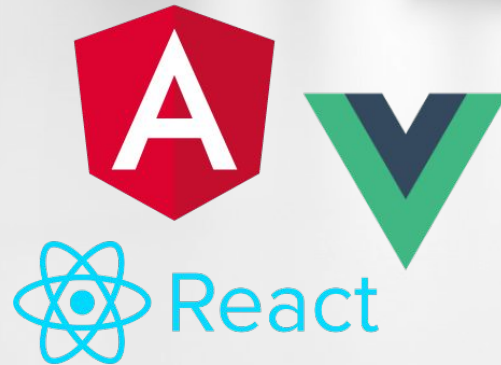
<https://docs.spring.io/spring-security/site/docs/current/reference/htmlsingle/#testing-bearer-authentication-2>

<https://docs.spring.io/spring-security/site/docs/current/reference/htmlsingle/#oauth2resourceserver-jwt-decoder-public-key>

<https://www.testcontainers.org/>

<https://github.com/dasniko/testcontainers-keycloak>

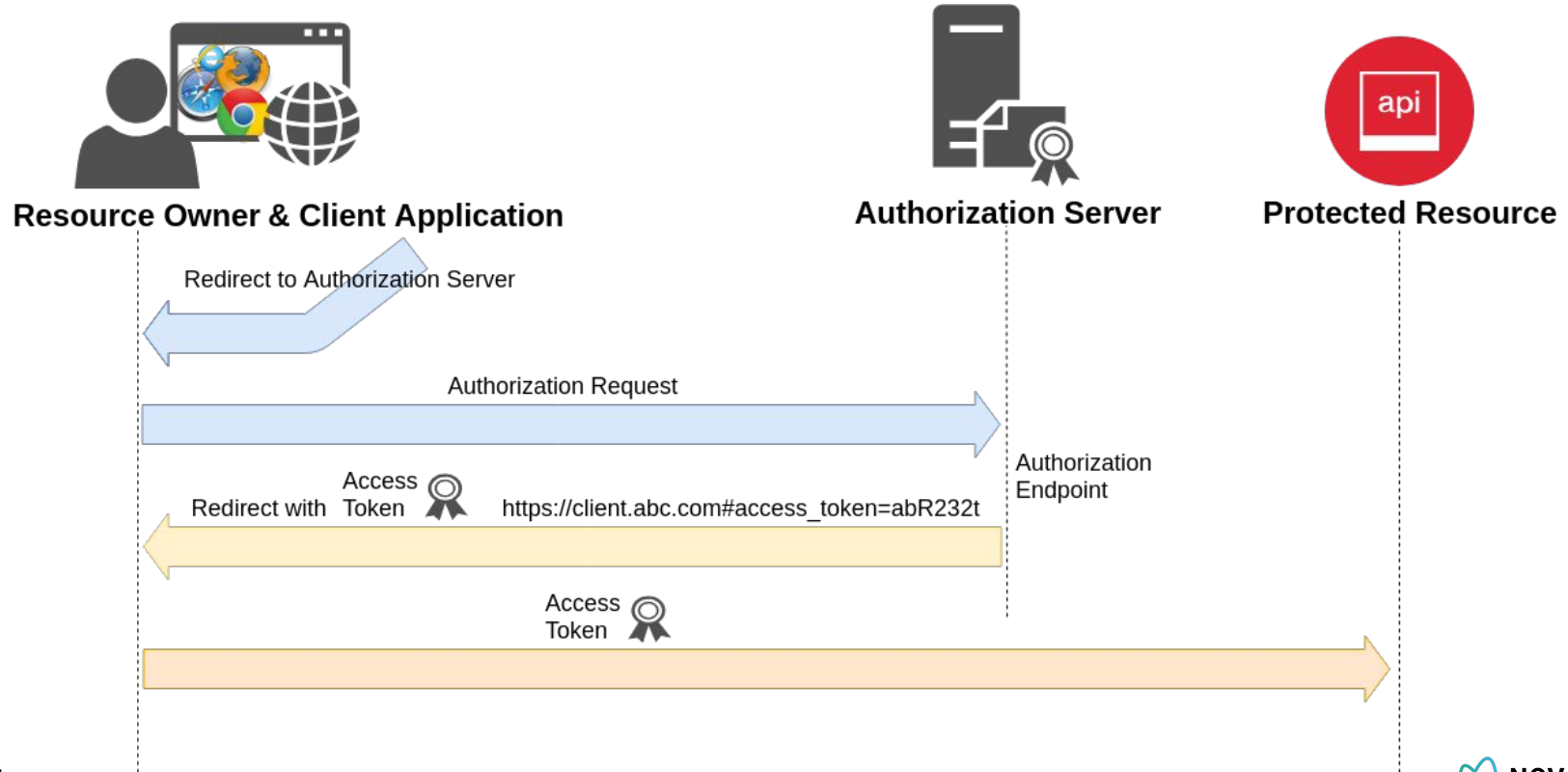
What about Single Page Applications?



