OAuth2 - SSO - Angular - Spring Boot

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OAuth2 - SSO - Angular - Spring Boot

1. OKTA Setup

1.1 Registration

https://dev-50623690-admin.okta.com/

daniel.xu4@ontario.ca / Cxxxxxx123!

1.2. Create Users

student1sso@mailinator.com / Cxxxxxx123!

student2sso@mailinator.com / Cxxxxxx123!

teacher1sso@mailinator.com / Cxxxxxx123!

teacher2sso@mailinator.com / Cxxxxxx123!

admin1sso@mailinator.com / Cxxxxxx123!

1.3. Add Claims

Steps to Add email as a Custom Claim in Access Token

1. **Go to OKTA Admin Console**
2. Navigate to:
   Security → API → Authorization Servers
3. Click your server (e.g., default)
4. Go to the **Claims** tab
5. Click **"Add Claim"**

E.g. Add claim "email" with the following expression:

```
(appuser != null) ? appuser.email : ""
```

1.4. Create UserManagementApp Application

- Spring Boot handles login redirects to OKTA
- OKTA returns code → backend exchanges for access/refresh/id tokens
- Backend maintains authenticated session
- Angular never directly communicates with OKTA
- Backend enforces role-based authorization from your DB

Step 1: Create 2 OIDC Web Applications in OKTA

create two confidential client applications:

✅ App 1 — **User Management Application (Backend)**

✅ App 2 — **Courses Management Application (Backend)**

For each:

1. **Go to**: OKTA Admin Console → Applications → Applications → **Create App Integration**
2. Choose:
    - **Sign-in method**: *OIDC - OpenID Connect*
    - **Application type**: *Web Application*
    - Click **Next**
3. Fill in details:
    - **Name**: e.g., UserManagementApp
    - **Grant type**:
        - ✅ Authorization Code
        - ✅ Refresh Token (checked by default for Web App)
        - ✅ Client Credentials (for microservice-to-microservice calls)
    - **Sign-in redirect URIs**: http://localhost:9001/login/oauth2/code/user-app (on gateway) **(Changed "okta" to "user-app" because separate gateways does not work and I have to use single gateway. Use "user-app" and "course-app" as registration id for the 2 applications)**
    - **Sign-out redirect URIs**: http://localhost:9001/logout (on gateway)
4. Click **Save**

Step 2: Get the Credentials

After saving, you will get:

- **Client ID**
- **Client Secret**
- **Issuer URL**: https://dev-50623690.okta.com/oauth2/default
    - Navigate to: **Security** → **API** → **Authorization Servers**

You'll need these for Spring Boot's application.yml.

Step 3: Enable Refresh Token & PKCE

- **PKCE is required** and automatically enabled for confidential clients in Spring Security when the user-agent is a browser.
- **Refresh Token** is enabled by default for Web Applications in OKTA.

1.5. Create application CourseManagementApp

Follow the same steps. Just use port **9002** which is the gateway of CourseManagementApp

1.6. Add Custom Claim to Access Token

1. **Go to OKTA Admin Console**
2. Navigate to:
   Security → **API** → **Authorization Servers**
3. Click your server (e.g., **default**)
4. Go to the **Claims** tab
5. Click **"Add Claim"**

Fill in the following:

Field	**Value**
Name	fistName
Include in token type	☑ Access Token
Value type	Expression
Value	**appUser.given_name**
Include in	Scopes: openid email profile

Click **Create**.

To find the field used for the above "Value",

1. **Go to OKTA Admin Console**
2. In the left menu, click **Directory** → **Profile Editor**
3. In the list of **Applications**, find your application: e.g., UserManagementApp

Create the following custom claims:

sub	appuser.userName
email	appuser.email
firstName	appuser.given_name
lastName	appuser.family_name

2. Architecture and Design

2.1 Architecture

2.1.1 Architecture Options

2.1.1.1 Should we use PKCE?

OKTA recommends PKCE only for **public clients** (e.g., SPAs or mobile apps).

Even though our frontend is an SPA:

- The **Angular app never talks to Okta directly**
- All OAuth2 traffic goes **through the Spring Boot Gateway**
- And that gateway uses a **client ID + secret** = **confidential client**

The backend does not expose credentials to the browser, so **PKCE** is **NOT recommended** in our case.

2.1.1.2 Communication between FE and BE

Expose only the gateway to the public.

All frontend (browser) requests should go through the **gateway** (Spring Cloud Gateway).

All microservices like user-profile-svc, course-query-svc, etc. should:

- Be **behind the gateway**
- Be accessible **only inside the internal network**

Currently for POC purpose, we are using 2 separate gateways (SCG). Given our application, the actual implementation should use **SINGLE** gateway.

2.1.1.3 Inter-Service (Microservices) Communication

- It currently includes the user's access token in the **Authorization: Bearer ... header**
- user-profile-svc accepts that **token** via Spring Security's **oauth2ResourceServer.jwt** config

✅ What's Protected

- The **user's identity and token** is validated at user-profile-svc
- The API is not open to the public without a valid OKTA token

❌ What's Not Protected

- Anyone on the same network (e.g., compromised internal machine or Docker container) could call with a valid OKTA access token and get data — because there's no **caller identity verification**

🟢 Recommendation for You (Today)

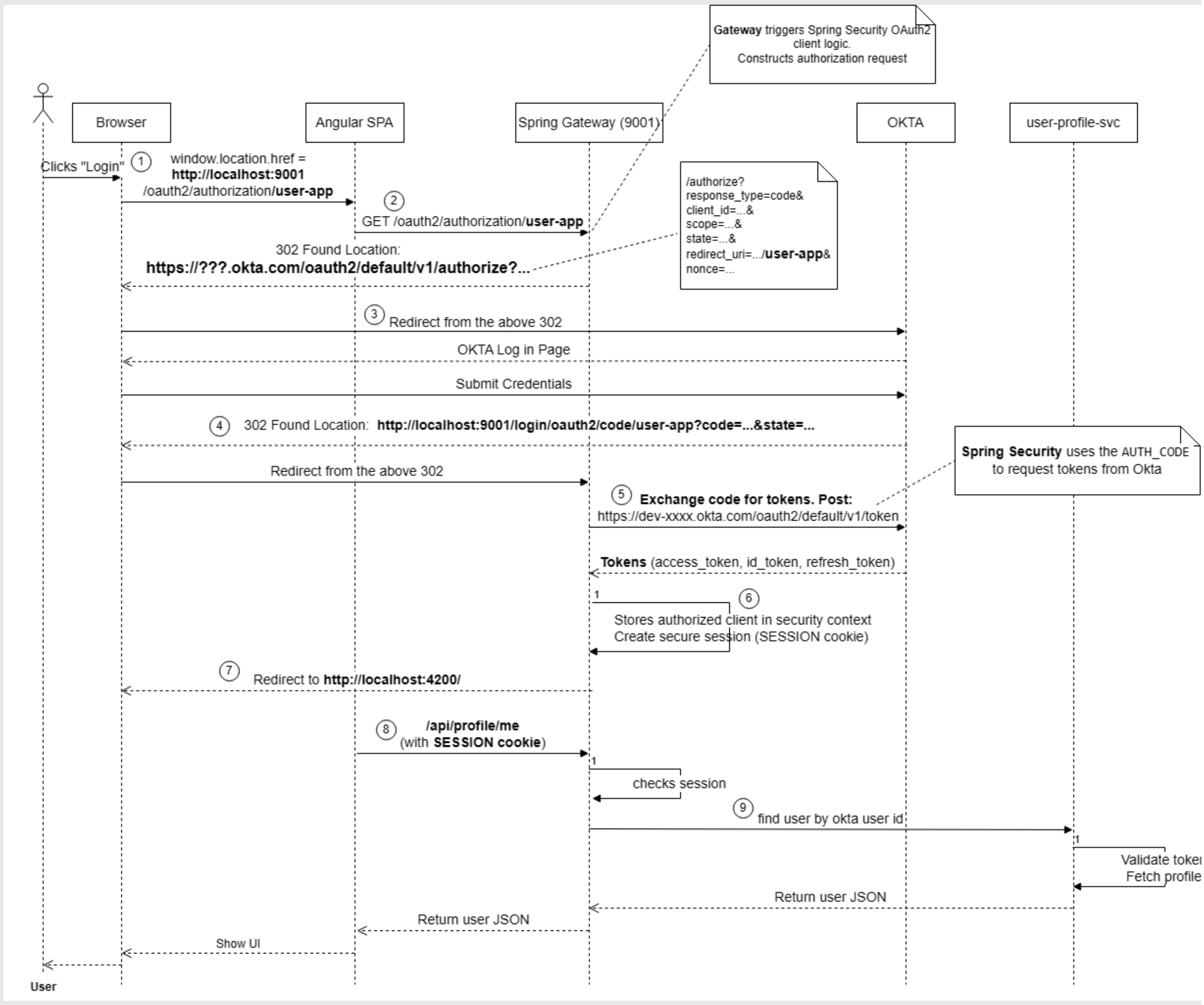
Since your goal is **app-managed roles and backend-only access**, here's what's ideal right now:

Protection Type	Recommended Now?	Notes
Private network	✅ Must-have	Use internal-only ports/IPs

Token validation	✅ Already used	Validates user's identity
Caller identity check	✅ Add header check	Fast and simple
mTLS / service JWTs	🔜 Optional later	Use when hardening prod

2.2 Design

2.2.1 Login Sequence Diagram


Gateway triggers Spring Security OAuth2 client logic. Constructs authorization request
Browser
Angular SPA
Spring Gateway (9001)
OKTA
user-profile-svc
Clicks "Login"
1
window.location.href = http://localhost:9001 /oauth2/authorization/user-app
2
GET /oauth2/authorization/user-app
/authorize?
response_type=code&
client_id=...&
scope=...&
state=...&
redirect_uri=.../user-app&
nonce=...
302 Found Location:
https://???.okta.com/oauth2/default/v1/authorize?...
3
Redirect from the above 302
OKTA Log in Page
Submit Credentials
4
302 Found Location: http://localhost:9001/login/oauth2/code/user-app?code=...&state=...
Spring Security uses the AUTH_CODE to request tokens from Okta
Redirect from the above 302
5
Exchange code for tokens. Post:
https://dev-xxxx.okta.com/oauth2/default/v1/token
Tokens (access_token, id_token, refresh_token)
1
6
Stores authorized client in security context
Create secure session (SESSION cookie)
7
Redirect to http://localhost:4200/
8
/api/profile/me
(with SESSION cookie)
1
checks session
9
find user by okta user id
1
Validate toke
Fetch profile
Return user JSON
Return user JSON
Show UI
User

2.2.1.1 Actors Involved:

- **User**: A person interacting with the app.
- **Browser**: Executes the Angular SPA and handles HTTP redirects.
- **Angular SPA**: Frontend app running in the browser on port 4200.
- **Spring Cloud Gateway**: Backend reverse proxy with OAuth2 login configured on port 9001.
- **Okta**: The identity provider handling login and token issuance.