OAuth 2.0 Grant Flows

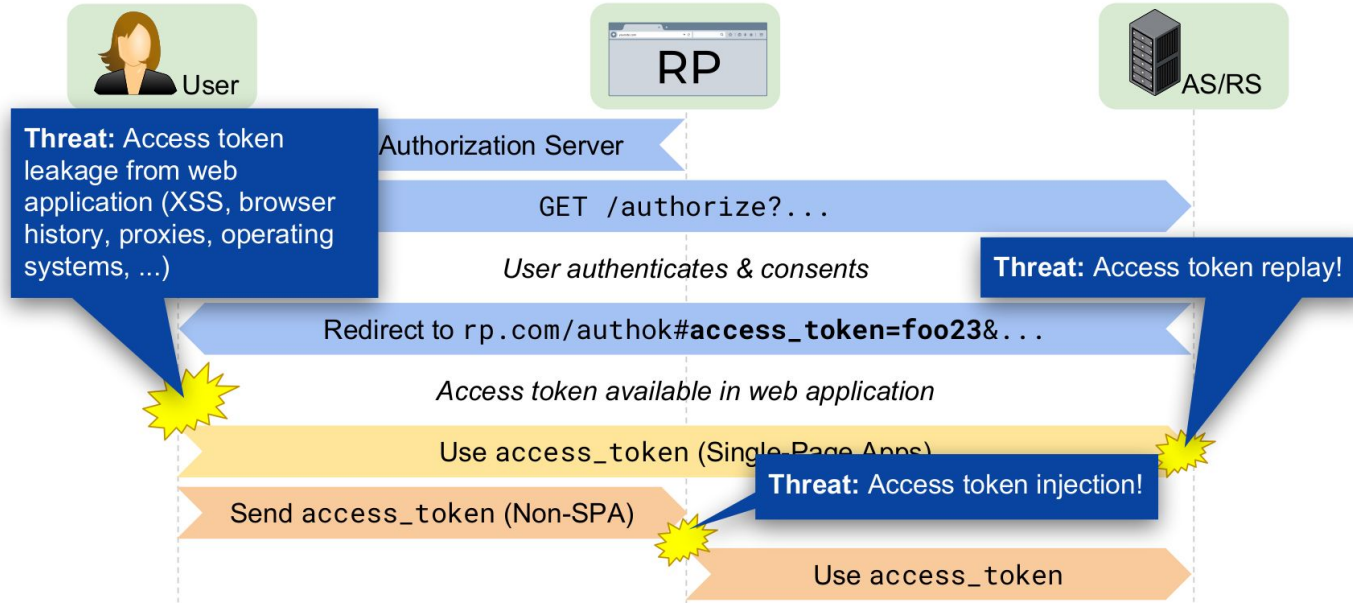
Client Type	Flow	Refresh Tokens
Confidential	Authorization Code	X
Public (Native)	Authorization Code (PKCE)	X
Public (SPA)	Implicit	--
Trusted	RO Password Creds	X
No Resource Owner	Client Credentials	--

OAuth 2.0 Implicit Flow



OAuth 2.0 Implicit Grant Flow is at Risk !

Don't use the OAuth Implicit Grant any longer!