2.2.1.2 Full Authentication Sequence (Authorization Code Flow with PKCE)

1. **User initiates login**

- **User** clicks “Login” in the Angular app.
- **Angular SPA** triggers:
→ window.location.href = http://localhost:9001/oauth2/authorization/user-app

2. **Redirect to Okta for login**

- **Browser** sends GET /oauth2/authorization/user-app to **Gateway**
- **Gateway** triggers Spring Security OAuth2 client logic:
    - Constructs authorization request
    - Redirects to:

https://dev-50623690.okta.com/oauth2/default/v1/authorize?
response_type=code&
client_id=...&
scope=...&
state=...&
redirect_uri=http://localhost:9001/login/oauth2/code/user-app&
nonce=...

3. **User authenticates with Okta**

- **Browser** follows redirect to Okta (See the above 302 location).
- **User** enters username and password on the **Okta login page**
- If MFA is enabled, **User** completes MFA (e.g. Okta Verify)
- **Okta** validates credentials and MFA

4. Okta returns authorization code

. Okta redirects back to **http://localhost:9001/login/oauth2/code/user-app?code=...&state=...**

5. Spring Gateway exchanges code for tokens

- **Gateway** receives the request on /login/oauth2/code/**user-app**
- **Spring Security** uses the AUTH_CODE to request tokens from Okta:
    - Spring Security captures the redirect (/login/oauth2/code/user-app)
    - extracts the code=... from the URL
    - sends a **POST** request to Okta’s token endpoint

  -
    ```
    POST https://your-domain.okta.com/oauth2/default/v1/token
    Content-Type: application/x-www-form-urlencoded

    grant_type=authorization_code
    code=abc123...
    redirect_uri=http://localhost:9001/login/oauth2/code/okta
    client_id=...
    client_secret=...
    ```
  - If valid, Okta responds with:

  -
    ```
    {
      "access_token": "...",
      "id_token": "...",
      "expires_in": 3600,
      "token_type": "Bearer"
    }
    ```
  - Spring stores these tokens (usually in session)
  - User is now authenticated

6. Session established on Gateway

- **Gateway** stores the authorized client in the security context
- A secure session (SESSION cookie) is created

7. Gateway redirects user back to Angular

- **Gateway** redirects user to configured success URL

```
http://localhost:4200
```

8. Angular bootstraps and requests user profile

- **Angular SPA** loads
- It calls:
  → GET /api/profile/me via proxy (→ http://localhost:9001/api/profile/me)
- **Gateway** checks session, forwards request with access token to backend
  - **Spring Security inspects the session cookie (SESSION)**:
    - This session was created during login (/login/oauth2/code/user-app).
    - The session holds the **OAuth2AuthorizedClient** object, which contains:
      - Access token
      - Refresh token (optional)
      - Client registration metadata
  - The session is **authenticated**, so request proceeds.
  - Because we added the filter "**TokenRelay**",

        - **SCG** retrieves the **access token** from the **OAuth2AuthorizedClient** in the session and,
        - Adds header: `Authorization: Bearer eyJhbGciOi...`
        - **SCG forwards the request** to the backend microserviceservice discovery (via `lb://...` in uri 😊.

9. **Spring Boot microservice** validates token, fetches profile, and returns JSON

🔄 Incoming Request to microservice:

```
GET /api/profile/me
Authorization: Bearer eyJhbGciOi...
```

- We have configured the service as a **JWT resource server**:

```
spring:
  security:
    oauth2:
      resourceserver:
        jwt:
          issuer-uri: https://dev-xxxxx.okta.com/oauth2/default
```

- **Spring Security validates the token**:
    - **Decodes** the **JWT**
    - **Checks claims** like:
        - **iss** (issuer)
        - **exp** (expiration)
        - **aud** (audience, if configured)
    - If the token is valid:
        - Spring populates the `Authentication` object with a `JwtAuthenticationToken`
        - In Java code, we can access claims via:

```
@AuthenticationPrincipal Jwt jwt
```

- controller or service logic uses the claim (e.g., email) to fetch the user profile

```
AppUser user = userRepository.findByEmail(jwt.getClaimAsString("email"));
```

2.2.2 Design Approach for Separate Schemas

2.2.2.1 Tables

1. app_user – in schema **ssouser**
2. course – in schema **ssocourse**

3. course_enrollment – join table in **ssocourse** schema
4. course_application in **ssocourseapp** schema

🔹 course-enrollment table structure

Column	Type	Description
course_id	BIGINT	FK to course.id
student_id	BIGINT	FK to app_user.id (role=STUDENT)
created_at	TIMESTAMP	optional, for audit

> ⚠ No actual FK constraint on **student_id** since it's cross-schema — handle integrity in application logic.

> ⚠ **Do not share entities across services** unless they use the same schema.
> Misusing might cause the same entity creates DB table in multiple databases (schemas)
>
> In our case, we have the following entities created in common-lib:
>
> - com.dxu.sso.common.model.**user**.AppUser
> - com.dxu.sso.common.model.**course**.Course
> - com.dxu.sso.common.model.**course**.CourseEnrollment
> - com.dxu.sso.common.model.**course**.CourseEnrollmentId
> - com.dxu.sso.common.model.**courseapp**.CourseApplication
>
> We create them in different packages, then we can scan them separately in necessary microservices

For inter-service communication between services for different databases/schemas, use DTO instead

2.2.3 Should It Be Reactive?

If you’re architecting for **scalability**, **non-blocking I/O**, or **reactive event flows**, go fully reactive. Otherwise, **Spring MVC + REST is still the best choice for simplicity, stability, and maintainability**.

2.2.3.1 When Fully Reactive *Is* Better

If you're building a system that:

1. ✅ Needs **massive scalability** (thousands of concurrent I/O requests)
2. ✅ Does **a lot of non-blocking I/O** (e.g., calling external APIs, DBs)
3. ✅ Uses **reactive databases** (like MongoDB Reactive or R2DBC)
4. ✅ Wants **streaming support** (e.g., server-sent events, backpressure)
5. ✅ Integrates well into **event-driven architectures** (e.g., Kafka, WebSockets)

> **Then yes, reactive is superior.**

❌ But Reactive Has Drawbacks — Even If Complexity Doesn't Matter

Drawback	Why it matters
Thread stack traces are harder to debug	Because reactive chains are not call-stack based
Not all libraries are reactive	You still may need to block (JDBC, legacy code)
Testability is more complex	Especially for async flows, step-by-step verification
Learning curve	Your team still has to onboard, maintain, and reason through it
Not CPU-bound optimized	Reactive is for I/O efficiency, not raw CPU performance
Overhead for small apps	Reactive adds complexity where simple MVC is more than sufficient

General Guidance

System Type	Go Reactive?
API Gateway (WebFlux)	✅ Yes — great fit
High-concurrency public APIs	✅ Yes
DB-heavy service with JDBC	❌ No (unless you use R2DBC)
Simple internal microservice	❌ No (traditional MVC is fine)
Data streaming or SSE/WebSocket	✅ Yes
Event-driven systems	✅ Yes (Kafka, WebSockets, etc.)

2.2.3.2 Analysis

Service	Reactive Now?	Should Be Reactive?	Why / Why Not
api-gateway	✅ Yes	✅ Yes	Spring Cloud Gateway is reactive by design **(Already reactive)**
user-profile-svc	❌ No (JPA)	❌ No (unless you migrate to R2DBC)	It's simple, DB-bound, blocking JDBC
user-admin-svc	❌ No (JPA)	❌ No	Admin-only, low traffic, blocking DB

course-query-svc	❌ No (JPA)	🔁 Optional	If you need high-speed public course browsing (and use caching or R2DBC), it might benefit from reactive
course-management-svc	❌ No (JPA)	❌ No	Mostly write operations, admin-focused
course-application-svc	❌ No	✅ Yes	Good candidate: async logic, Kafka/event-driven, multi-service orchestration, non-blocking fits well
Kafka consumers/producers	❌ Partial	✅ Yes	If part of an event-driven workflow, reactive Kafka (via Project Reactor or Spring Cloud Stream) is ideal
Inter-service WebClient calls	⛔ Blocking with .block()	✅ Yes	Easy win — move to Mono, Flux to avoid blocking threads unnecessarily

> ⚠ Tried to apply fully reactive solution for course-application-svc, UserWebClient and CourseWebClient. However, it failed due to thread issue.

2.2.4 Kafka Integration

2.2.4.1 Event for Course Application Approved

✅ **Goal**: When a course application is approved in course-application-svc, emit a Kafka event to inform course-management-svc to create a new course enrollment record.

2.2.4.2 Saga Pattern - Data Integrity

2.2.5 Saga Pattern

2.2.6 Drools Integration

3. Back End Implementation

3.1 Config Server, Gateway and Eureka Server

3.1.1 Overview

- **Single Eureka Server**: All microservices register with one service registry.
- **Single Gateway** (e.g. api-gateway or user-gateway): Handles all routing and security.

3.1.2 Design Considerations

3.1.2.1 Use Single Gateway

Issue:

1. Originally my Angular frontend uses a proxy config to forward:

- /api/profile/* to http://localhost:9001 (user-gateway)
- /api/courses/* to http://localhost:9011 (course-gateway)

2. **user-gateway** is likely managing the session (holding cookies like SESSION) and properly configured for Okta login.

3. **course-gateway** is not sharing the session, so when /api/courses is called, it has:

- No access token or session info
- Spring Security thinks you're not logged in → returns 302 redirect to login (/oauth2/authorization/okta)

4. Once the browser follows that 302 redirect, it may overwrite cookies, invalidate session, or otherwise interfere with your current login context — causing /api/profile/me to stop working too.

Solution:

1. Route all API calls through a **single gateway**, such as **api-gateway**, which ensures:

- All routes go through a **single OAuth2 login session**
- **TokenRelay** forwards the same token to both backend services
- **Session consistency** is maintained

2. Ensure **withCredentials: true** is used in Angular. This ensures **cookies** like **SESSION** are **included** in the request.

```
this.http.get('/api/profile/me', { withCredentials: true })
```

3. Make sure CORS is enabled in all backend services

Each service (course-query-svc, user-profile-svc, etc.) must allow:

- Origin from your Angular dev server (http://localhost:4200)
- Allow credentials
- Allow headers like Authorization

4. We are using **OAuth2 Resource Server** on backend, Backends like **course-query-svc** must accept **JWT** via:

```yaml
spring:
  security:
    oauth2:
      resourceserver:
        jwt:
          issuer-uri: https://dev-xxxx.okta.com/oauth2/default
```

3.1.2.1.2 How to Support Multiple Okta Applications

Spring Security can distinguish between multiple clients by using **multi-client configuration**:

```yaml
spring:
  security:
    oauth2:
      client:
        registration:
          user-app:
            provider: okta
            client-id: 0oaooqy915xbkRCKT5d7
            client-secret: Ew-4IiHuFr6cgY1w3JhJ5PFWzvB-yZGx6xdD_y3rxhSWioOG-U_NGsCViCvlAxfe
            scope: openid, profile, email
            authorization-grant-type: authorization_code
            redirect-uri: "{baseUrl}/login/oauth2/code  /user-app"
          course-app:
            provider: okta
            client-id: 0oaoor5c1wl5NU1ef5d7
            client-secret: AC-_PThmy1t69J7Q1Je2g4HNRXq1mPqAUGDspKsy6dTFGk7RVV00a5jKiwZVuJ3z
            scope: openid, profile, email
            authorization-grant-type: authorization_code
            redirect-uri: "{baseUrl}/login/oauth2/code/course-app"
        provider:
          okta:
            issuer-uri: https://dev-50623690.okta.com/oauth2/default
```

And in your **gateway security config**, you can customize the OAuth2 login:

3.1.2.2 Use Single Eureka Server

3.1.2.2.1 Drawbacks of Using Multiple Eureka Servers

Concern	Issue
🔄 Complexity	You need multiple gateways or static routing
🚧 Discovery Isolation	Each Eureka server only knows part of the ecosystem
🔐 Inconsistent Security	Session/cookie/token state may conflict
💥 Troubleshooting	Harder to trace request flow across domains

3.1.2.2.2 Benefits of Using a Single Eureka Server

1. **Centralized Service Discovery**
    - All **microservices** (user-related, course-related, etc.) **register to the same registry**.
    - The gateway has a complete view and can route using lb://service-name.
2. **Clean and Simple Gateway Config**
    - You don’t need to hardcode static URIs or worry about manual routing.
    - Just use lb://course-query-svc or lb://user-profile-svc.
3. **Better Load Balancing and Failover**
    - Spring Cloud LoadBalancer works best with Eureka.
    - Failover, health checks, retries, and service instance awareness are automatic.
4. **Better Observability**
    - You can view all microservices and their status in one Eureka dashboard.
5. **Simpler Configuration Management**
    - You can use a unified Spring Cloud Config Server or application.yml setup across services.
6. **Less Error-Prone Security Handling**
    - Session, token relay, and login logic (especially with Okta/OAuth2) are more consistent.

3.2 User Management

3.2.1 Backend Implementation

3.2.1.1 Overview

3.2.1.1.1 Authentication & Authorization

- **OAuth2 login via OKTA** is handled **only by api-gateway**
- Each backend service is:
  - **Stateless**
  - Secured via **JWT** (relayed by gateway using TokenRelay)
  - Uses spring-boot-starter-oauth2-resource-server for validating tokens
- **Authorization** is managed by application itself

3.2.1.1.2 Components

Component	Purpose	Port
api-gateway	Central entry point (handles login & token relay), SINGLE Gateway	9001
user-profile-svc	Saves profile of the logged-in OKTA user	9002
user-admin-svc	Allows admin to manage user accounts	9003
user-config-server	Centralized configuration	9004
eureka-server	SINGLE Service discovery	**9761**
MySQL DB 8	Stores internal user profile info (email, roles, etc.)	—

Spring Boot: 3.4.5

Spring Cloud: 2024.0.1

3.2.1.2 user-config-server

Dependencies:

- spring-cloud-config-server
- spring-boot-starter-actuator

application.yml

```
server:
  port: 9004

spring:
  application:
    name: user-config-server
  profiles:
    active: native

  cloud:
    config:
      server:
        native:
          search-locations: file:../user-config-repo
      fail-fast: true
```

@EnableConfigServer

Add the following YAML files for the applications that want to externalize their configurations

- **eureka-server**.yml
- **api-gateway**.yml
- **user-profile-svc**.yml
- **user-admin-svc**.yml

3.2.1.3 user-eureka-server

Dependencies:

- spring-cloud-starter-netflix-eureka-server
- spring-cloud-starter-config
- spring-boot-starter-actuator

application.yml

```
server:
  port: 9761

spring:
  application:
    name: user-eureka-server
  config:
    import: configserver:http://localhost:9004

eureka:
  client:
    register-with-eureka: false
    fetch-registry: false
    service-url:
      defaultZone: http://localhost:9761/eureka/

  server:
    enable-self-preservation: false
    enable-replication: false
```

@EnableEurekaServer

Note: The following configurations are MUST to avoid replication which cause issues:

```yaml
eureka:
  client:
    service-url:
      defaultZone: http://localhost:9761/eureka/

  server:
    enable-self-preservation: false
    enable-replication: false
```

Spring Cloud Eureka Server is a special case where most of its critical configuration must remain local, and cannot be externalized to the
Config Server, because:

- **Startup Dependency Loop**
  - The Eureka Server needs its config **before** it can connect to other services.
  - If you try to **externalize application.yml** to the config server, but the Eureka server itself hasn't started yet, it **cannot connect to the config server**.
  - This causes a **bootstrap deadlock**.
- **It’s not a config client by default**
  - Eureka Server **serves** the registry and is expected to be **fully self-contained**.

3.2.1.4 api-gateway

Dependencies:

- spring-cloud-starter-gateway
- spring-boot-starter-oauth2-client
- spring-boot-starter-security
- spring-cloud-starter-config
- spring-cloud-starter-netflix-eureka-client
- spring-boot-starter-actuator

application.yml

```yaml
server:
  port: 9001

spring:
  application:
    name: api-gateway
  config:
    import: configserver:http://localhost:9004

  cloud:
    gateway:
      routes:
        - id: user-profile
          uri: lb://user-profile-svc
          predicates:
            - Path=/api/profile/**
          filters:
            - TokenRelay

        - id: user-admin
          uri: lb://user-admin-svc
          predicates:
            - Path=/api/admin/**
          filters:
            - TokenRelay

  security:
    oauth2:
      client:
        registration:
          okta:
            client-id: 0oaooqy915xbkRCKT5d7
            client-secret: Ew-4IiHuFr6cgY1w3JhJ5PFWzvB-yZGx6xdD_y3rxhSWioOG-U_NGsCViCvlAxfe
            scope: openid, profile, email
            authorization-grant-type: authorization_code
            redirect-uri: "{baseUrl}/login/oauth2/code/okta"
        provider:
          okta:
            issuer-uri: https://dev-50623690.okta.com/oauth2/default

eureka:
  client:
    service-url:
      defaultZone: http://localhost:9761/eureka/

  instance:
    prefer-ip-address: true
    hostname: localhost

angular:
  redirect_url: http://localhost:4200
```

SecurityConfig.java

```java
@Configuration
@EnableWebFluxSecurity
public class SecurityConfig {

    @Value( "${angular.redirect-url}")
    private String angularRedirectUrl;   // This must be one of the

    @Bean
    public SecurityWebFilterChain springSecurityFilterChain(ServerHttpSecurity http,
                                                            ReactiveClientRegistrationRepository
clientRegistrationRepository) {
        return http
                .csrf(csrf -> csrf.disable())
                .authorizeExchange(authorize -> authorize
                                .pathMatchers("/actuator/**", "/public/**").permitAll()
                                .anyExchange().authenticated())
                .oauth2Login(login -> login
                                .authenticationSuccessHandler(redirectToAngular()))
                .logout(logout -> logout
                        .logoutSuccessHandler(oidcLogoutSuccessHandler(clientRegistrationRepository)))
                .build(); // ✅ No more .oauth2Client()
    }

    private ServerLogoutSuccessHandler oidcLogoutSuccessHandler(
            ReactiveClientRegistrationRepository clientRegistrationRepository) {

        OidcClientInitiatedServerLogoutSuccessHandler handler =
                new OidcClientInitiatedServerLogoutSuccessHandler(clientRegistrationRepository);

        // Redirect back to Angular after logging out of Okta
        handler.setPostLogoutRedirectUri(String.valueOf(URI.create(angularRedirectUrl)));
        return handler;
    }

    private ServerAuthenticationSuccessHandler redirectToAngular() {
        return new RedirectServerAuthenticationSuccessHandler(angularRedirectUrl);
    }
}
```

Note: It turns out the **externalized configuration is not working** for api-gateway as well. Have to move all configurations to application.yml

> With "**issuer-uri: https://dev-50623690.okta.com/oauth2/default**",
>
> Spring will:
>
> - Fetch public signing keys from OKTA:
>
>   **https://dev-50623690.okta.com/oauth2/default/v1/keys**
>
> - Use those to validate:
>
>   - Signature
>   - Expiry (exp)
>   - Issuer (iss)
>   - Audience (aud) if configured
>
> ✅ So if the token is invalid, the request is rejected with **401 Unauthorized before it hits your controller**.

3.2.1.5 user-profile-svc

Dependencies:

- spring-boot-starter-web
- spring-boot-starter-data-jpa
- spring-boot-starter-oauth2-resource-server
- spring-boot-starter-oauth2-client
- spring-boot-starter-security
- spring-cloud-starter-config
- spring-cloud-starter-netflix-eureka-client
- mysql-connector-j
- lombok

application.yml

```yaml
spring:
  application:
    name: user-profile-svc

  config:
    import: configserver:http://localhost:9004

# See other configurations in user-config-repo/user-profile-svc.yml
```

MySQL:

```
CREATE DATABASE ssouser CHARACTER SET utf8mb4 COLLATE utf8mb4_bin;
CREATE USER 'ssouser'@'localhost' IDENTIFIED BY 'passw0rd';
GRANT ALL PRIVILEGES ON ssouser.* TO 'ssouser'@'localhost';
FLUSH PRIVILEGES;
```

3.2.1.6 user-admin-svc

Mostly same as user-profile-svc

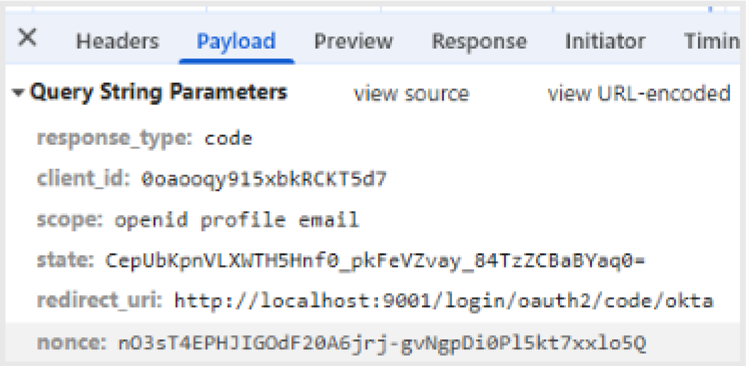
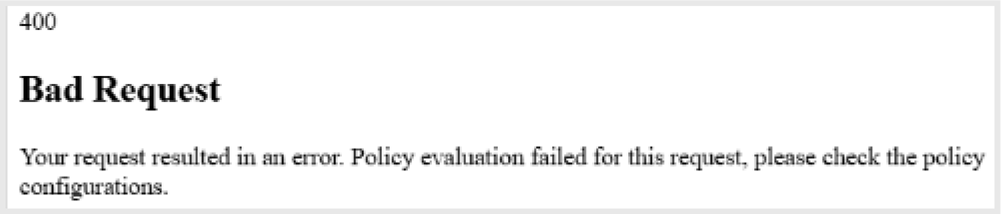
3.2.1.7 Authentication Test

Go to http://localhost:**9001**/api/profile/me

Issue 1:

Expected: Redirect to OKTA login page

Actual:

http://localhost:9001/api/profile/me	302. Location: /oauth2/authorization/okta
http://localhost:9001/oauth2/authorization/okta	302. Location: https://dev-50623690.okta.com/oauth2/default/v1/authorize?response_type=code&client_id=0oaooqy915xbkRCKT5d7&scope=openid%20profile%20email&state=CepUbKpnVLXWTH5Hnf0_pkFeVZvay_84TzZCBaBYaq0%3D&redirect_uri=http://localhost:9001/login/oauth2/code/okta&nonce=nO3sT4EPHJIGOdF20A6jrj-gvNgpDi0Pl5kt7xxlo5Q
The above URL of the 302 location	 ▾ Query String Parameters view source view URL-encoded response_type: code client_id: 0oaooqy915xbkRCKT5d7 scope: openid profile email state: CepUbKpnVLXWTH5Hnf0_pkFeVZvay_84TzZCBaBYaq0= redirect_uri: http://localhost:9001/login/oauth2/code/okta nonce: nO3sT4EPHJIGOdF20A6jrj-gvNgpDi0Pl5kt7xxlo5Q  400 **Bad Request** Your request resulted in an error. Policy evaluation failed for this request, please check the policy configurations.