<https://tools.ietf.org/html/draft-ietf-oauth-security-topics>

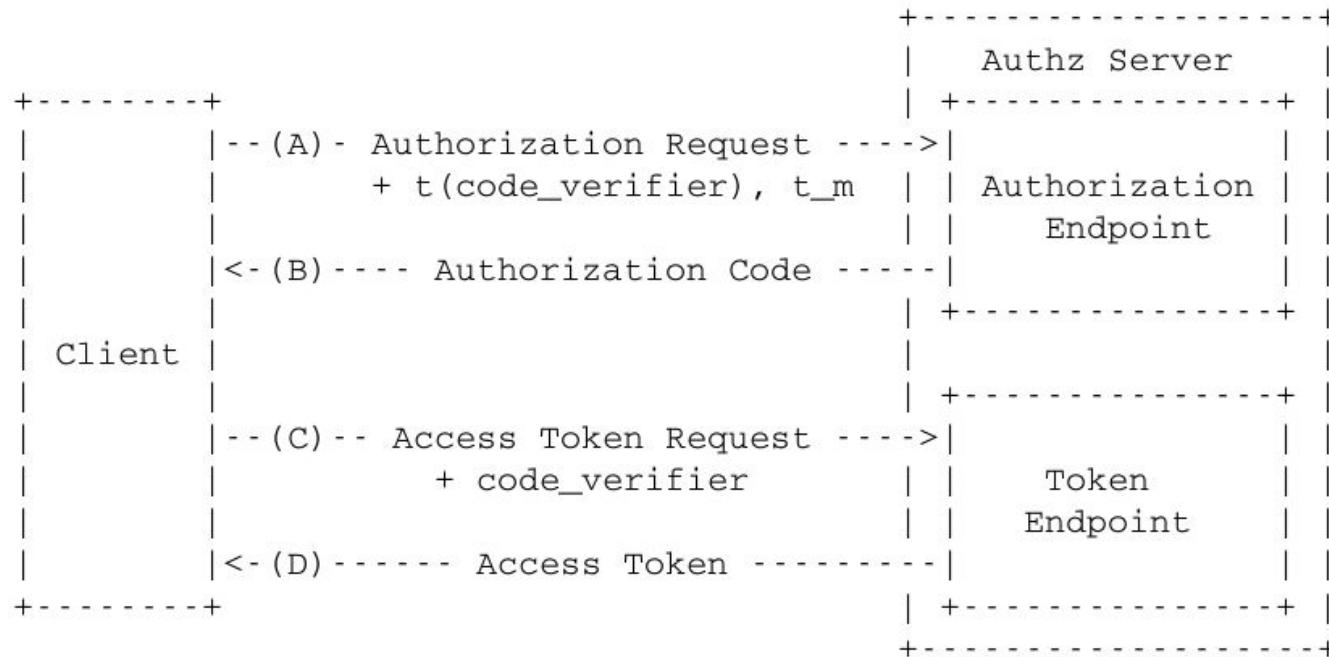
“OAuth 2.1” Grant Flows

Client Type	Flow	Refresh Tokens
Confidential	Authorization Code (PKCE)	X
Public (Native)	Authorization Code (PKCE)	X
Public (SPA)	Authorization Code (PKCE)	--
Trusted	RO Password Creds	X
No Resource Owner	Client Credentials	--

Authorization Code + PKCE Grant Flow

- PKCE-Proof Key for Code Exchange (“pixy”)
- Mitigates authorization code interception attack
- Public clients cannot keep secrets (“client_secret”)
 - PKCE adds a dynamically created cryptographically random key: The “code verifier”

OAuth 2.0 Auth Code + PKCE Grant Flow



`code_verifier`:
Random string
(43-128
characters)

`t(code_verifier)`:
"code_challenge",
Hashed
`code_verifier`

`t_m`: Hashing
algorithm to be
used
("S256" or
"None")

<https://tools.ietf.org/html/rfc7636>



What's new in Spring Security 5.2&5.3

Spring Security 5.2

- Client Support for PKCE
- OpenID Connect RP-Initiated Logout
- Support for OAuth 2.0 Token Introspection
- Resource Server Multi-tenancy (Servlet & Reactive)
- Use symmetric keys with JwtDecoder
- JWT Flow API in Test Support

<https://spring.io/blog/2019/10/01/spring-security-5-2-goes-ga>

Support for Opaque Tokens

```
class ResSrvConfig extends WebSecurityConfigurerAdapter {  
  
    @Override  
    protected void configure(HttpSecurity http)  
        throws Exception {  
        http.oauth2ResourceServer()  
            .opaqueToken()  
                .introspectionUri(this.introspectionUri)  
                .introspectionClientCredentials(  
                    this.clientId, this.clientSecret);  
    }  
}
```

Resource Server Multi-Tenancy

```
class ResSrvConfig extends WebSecurityConfigurerAdapter {  
    @Override protected void configure(HttpSecurity http) {  
        http.oauth2ResourceServer()  
            .authenticationManagerResolver(  
                multitenantAuthenticationManager());  
    }  
  
    @Bean AuthenticationManagerResolver<HttpServletRequest>  
        multiTenantAuthMgr() {...}  
  
    AuthenticationManager jwt() {...}  
    AuthenticationManager opaque() {...}  
}
```