Reason: caused by **missing or misconfigured access policy rules** on OKTA's **Authorization Server**, specifically for your OIDC Web App

Solution: Create an Access Policy + Rule

✅ **Step 1: Go to Authorization Server Settings**

1. Open your OKTA Admin Console
2. Go to:
   Security → API → Authorization Servers
3. Click on the **default** authorization server

✅ **Step 2: Create a New Access Policy**

1. Go to the **Access Policies** tab
2. Click **"Add Policy"**
3. Fill in:
   - **Name**: Allow Spring Boot Clients
   - **Description**: Policy to allow authorization code flow for api-gateway
   - Leave defaults for user matching
4. Click **"Create Policy"**

✅ **Step 3: Add a Rule to That Policy**

After creating the policy:

1. Click **"Add Rule"**
2. Fill in:
   - **Name**: Allow code flow for gateway
   - **IF Grant type is**: ✅ Authorization Code, ✅ Refresh Token
   - **IF User is**: ✅ Any user
   - **IF Client is**: ✅ (select your app client — api-gateway / client ID: 0oaooqy915xbkRCKT5d7)
3. Click **Create Rule**

Issue 2

Error: **UnknownHostException** for **dxpsdesktop.mshome.net**

Reason:

- api-gateway cannot resolve the host name via DNS
- it relies on Eureka for routing (using lb://user-profile-svc), and the system fails because the actual network host is unknown or unreachable

Solution: Force Eureka to Register localhost or IP Instead

For user-profile-svc, user-admin-svc and api-gateway, add the following configuration:

```yaml
eureka:
  instance:
    prefer-ip-address: true
    hostname: localhost
```

This tells Eureka to:

- Register using your machine’s **IP address or localhost**
- Avoid relying on system hostnames (like dxpsdesktop.mshome.net)

Issue 3

Error:

In browser	**URL**: https://dev-50623690.okta.com/oauth2/default/v1/authorize?response_type=code&client_id=0oaooqy915xbkRCKT5d7 &scope=openid%20profile%20email&state=LyJq5kOzBNHCfBKGrKy6zNLM7KFXO9_KZ2KYhhvaBtM%3D &redirect_uri=http://172.21.48.1:9002/login/oauth2/code/okta&nonce=HEqMZvTveDA0yLLvHmVeVKdF0n0aRY_ZC5jibYO_H34 **Response**: 400 bad request Your request resulted in an error. The 'redirect_uri' parameter must be a Login redirect URI in the client app settings: https://dev-50623690-admin.okta.com/admin/app/oidc_client/instance/0oaooqy915xbkRCKT5d7#tab-general

Reason:

From OKTA's point of view:

- Your app sent this in the authorization request: **redirect_uri=http://172.21.48.1:9002/login/oauth2/code/okta**

But in your OKTA app settings, the allowed **Sign-in redirect URI** is:

- http://localhost:9001/login/oauth2/code/okta

➡️ These **do not match**, and OKTA rejects the request.

Solution: **Only** let **Gateway** Handles Login

Remove any Spring Boot login configs from **user-profile-svc** and **user-admin-svc**, which is:

```yaml
spring:
  security:
    oauth2:
      client:
        registration:
          okta:
            client-id: 0oaooqy915xbkRCKT5d7
            client-secret: Ew-4IiHuFr6cgY1w3JhJ5PFWzvB-yZGx6xdD_y3rxhSWioOG-U_NGsCViCvlAxfe
            scope: openid, profile, email
            authorization-grant-type: authorization_code
            redirect-uri: "{baseUrl}/login/oauth2/code/okta"
        provider:
          okta:
            issuer-uri: https://dev-50623690.okta.com/oauth2/default
```

Issue 4:

Now, the log in page is displayed, but the URL is **http://172.21.48.1:9002/login**, 172.21.48.1 is my machine's IP address

Reason:

> Spring Boot auto-configures security using default behavior because:
>
> - You **included spring-boot-starter-security**
> - But you **didn't override or disable** the default security configuration
>
> When no explicit SecurityFilterChain bean is defined, Spring Security falls back to:
>
> - Securing **all endpoints**
> - Showing a default login page at /login

Solution:

Add a **SecurityConfig** class in `user-profile-svc` / `user-admin-svc to`

- rely on the **Gateway** to enforce auth for **request from UI**
- **permit all** requests of "**/public/****"
- **Other** requests must be **authenticated**

```java
@Configuration
public class SecurityConfig {

    @Bean
    public SecurityFilterChain filterChain(HttpSecurity http) throws Exception {
        http.authorizeHttpRequests(authorize -> authorize
                        .requestMatchers("/public/**").permitAll()
                        .anyRequest().authenticated())
                .csrf(csrf -> csrf.disable())
                .oauth2ResourceServer(oauth2 -> oauth2.jwt(Customizer.withDefaults()));

        return http.build();
    }
}
```

add the **Spring Security OAuth2 Resource Server** dependency

```xml
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-oauth2-resource-server</artifactId>
</dependency>
```

Also, Spring Security needs a **JwtDecoder bean. Below** let Spring Boot auto-configure JwtDecoder using the OKTA issuer URI

```
spring:
  security:
    oauth2:
      resourceserver:
        jwt:
          issuer-uri: https://dev-50623690.okta.com/oauth2/default
```

🔁 Recap What’s Happening

Now that you’ve added in **SecurityConfig** in **user-profile-svc**:

```
.oauth2ResourceServer(oauth2 -> oauth2.jwt(Customizer.withDefaults()))
```

This tells Spring Security to validate incoming requests using JWT tokens, and it auto-wires the logic behind the scenes.

Spring Security expects to **decode JWT tokens** from incoming requests (relayed from your gateway).

To do this, it needs to know:

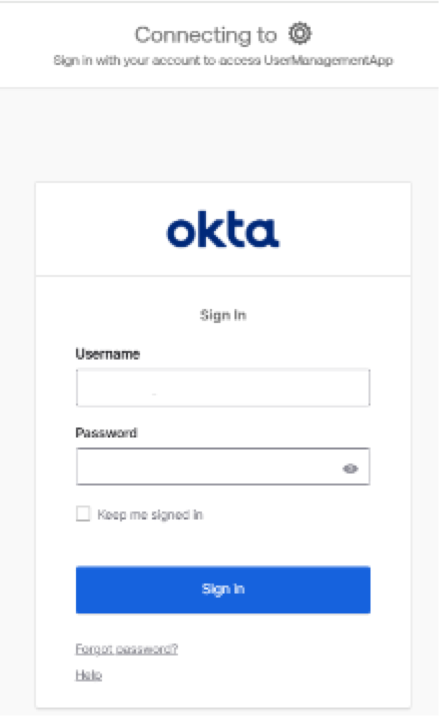
- **Where** to fetch the public keys (JWKS) from
- **How** to decode and validate the access token

By providing the issuer-uri, Spring Boot will:

- Auto-configure a JwtDecoder bean
- Download your OKTA public keys from:

  ```
  https://dev-50623690.okta.com/oauth2/default/v1/keys
  ```

Now access **http://localhost:9001/api/profile/me**, and the OKTA login page is displayed:



Connecting to

Sign in with your account to access UserManagementApp

3.3 Course Management

3.3.1 Backend Implementation

3.3.1.1 Overview

3.3.1.1.1 Authentication & Authorization

- **OAuth2 login via OKTA** is handled **only by api-gateway**
- Each backend service is:
  - **Stateless**
  - Secured via **JWT** (relayed by gateway using TokenRelay)
  - Uses spring-boot-starter-oauth2-resource-server for validating tokens
- **Authorization** is managed by application itself
- **User roles (student, teacher, admin)** are retrieved from the **User Management Application's API**

3.3.1.1.2 Components

Component	Port	Purpose
course-query-svc	9012	Read-only API for all roles
course-management-svc	9013	Admin/teacher APIs for course updates
course-application-svc	9014	Student course application + approval
config-server (shared)	9015	Centralized config
MySQL (shared)	—	Stores course, enrollment, and application data

3.3.1.2 course-config-server

Dependencies:

- spring-cloud-config-server
- spring-boot-starter-actuator

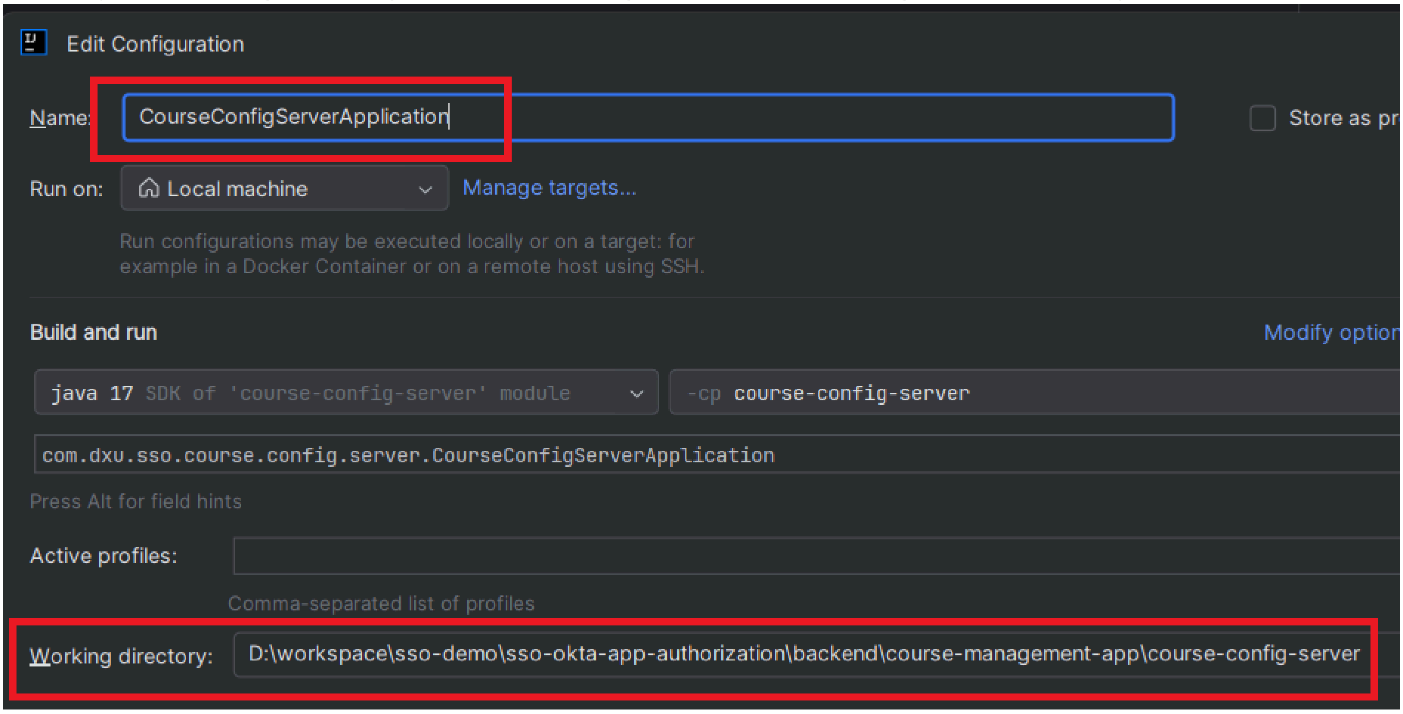
application.yml

```
server:
  port: 9015

spring:
  application:
    name: course-config-server
  profiles:
    active: native

  cloud:
    config:
      server:
        native:
          search-locations: file:../course-config-repo
      fail-fast: true
```

@EnableConfigServer

> **Issue**: Does not load configurations from folder "course-config-repo"
> **Reason**: IntelliJ defaults to the **working directory of the first module with a main() method**, or sometimes the directory containing the .iml file for that module.