Support for Symmetric Keys

```
class ResSrvConfig extends WebSecurityConfigurerAdapter {  
    @Value("${spring.security.oauth2.resourceserver.  
            jwt.key-value}") RSAPublicKey key;  
  
    @Override protected void configure(HttpSecurity http) {  
        http.oauth2ResourceServer().jwt().decoder(jwtDecoder());  
    }  
  
    @Bean JwtDecoder jwtDecoder() throws Exception {  
        return NimbusJwtDecoder.  
            withPublicKey(this.key).build();  
    }  
}
```

JWT Flow API in Test Support

```
public class OAuth2ResourceServerTest {  
  
    @Test  
    public void testRequestPostProcessor() {  
        mockMvc.perform(get("/message")  
            .with(mockAccessToken().scope("message:read"))  
            .andExpect(status().isOk())  
  
        mockMvc.perform(get("/")  
            .with(jwt().claim(SUB, "the-subject"))  
            .andExpect(status().isOk())  
        }  
    }  
}
```

Lambda DSL

```
protected void configure(HttpSecurity http) throws Exception {  
    http.authorizeRequests(authorizeRequests ->  
        authorizeRequests  
            .antMatchers("/blog/**").permitAll()  
            .anyRequest().authenticated()  
    ).formLogin(formLogin ->  
        formLogin  
            .loginPage("/login")  
            .permitAll()  
    );  
}
```

<https://spring.io/blog/2019/11/21/spring-security-lambda-dsl>

Spring Security 5.3

- Support OAuth 2.0 / OIDC Authorization Server:
 - OpenID Connect 1.0 (Authorization Code Flow)
 - PKCE
 - OAuth 2.0 Client Credentials Grant
 - JWT Access Token format
 - JWK Set Endpoint
 - Opaque Access Token format

Spring Security team has decided to no longer provide support for authorization servers (...but still in discussion...)

<https://spring.io/blog/2019/11/14/spring-security-oauth-2-0-roadmap-update>

Spring Security 5.3

- Resource server support for multiple trusted JWT access token issuers
- OidcIdToken.Builder & OidcUserInfo.Builder
- Opaque Token MockMvc & Reactive Test Support
- Oidc Login MockMvc & Reactive Test Support
- ...

<https://spring.io/blog/2020/01/08/spring-security-5-3-0-m1-released>



What about other Microframeworks?

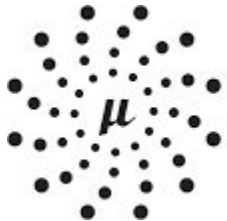
OpenID Connect in other Micro-Frameworks

Already good support for JWT based authentication in:

- Micronaut <https://micronaut-projects.github.io/micronaut-security/latest/guide/#jwt>
- Quarkus <https://quarkus.io/guides/jwt-guide>



QUARKUS



MICRONAUT™

OpenID Connect in other Micro-Frameworks

See Bonus-Lab containing a demo for Micronaut!





Books and Online References

Books and Online References (1)

- Justin Richer et.al: OAuth2 in Action (Manning, 2017, ISBN 978-1617293276)
- Michael Schwartz et.al: Securing the Perimeter (Apress, 2018, ISBN 978-1484226001)
- [RFC 6749: The OAuth 2.0 Authorization Framework](#)
- [RFC 6750: OAuth 2.0 Bearer Token Usage](#)
- [RFC 6819: OAuth 2.0 Threat Model and Security Considerations](#)
- [RFC 7636: Proof Key for Code Exchange \("Pixy"\)](#)
- [OpenID Connect Core 1.0 Specification](#)
- [OpenID Connect Dynamic Client Registration 1.0](#)
- [OpenID Connect Discovery 1.0](#)
- [RFC 7519: JSON Web Token \(JWT\)](#)
- [JSON Web Token Best Current Practices](#)

Books and Online References (2)

- [Why you should stop using the OAuth implicit grant](#)
- [OAuth 2.0 Security Best Current Practice](#)
- [OAuth 2.0 for Browser-Based Apps](#)
- [OAuth 2.0 Mutual TLS Client Authentication and Certificate-Bound Access Tokens](#)
- [JSON Web Token \(JWT\) Profile for OAuth 2.0 Access Tokens](#)
- [OAuth 2.0 Token Exchange](#)

Books and Online References (3)

- [Resource Indicators for OAuth 2.0](#)
- [Spring Security 5.2 Reference Documentation](#)
- [Microservices Security Patterns & Protocols with Spring Security \(Devoxx Video\)](#)
- [Microservices Security Patterns & Protocols \(SpringOne Platform 2019 Video\)](#)
- [How to secure your Spring apps with Keycloak by Thomas Darimont \(Video\)](#)



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