Solution:
Explicitly set **Working directory** for **course-config-server** in **Edit configuration** in **Intellij IDEA**



Edit Configuration

Name: CourseConfigServerApplication

□ Store as pr

Run on: Local machine

Manage targets...

Run configurations may be executed locally or on a target: for example in a Docker Container or on a remote host using SSH.

Build and run

Modify option

java 17 SDK of 'course-config-server' module

-cp course-config-server

com.dxu.sso.course.config.server.CourseConfigServerApplication

Press Alt for field hints

Active profiles:

Comma-separated list of profiles

Working directory: D:\workspace\sso-demo\sso-okta-app-authorization\backend\course-management-app\course-config-server

~~3.3.1.3 course-eureka-server~~

> ⚠ Removed since we use **SINGLE** eureka server to prevent complexity

~~3.3.1.4 course-gateway~~

> Removed since we use **SINGLE** gateway to prevent complexity

3.3.1.5 course-query-svc

Dependencies:

- spring-boot-starter-web
- spring-boot-starter-data-jpa
- spring-boot-starter-oauth2-resource-server
- spring-boot-starter-oauth2-client
- spring-boot-starter-security
- spring-cloud-starter-config
- spring-cloud-starter-netflix-eureka-client
- mysql-connector-j
- lombok

application.yml

```yaml
spring:
  application:
    name: course-query-svc

  config:
    import: configserver:http://localhost:9015

# See other configurations in course-config-repo/course-query-svc.yml
```

course-query-svc.yml

```
server:
  port: 9012

spring:
  config:
    activate:
      on-profile: default

  security:
    oauth2:
      resourceserver:
        jwt:
          issuer-uri: https://dev-50623690.okta.com/oauth2/default

  datasource:
    url: jdbc:mysql://localhost:3306/ssocourse
    username: ssocourse
    password: passw0rd

  jpa:
    hibernate:
      ddl-auto: update
    show-sql: true

eureka:
  client:
    service-url:
      defaultZone: http://localhost:9761/eureka/

  instance:
    prefer-ip-address: true
    hostname: localhost

# URL of User Profile API in User Management App
user-profile:
  url: http://localhost:9002/api/profile/me
```

As per best practice, the **communication between backend** microservices **should not via gateway**, so the CourseController is calling ProfileController directly (9002).

To protect these direct API calls, update "**anyRequest().permitAll()**" the **SecurityConfig** of **user-profile-svc** which is the application of the called API as below:

```
    @Bean
    public SecurityFilterChain filterChain(HttpSecurity http) throws Exception {
        http.authorizeHttpRequests(authorize -> authorize
                        .requestMatchers("/public/**").permitAll()
                        .anyRequest().authenticated())
                .csrf(csrf -> csrf.disable())
                .oauth2ResourceServer(oauth2 -> oauth2.jwt(Customizer.withDefaults()));

        return http.build();
    }
```

MySQL:

```
CREATE DATABASE ssocourse CHARACTER SET utf8mb4 COLLATE utf8mb4_bin;
CREATE USER 'ssocourse'@'localhost' IDENTIFIED BY 'passw0rd';
GRANT ALL PRIVILEGES ON ssocourse.* TO 'ssocourse'@'localhost';
FLUSH PRIVILEGES;
```

3.3.1.6 course-management-svc

Mostly same as course-query-svc

3.3.1.7 course-application-svc

3.3.1.7.1 Database

```
CREATE DATABASE ssocourseapp CHARACTER SET utf8mb4 COLLATE utf8mb4_bin;
CREATE USER 'ssocourseapp'@'localhost' IDENTIFIED BY 'passw0rd';
GRANT ALL PRIVILEGES ON ssocourseapp.* TO 'ssocourseapp'@'localhost';
FLUSH PRIVILEGES;
```

3.3.1.7.2 Reactive

> Tried to change to fully reactive solution, but not successful. Stashed the code to branch **stashed/reactive-impl-notwork**

3.3.1.7.3 Kafka Event - Create **course-enrollment** when **course-application** get approved

✅ **Step-by-Step Plan**

🔹 In course-application-svc:

- Define CourseApplicationApprovedEvent
- Configure Kafka producer
- Publish the event after approval

🔹 In course-management-svc:

- Configure Kafka consumer
- Handle the event to insert a new record into the course_enrollment table

Step 1: Add Kafka Dependencies

In both services (**course-application-svc** and **course-management-svc**):

```xml
<dependency>
  <groupId>org.springframework.kafka</groupId>
  <artifactId>spring-kafka</artifactId>
</dependency>
```

Step 2: Define the Kafka Event Payload

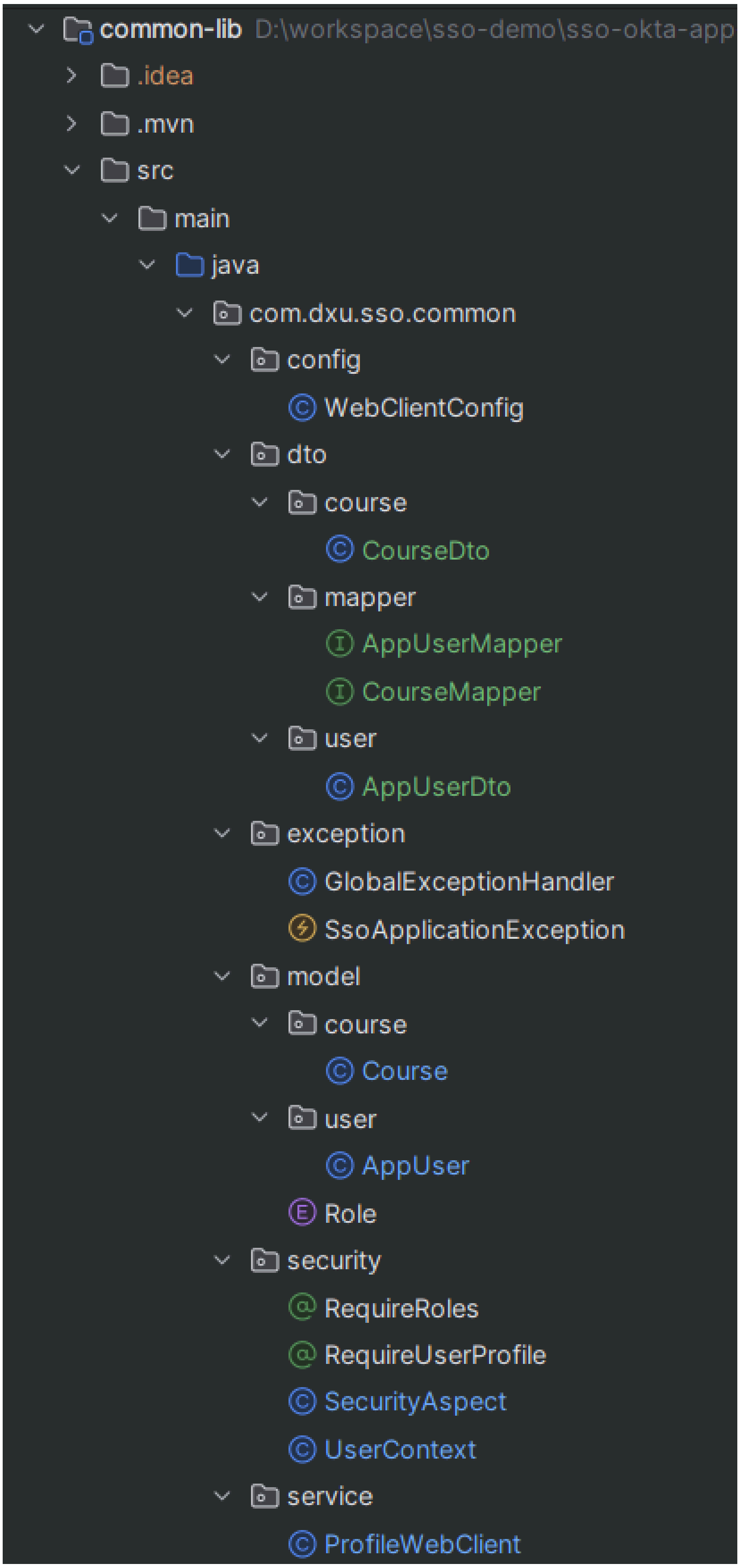
In common-lib

3.4 Shared Library common-lib

3.4.1 Overview

For reusability and preventing duplicate code, move shared code to a shared module that can be reused by both the Course Management and User Management applications.

3.4.2. Implementation



```
common-lib D:\workspace\sso-demo\sso-okta-app
  .idea
  .mvn
  src
    main
      java
        com.dxu.sso.common
          config
            WebClientConfig
          dto
            course
              CourseDto
            mapper
              AppUserMapper
              CourseMapper
            user
              AppUserDto
          exception
            GlobalExceptionHandler
            SsoApplicationException
          model
            course
              Course
            user
              AppUser
            Role
          security
            RequireRoles
            RequireUserProfile
            SecurityAspect
            UserContext
          service
            ProfileWebClient
```

- **WebClientConfig**: Create WebClient.builder that is shared by applications to do the **inter-application communication**
- **GlobalExceptionHandler**: The global exception handler
- **dto**: Shared DTOs, mapper, etc
- **model**: Shared entity

- **security**: Annotations for custom authentication/authorization shared by all applications
- **ProfileWebClient**: Shared service that contains shared operations such as fetch profile information from **/api/profile/me** in **user-profile-svc**

3.4.2.1 WebClientConfig

The consuming application use @Qualifier("commonWebClientBuilder") to distinguish with other WebClient (if exists)

```
    @Bean
    @Qualifier("commonWebClientBuilder")
    public WebClient.Builder commonWebClientBuilder() {
        return WebClient.builder();
    }
```

3.4.2.2 ProfileWebClient

Service of handling operations shared by applications.

Note: Need to set Authorization header with bearer token

```
    public AppUserDto getUserProfile() {
        log.info("Fetching user profile");

        // Return cached user if already fetched
        if (userContext.getAppUser() != null) {
            return userContext.getAppUser();
        }

        String authHeader = getAuthHeader();
        if (authHeader == null || !authHeader.startsWith("Bearer ")) return null;

        AppUserDto user = webClientBuilder.build()
                .get()
                .uri(userProfileUrl)
                .header(HttpHeaders.AUTHORIZATION, authHeader)
                .retrieve()
                .onStatus(HttpStatusCode::is4xxClientError, response -> Mono.empty())
                .bodyToMono(AppUserDto.class)
                .block();

        userContext.setAppUser(user); // ✅ cache it
        return user;
    }

    private static String getAuthHeader() {
        ServletRequestAttributes attrs = (ServletRequestAttributes)
RequestContextHolder.getRequestAttributes();
        if (attrs == null) return null;

        return  attrs.getRequest().getHeader(HttpHeaders.AUTHORIZATION);
    }
```

> Optimization - Cache the AppUser object per request using Spring's @RequestScope, to avoid multiple calls to /api/profile/me in the same request

```java
@RequestScope
@Component
@Getter
@Setter
public class UserContext {
    private AppUserDto appUser;
}

@Service
public class ProfileWebClient {
    ... ...
    public AppUserDto getUserProfile() {
        log.info("Fetching user profile");

        // Return cached user if already fetched
        if (userContext.getAppUser() != null) {
            return userContext.getAppUser();
        }

        ... ...
        AppUserDto user = ... ...;

        userContext.setAppUser(user); // ✅ cache it
        return user;
    }
```

2.3 Models

Shared JPA entities.

> **Do not share entities across services** unless they use the same schema.
> Misusing might cause the same entity creates DB table in multiple databases (schemas)
>
> In our case, we have the following entities created in common-lib:
>
> - com.dxu.sso.common.model.**user**.AppUser
> - com.dxu.sso.common.model.**course**.Course
> - com.dxu.sso.common.model.**course**.CourseEnrollment
>
> We create them in different packages, then we can scan them separately in necessary microservices

3.4.2.4 DTOs

Shared DTOs, mappers, etc.

3.4.2.5 Security

3.4.2.5.1 Anotation

- **@RequireRoles**: Ensures the user has one of the specified roles based on their profile from **/api/profile/me**. If not, throws a **403** ApplicationException
- **@RequireUserProfile**: Ensures the user is registered in the User Management application. If the profile is not found, throws a **403** ApplicationException

```
@Aspect
@Component
@RequiredArgsConstructor
public class SecurityAspect {

    private final ProfileWebClient profileWebClient;

    @Around("@annotation(requireUserProfile)")
    public Object checkUserProfile(ProceedingJoinPoint joinPoint, RequireUserProfile
requireUserProfile)
            throws Throwable {
        AppUserDto user = profileWebClient.getUserProfile();
        if (user == null) {
            throw new SsoApplicationException(HttpStatus.FORBIDDEN.value(), "User profile not
found");
        }
        return joinPoint.proceed();
    }

    @Around("@annotation(requireRoles)")
    public Object checkUserRole(ProceedingJoinPoint joinPoint, RequireRoles requireRoles) throws
Throwable {
        AppUserDto user = profileWebClient.getUserProfile();
        if (user == null) {
            throw new SsoApplicationException(HttpStatus.FORBIDDEN.value(), "User profile not
found");
        }

        List<String> allowedRoles = Arrays.asList(requireRoles.value());
        if (!allowedRoles.contains(user.getRole())) {
            throw new SsoApplicationException(HttpStatus.FORBIDDEN.value(), "User role not
permitted");
        }

        return joinPoint.proceed();
    }
}
```

3.4.2.6 Exception Handling

- SsoApplicationException: The global exception handler shared by applications

Note: SsoApplicationException **MUST extends RuntimeException**.

Spring AOP uses **dynamic proxies** by default (JDK proxies or CGLIB), and **unchecked exceptions (like RuntimeException) are passed through**, but **checked exceptions (or any custom exception that isn't declared) get wrapped** in UndeclaredThrowableException.This tells Spring AOP and Java proxying:

> “This is an **unchecked exception**, don’t wrap it — just let it bubble.”

```java
@Getter
@Setter
public class SsoApplicationException extends RuntimeException {

    private final int statusCode;

    public SsoApplicationException(int statusCode, String message) {
        super(message);
        this.statusCode = statusCode;
    }
}
```

```
@Slf4j
@AllArgsConstructor
@ControllerAdvice
public class GlobalExceptionHandler extends ResponseEntityExceptionHandler {

    @ExceptionHandler(SsoApplicationException.class)
    public ResponseEntity<?> handleApplicationException(SsoApplicationException ex) {
        log.error("GlobalExceptionHandler: ", ex);

        return ResponseEntity
                .status(ex.getStatusCode())
                .body(new ErrorResponse(ex.getStatusCode(), ex.getMessage()));
    }

    @ExceptionHandler({ Exception.class })
    @ResponseBody
    @ResponseStatus(HttpStatus.INTERNAL_SERVER_ERROR)
    public ResponseEntity<?> handleGenericException(Exception ex, WebRequest req) {
        log.error("Exception: ", ex);

        return ResponseEntity
                .status(HttpStatus.INTERNAL_SERVER_ERROR)
                .body(new ErrorResponse(HttpStatus.INTERNAL_SERVER_ERROR.value(), ex.getMessage()));
    }

    @Override
    protected ResponseEntity<Object> handleMethodArgumentNotValid(MethodArgumentNotValidException
ex,
                                                                  HttpHeaders headers,
                                                                  HttpStatusCode status,
                                                                  WebRequest request) {

        Map<String, String> errors = new HashMap<>();
        ex.getBindingResult().getAllErrors().forEach((error) -> {
            String fieldName = ((FieldError) error).getField();
            String errorMessage = error.getDefaultMessage();
            errors.put(fieldName, errorMessage);
        });

        return ResponseEntity.status(HttpStatus.BAD_REQUEST).body(errors);
    }

    record ErrorResponse(int statusCode, String message) {}
}
```

3.4.2.7 Troubleshooting

3.4.2.7.1 Unable to find main class on "mvn clean install"

Reason: common-lib is a **shared library**, it does **not need a main() class**, and it **should not be packaged as a Spring Boot executable JAR**.
Solution: **Remove** the Spring Boot plugin:

3.4.3. Use common-lib in Microservices

3.4.3.1 How to Use common-lib in Your Microservices

- Add common-lib dependency in each microservice

```
<dependency>
    <groupId>com.dxu.sso.common.lib</groupId>
    <artifactId>common-lib</artifactId>
    <version>0.0.1-SNAPSHOT</version>
</dependency>
```

- Enable AOP in each microservice

```
@SpringBootApplication
@EnableAspectJAutoProxy
public class CourseManagementServiceApplication {
    ...
}
```

3.4.3.2 Troubleshooting During Implementation

3.4.3.2.1 Could not autowire. No beans of 'ProfileWebClient

> **Reason**: Spring **doesn't automatically scan components (@Service, @Component, etc.) in external libraries**

Solution

Explicit **@ComponentScan** in the consuming applicatio

```
@ComponentScan(basePackages = {
        "com.dxu.sso.course.query",
        "com.dxu.sso.common"           // shared library "common-lib"
})
```

3.4.3.2.2 IllegalArgumentException - Not a managed type: class com.dxu.sso.common.model.Course

> **Reason**: Spring Data JPA **only scans and registers entities (@Entity)** that are located in the **current application's @EntityScan base packages**

Solution

Explicit **@EntityScan** in the consuming applicatio

```
@EntityScan(basePackages = {
        "com.dxu.sso.common.model",       // 👈 include shared Course entity
        "com.dxu.sso.course.query.model"  // if you have your own entities
})
```

3.4.3.2.3 Sopped Loading Configurations from course-config-server

> **Reason**: Did not delete **application.properties** of common-lib which **interferes with the actual microservice's identity** during startup. This confuses the config client, which tries to fetch configuration for the wrong service name.

Solution

Delete **application.properties** for common-lib, or remove property **spring.application.name** in it

3.4.3.2.4 Aspect is not triggered

The following aspect is not triggered:

```
@RequireUserProfile
@GetMapping
public ResponseEntity<List<Course>> findCourses(@AuthenticationPrincipal Jwt jwt) { ... }
```

> **Reason**: The method is in a @RestController, not a @Service
>
> Spring AOP by default only proxies **Spring beans**, and only if:
>
> - The bean is **injected through Spring**
> - The call is made **through the proxy** (i.e. external call, not self-call)
> - The aspect is set up correctly

Solution

Enable **proxyTargetClass** mode

```java
@SpringBootApplication
@EnableAspectJAutoProxy(proxyTargetClass = true)
@EntityScan(basePackages = {
        "com.dxu.sso.common.model.course",   // 👈 include shared Course entity
        "com.dxu.sso.course.query.model"  // if you have your own entities
})
@ComponentScan(basePackages = {
        "com.dxu.sso.course.query",
        "com.dxu.sso.common"           // shared library "common-lib"
})
public class CourseQuerySvcApplication {

    public static void main(String[] args) {
        SpringApplication.run(CourseQuerySvcApplication.class, args);
    }

}
```

3.4.3.2.5 JPA N+1 query problem

For the following entities definitions, there is JPA N+1 query problem because, by default, JPA lazily loads the collection, resulting in:

- 1 query to fetch all courses
- 1 separate query per course to fetch enrolledStudentIds from course_enrollment

```
@Entity
@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
@Table(name = "course", schema = "ssocourse", uniqueConstraints = {
        @UniqueConstraint(columnNames = "name")
})
public class Course {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    private String name;
    private String description;
    private LocalDate startDate;
    private LocalDate endDate;

    @JoinColumn(name = "teacher_id")
    private Long teacherId;    // FK reference to AppUser.id (role=TEACHER)

    @ElementCollection
    @CollectionTable(name = "course_enrollment", schema = "ssocourse", joinColumns = @JoinColumn(name =
"course_id"))
    @Column(name = "student_id")
    private List<Long> enrolledStudentIds = new ArrayList<>();
}

@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
@Entity
@Table(name = "course_enrollment", schema = "ssocourse")
public class CourseEnrollment {

    @EmbeddedId
    private CourseEnrollmentId id;

    @Column(name = "created_at")
    private LocalDateTime createdAt = LocalDateTime.now();
}

@Embeddable
public class CourseEnrollmentId implements Serializable {

    @Column(name = "course_id")
    private Long courseId;

    @Column(name = "student_id")
    private Long studentId;
}
```

Solution:

Replace **@ElementCollection** with an explicit **@OneToMany** relationship in **Course.java**

```
    @OneToMany(mappedBy = "course", cascade = CascadeType.ALL, orphanRemoval = true)
    private List<CourseEnrollment> enrollments = new ArrayList<>();
```

Updated **CourseEnrollment.java**

```
@Entity
@Table(name = "course_enrollment", schema = "ssocourse")
public class CourseEnrollment {

    @EmbeddedId
    private CourseEnrollmentId id;

    @ManyToOne(fetch = FetchType.LAZY)
    @MapsId("courseId") // Maps to embedded ID field
    @JoinColumn(name = "course_id")
    private Course course;

    @Column(name = "created_at")
    private LocalDateTime createdAt = LocalDateTime.now();

    public Long getStudentId() {
        return id != null ? id.getStudentId() : null;
    }
}
```

Add **findAllWithEnrollments** query in the **CourseRepository**:

```
@Repository
public interface CourseRepository extends JpaRepository<Course, Long>  {

    @Query("SELECT c FROM Course c LEFT JOIN FETCH c.enrollments")
    List<Course> findAllWithEnrollments();
}
```

Revise CourseService.**updateCourse**()

```
    public CourseDetailsDto updateCourse(Long id, CourseSaveRequest request) {
        Course course = courseRepository.findById(id)
                .orElseThrow(() -> new SsoApplicationException(HttpStatus.BAD_REQUEST.value(), "Course not
found"));

        course.setName(request.getName());
        course.setDescription(request.getDescription());
        course.setStartDate(request.getStartDate());
        course.setEndDate(request.getEndDate());
        course.setTeacherId(request.getTeacherId());

        // 💥 Rebuild enrollment list
        List<CourseEnrollment> newEnrollments = request.getEnrolledStudentIds() != null
                ? request.getEnrolledStudentIds().stream()
                .map(studentId -> CourseEnrollment.builder()
                        .id(new CourseEnrollmentId(course.getId(), studentId))
                        .course(course)
                        .build())
                .toList()
                : new ArrayList<>();

        // ⚠️ Clear and replace enrollments
        course.getEnrollments().clear();
        course.getEnrollments().addAll(newEnrollments);

        Course updated = courseRepository.save(course);
        return getCourseDetails(updated);
    }
```

3.4.4. Best Practices for Shared Libraries like common-lib

- ❌ **Do not include application.properties or application.yml in common-lib**
    - Even empty files can override parent config
- ✅ Move all configuration to the microservices or external config repo
- ✅ Use @Value, @ConfigurationProperties, or @EnableConfigurationProperties in common-lib to read properties — **but define the values externally** (in the consuming service)
- ❌ **Do not share entities across services** unless they use the same schema.

3.5 Kafka Integration

3.5.1 Overview

To support decoupled communication between services and ensure eventual consistency, we integrate Apache Kafka into our course management system for two key scenarios:

First, when a course application is approved in course-application-svc, a **CourseApplicationApprovedEvent** is published to Kafka.

- This event is consumed by course-management-svc to automatically create a course enrollment record, avoiding direct service-to-service calls.

Second, implement a **Saga pattern** using Kafka to coordinate the **deletion of a student** across multiple microservices.

- This involves **publishing** and **handling** a series of events to update the **app_user**, **course_enrollment**, and **course_application** tables. If any step in the sequence fails, compensating actions are triggered to **roll back** changes, ensuring system-wide data **consistency**.

3.5.2 Integration Implementation

3.5.2.1 Set Up Kafka

See Introduction to Kafka with Spring Boot

3.5.2.2 Integrate Kafka

> ⚠ In the following configuration for Kafka, it is using the IP address of your WSL instance instead of "localhost", because the Kafka is installed under WSL2 which needs special handling.
> See Introduction to Kafka with Spring BootType your warning message here.

3.5.2.2.1 Event on Course Application Approval

Use case

1. course-application-svc (**Producer**)

- When a student’s course **application** is **approved**
- Creates and sends a **CourseApplicationApprovedEvent** to topic **course-application-approved**

2. Kafka (**Message Broker**)

- Stores the event in a **topic** named course-application-approved
- Keeps it until it's consumed (and optionally even after)

3. course-management-svc (**Consumer**)

- **Listens** to that topic
- When it sees a new approved application, it inserts a record into course_enrollment

✅ This decouples the two services:

- They don’t need to call each other directly
- If one is down, the event is still stored and processed later

Implementation

✅Step 1: Add Kafka Dependencies

In both services (course-application-svc and course-management-svc):

```xml
<dependency>
  <groupId>org.springframework.kafka</groupId>
  <artifactId>spring-kafka</artifactId>
</dependency>
```

✅ Step 2: Define the Kafka Event Payload

In common-lib

```java
@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
public class CourseApplicationApprovedEvent {
    private Long courseId;
    private Long studentId;
    private LocalDateTime approvedAt;
}
```

✅ Step 3: Kafka Producer in course-application-svc

course-application-svc.yml: **with retry configurations**

```yaml
  kafka:
    bootstrap-servers: localhost:9092
    producer:
      key-serializer: org.apache.kafka.common.serialization.StringSerializer
      value-serializer: org.springframework.kafka.support.serializer.JsonSerializer
      retries: 3
      retry-backoff-ms: 1000
```

KafkaProducerService.java

```
public class KafkaProducerService {

    private final KafkaTemplate<String, CourseApplicationApprovedEvent> kafkaTemplate;

    private static final String TOPIC = "course-application-approved";

    public void sendApplicationApprovedEvent(CourseApplicationApprovedEvent event) {
        log.info("send application approved event. course: {} student: {}", event.getCourseId(),
event.getStudentId());
        kafkaTemplate.send(TOPIC, event);
    }
}
```

Register **KafkaTemplate** Bean

```
@Configuration
public class KafkaProducerConfig {
    @Bean
    public KafkaTemplate<String, CourseApplicationApprovedEvent> kafkaTemplate(
            ProducerFactory<String, CourseApplicationApprovedEvent> producerFactory) {
        return new KafkaTemplate<>(producerFactory);
    }
}
```

✅ Step 4: Emit Event on Approval

Update **CourseApplicationService** in **decide()** method

```
        if (approve) {
            sendApprovedEvent(savedApp);
        }

    private void sendApprovedEvent(CourseApplicationDto savedApp) {
        CourseApplicationApprovedEvent event = CourseApplicationApprovedEvent.builder()
                .courseId(savedApp.getCourseId())
                .studentId(savedApp.getStudentId())
                .approvedAt(LocalDateTime.now())
                .build();

        kafkaProducerService.sendApplicationApprovedEvent(event);
    }
```

✅ Step 5: Kafka Consumer in course-management-svc

course-management-svc.yml

```
  kafka:
    bootstrap-servers: localhost:9092
    consumer:
      group-id: course-management-group
      key-deserializer: org.apache.kafka.common.serialization.StringDeserializer
      value-deserializer: org.springframework.kafka.support.serializer.JsonDeserializer
      properties:
        spring.json.trusted.packages: "*"
    listener:
      missing-topics-fatal: false
```

KafkaConsumerService.java

```
@Component
@RequiredArgsConstructor
public class KafkaConsumerService {

    private final CourseEnrollmentService enrollmentService;

    @KafkaListener(topics = "course-application-approved", groupId = "course-management-group")
    public void consumeApplicationApproved(CourseApplicationApprovedEvent event) {
        enrollmentService.enrollStudent(event.getCourseId(), event.getStudentId());
    }
}
```

✅ Step 6: CourseEnrollmentService in course-management-svc

> Please note it has to set "course" for CourseEnrollment. Here we use courseRepository.getReferenceById(courseId)

```java
public class CourseEnrollmentService {

    private final CourseRepository courseRepository;
    private final CourseEnrollmentRepository courseEnrollmentRepository;

    @Transactional
    public void enrollStudent(Long courseId, Long studentId) {
        log.info("enroll student {} to course {}", studentId, courseId);

        // Do nothing if the course enrollment exists
        CourseEnrollmentId enrollmentId = new CourseEnrollmentId(courseId, studentId);
        boolean alreadyEnrolled = courseEnrollmentRepository.existsById(enrollmentId);
        if (alreadyEnrolled) {
            log.info("Student {} already enrolled in course {}", studentId, courseId);
            return;
        }

        Course courseRef = courseRepository.getReferenceById(courseId);
        // Create course enrollment
        CourseEnrollment enrollment = CourseEnrollment.builder()
                .id(new CourseEnrollmentId(courseId, studentId))
                .course(courseRef)
                .createdAt(LocalDateTime.now())
                .build();

        courseEnrollmentRepository.save(enrollment);
    }
}
```

Step 7: Kafka Listener Retry with Exponential Backoff

Spring Kafka supports retry with exponential backoff via @KafkaListener and a DefaultErrorHandler

course-management-svc.yml

```yaml
custom:
  kafka:
    retry:
      initial-delay: 1000       # in milliseconds
      multiplier: 2.0
      max-delay: 10000          # in milliseconds
      max-attempts: 3
```

```java
@Configuration
public class KafkaConsumerConfig {

    private final KafkaRetryProperties retryProperties;

    @Bean
    public DefaultErrorHandler errorHandler() {
        // Backoff with initial delay 1s, multiplier 2x, max delay 10s, max attempts 3
        ExponentialBackOffWithMaxRetries backoff =
                new ExponentialBackOffWithMaxRetries(retryProperties.getMaxAttempts());
        backoff.setInitialInterval(retryProperties.getInitialDelay());
        backoff.setMultiplier(retryProperties.getMultiplier());
        backoff.setMaxInterval(retryProperties.getMaxDelay());

        DefaultErrorHandler errorHandler = new DefaultErrorHandler(backoff);

        // Log the exception
        errorHandler.setRetryListeners((record, ex, deliveryAttempt) -> {
            log.warn("❌ Retry {} for record: {}", deliveryAttempt, record, ex);
        });

        return errorHandler;
    }

    /**
     * registers a custom Kafka listener container factory that tells Spring Kafka to:
     *   - Use your consumerFactory to build consumers
     *   - Use your DefaultErrorHandler (with retries + DLT logic)
     */
    @Bean
    public ConcurrentKafkaListenerContainerFactory<?, ?> kafkaListenerContainerFactory(
            ConsumerFactory<Object, Object> consumerFactory,
            DefaultErrorHandler errorHandler) {

        ConcurrentKafkaListenerContainerFactory<Object, Object> factory =
                new ConcurrentKafkaListenerContainerFactory<>();
        factory.setConsumerFactory(consumerFactory);
        factory.setCommonErrorHandler(errorHandler);
        return factory;
    }
}
```

Step 8: Add a Dead Letter Topic (DLT) for messages that fail even after all retries

✅ **1. common-lib**: Define **Event Classes** (shared module)

CourseApplicationApprovedEvent.java (Existing)

`CourseApplicationApprovedDLTMessage.java`

```
@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
public class CourseApplicationApprovedDLTMessage {
    private CourseApplicationApprovedEvent originalEvent;
    private String errorMessage;
    private String stackTrace;
}
```

✅ 2. Producer Side: course-application-svc

Update **KafkaProducerService.java**: Add "key" parameter for method "send" call

✅ 3. Consumer Side: course-management-svc

Add below to **course-management-svc.yml**

```
    listener:
      missing-topics-fatal: false
# This prevents the consumer app from crashing on startup if a Kafka topic doesn’t exist yet (e.g., in local/dev environments).
#It allows Spring Boot to continue running while Kafka topics get created dynamically or manually later.
```

Update above **KafkaConfig.java**

```
@Slf4j
@RequiredArgsConstructor
@Configuration
public class KafkaConfig {

    private final KafkaRetryProperties retryProperties;

    @Bean
    public DefaultErrorHandler errorHandler(
            @Qualifier("dltKafkaTemplate") KafkaTemplate<String, CourseApplicationApprovedDLTMessage>
dltKafkaTemplate) {
        // Backoff with initial delay 1s, multiplier 2x, max delay 10s, max attempts 3
        ExponentialBackOffWithMaxRetries backoff = new
ExponentialBackOffWithMaxRetries(retryProperties.getMaxAttempts());
        backoff.setInitialInterval(retryProperties.getInitialDelay());
        backoff.setMultiplier(retryProperties.getMultiplier());
        backoff.setMaxInterval(retryProperties.getMaxDelay());

        return new DefaultErrorHandler((record, exception) -> {
            log.error("📦 Sending to DLT: {}", exception.getMessage());

            Object value = record.value();
            if (value instanceof CourseApplicationApprovedEvent originalEvent) {
                CourseApplicationApprovedDLTMessage dltMessage =
CourseApplicationApprovedDLTMessage.builder()
                        .originalEvent(originalEvent)
                        .errorMessage(exception.getMessage())
                        .stackTrace(Arrays.toString(exception.getStackTrace()))
                        .build();
                dltKafkaTemplate.send("course-application-approved-dlt", (String)record.key(),
dltMessage);
            } else {
                log.warn("⚠️ Unrecognized message. Skipping DLT fallback.");
            }
        }, backoff);
    }

    /**
     * registers a custom Kafka listener container factory that tells Spring Kafka to:
     *  - Use your consumerFactory to build consumers
     *  - Use your DefaultErrorHandler (with retries + DLT logic)
     */
    @Bean
    public ConcurrentKafkaListenerContainerFactory<?, ?> kafkaListenerContainerFactory(
            ConsumerFactory<Object, Object> consumerFactory,
            DefaultErrorHandler errorHandler) {

        ConcurrentKafkaListenerContainerFactory<Object, Object> factory =
                new ConcurrentKafkaListenerContainerFactory<>();
        factory.setConsumerFactory(consumerFactory);
        factory.setCommonErrorHandler(errorHandler);
        return factory;
    }

    // ✅ Producer Factory for DLT messages
    @Bean
    public ProducerFactory<String, CourseApplicationApprovedDLTMessage> dltProducerFactory(
            @Value("${spring.kafka.bootstrap-servers}") String bootstrapServers) {

        Map<String, Object> configProps = new HashMap<>();
        configProps.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, bootstrapServers);
        configProps.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
        configProps.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, JsonSerializer.class);

        return new DefaultKafkaProducerFactory<>(configProps);
    }

    // ✅ Producer Factory for generic Object messages
    @Bean
    public ProducerFactory<String, Object> producerFactory(
            @Value("${spring.kafka.bootstrap-servers}") String bootstrapServers) {
        Map<String, Object> configProps = new HashMap<>();
        configProps.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, bootstrapServers);
        configProps.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, StringSerializer.class);
        configProps.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, JsonSerializer.class);
        return new DefaultKafkaProducerFactory<>(configProps);
    }

    /**
     * Shared KafkaTemplate for sending normal messages
     */
    @Bean
    public KafkaTemplate<String, Object> kafkaTemplate(
            ProducerFactory<String, Object> factory) {
        return new KafkaTemplate<>(factory);
    }

    /**
     * Dedicated KafkaTemplate for sending DLT messages
     */
    @Bean
    public KafkaTemplate<String, CourseApplicationApprovedDLTMessage> dltKafkaTemplate(
            ProducerFactory<String, CourseApplicationApprovedDLTMessage> dltProducerFactory) {
        return new KafkaTemplate<>(dltProducerFactory);
    }
}
```

Add/Update Kafka Listeners in KafkaConsumerService

```
@Slf4j
@Component
@RequiredArgsConstructor
public class KafkaConsumerService {

    private final CourseEnrollmentService enrollmentService;

    /**
     * containerFactory = "kafkaListenerContainerFactory" annotation tells Spring explicitly to use the
factory we
     * just defined (kafkaListenerContainerFactory) in KafkaConsumerConfig instead of the default one.
     * It ensures that the consumer uses:
     *  - Your retry/backoff configuration
     *  - The DLT error handler
     */
    @KafkaListener(
            topics = "course-application-approved",
            groupId = "course-management-group",
            containerFactory = "kafkaListenerContainerFactory"
    )
    public void consumeApplicationApproved(CourseApplicationApprovedEvent event) {
            log.info("consume application approved event: course: {} student: {}", event.getCourseId(),
event.getStudentId());
            enrollmentService.enrollStudent(event.getCourseId(), event.getStudentId());
    }

    @KafkaListener(topics = "course-application-approved-dlt", groupId = "dlt-monitor-group")
    public void handleDLT(CourseApplicationApprovedDLTMessage dltMessage) {
        log.error("🚨 DLT message received: {}\nError: {}\nStack Trace:\n{}",
                dltMessage.getOriginalEvent(),
                dltMessage.getErrorMessage(),
                dltMessage.getStackTrace());
    }
}
```

3.5.2.2.2 Implement Saga Pattern

4. Front End Implementation

4.1 Single Frontend Application

4.1.1 Create Angular Application course-app

4.1.1.1 Create Angular 19 App and Install Dependencies

```
npm install @angular/cli@19.0.1

ng new course-app --standalone --routing --style=scss

npm install @angular/material @angular/cdk bootstrap
```

angular.json

```
"styles": [
  "node_modules/bootstrap/dist/css/bootstrap.min.css",
  "node_modules/@angular/material/prebuilt-themes/indigo-pink.css",
  "src/styles.scss"
]
```

main.ts

```
import { bootstrapApplication } from '@angular/platform-browser';
import { appConfig } from './app/app.config';
import { AppComponent } from './app/app.component';

bootstrapApplication(AppComponent, appConfig)
  .catch((err) => console.error(err));
```

app.config.ts

```
import { ApplicationConfig, importProvidersFrom, provideZoneChangeDetection } from '@angular/core';
import { provideRouter } from '@angular/router';
import { HTTP_INTERCEPTORS, provideHttpClient, withInterceptorsFromDi } from '@angular/common/http';
import { BrowserAnimationsModule, provideAnimations } from '@angular/platform-browser/animations';
import { MatSnackBarModule } from '@angular/material/snack-bar';

import { routes } from './app.routes';
import { AppInterceptor } from './shared/core/app.interceptor';
import { DateFormatProvider } from './shared/core/date-format.provider';
import { MatNativeDateModule } from '@angular/material/core';

export const appConfig: ApplicationConfig = {
  providers: [
    provideZoneChangeDetection({ eventCoalescing: true }),
    provideHttpClient(withInterceptorsFromDi()), // ✅ This fixes HttpClient injection
    provideRouter(routes),
    {
      provide: HTTP_INTERCEPTORS,
      useClass: AppInterceptor,
      multi: true
    },
    importProvidersFrom(
      BrowserAnimationsModule,
      MatSnackBarModule
    ,
    provideRouter(routes),
    provideAnimations(),
    importProvidersFrom(MatNativeDateModule),     // For Date format
    DateFormatProvider    // For Date format
  ],
};
```

4.1.1.2 Initialize Components

```
ng generate component layout/header --standalone
ng generate component dashboard --standalone
ng generate component user/user-profile --standalone
ng generate component user/user-list --standalone
ng generate component course/course-list --standalone
ng generate component course/course-details --standalone
```

app.routes.ts

```
export const routes: Routes = [
  { path: '', component: DashboardComponent },
  // { path: 'profile', loadComponent: () => import('./user/user-profile/user-profile.component').then(m
=> m.UserProfileComponent), canActivate: [AuthGuard] },
  { path: 'profile', component: UserProfileComponent, canActivate: [ AuthGuard ] },
  { path: 'admin/users', component: UserListComponent, canActivate: [ AuthGuard, RoleGurad ], data: {
roles: ['ADMIN']} },
  { path: 'admin/users/:id', component: UserProfileComponent, canActivate: [ AuthGuard, RoleGurad ], data:
{ roles: ['ADMIN', "TEACHER"]} },
  { path: 'courses', component: CourseListComponent, canActivate: [ AuthGuard ] },
  { path: 'courses/manage', component: CourseDetailsComponent, canActivate: [ AuthGuard, RoleGurad ],
data: { roles: ['ADMIN']} }
];
```

app.componen

```
@Component({
  selector: 'app-root',
  standalone: true,
  imports: [RouterModule, HeaderComponent],
  template: `
    <app-header></app-header>
    <div class="container mt-4">
      <router-outlet></router-outlet>
    </div>
  `
})
export class AppComponent {}
```

4.1.1.3 Implement Others

header.component

```
export const LOGIN_URL = `${environment.userBackendHost}/oauth2/authorization/user-app`;
export class HeaderComponent {

  logoutUrl: string = `${environment.userBackendHost}/logout`

  constructor(private authService: AuthService) {}

  isAuthenticated() {
    return !!this.authService.profile;
  }

  isAdmin() {
    return this.authService.profile?.role === Role.ADMIN;
  }

  login(): void {
    window.location.href = LOGIN_URL;
  }

  logout(): void {
    const form = document.getElementById('logoutForm') as HTMLFormElement;
    form?.submit(); // ✅ Spring handles the logout, redirect, and session invalidation
  }
}
```

```
<nav class="navbar navbar-expand-lg navbar-dark bg-primary">
  <div class="container-fluid">
    <a class="navbar-brand" routerLink="/">Course Management</a>

    <div class="d-flex ms-auto" *ngIf="isAuthenticated(); else guest">
      <a class="btn btn-light btn-sm me-2" routerLink="/profile">My Profile</a>

      <!-- Role-based options (ADMIN / TEACHER / STUDENT) -->
      <a class="btn btn-warning btn-sm me-2" *ngIf="isAdmin()" routerLink="/admin/users">Admin</a>
      <a class="btn btn-light btn-sm me-2" routerLink="/courses">Courses</a>

      <!-- ✅ Logout button -->
      <button class="btn btn-outline-light btn-sm" (click)="logout()">Logout</button>

      <!-- ✅ Hidden logout form -->
      <form id="logoutForm" method="POST" action="{{logoutUrl}}" style="display: none;"></form>
    </div>

    <ng-template #guest>
      <button class="btn btn-outline-light btn-sm" (click)="login()">Login</button>
    </ng-template>
  </div>
</nav>
```

profile.service.ts

```
  getProfile(): Observable<any> {
    return this.http.get<any>(URL_PROFILE, { withCredentials: true });
  }

  createProfile(): Observable<any> {
    return this.http.post<any>(URL_PROFILE, null, { withCredentials: true });
  }

  updateProfile(user: UserForm): Observable<any> {
    return this.http.put<UserForm>(URL_PROFILE, user, { withCredentials: true });
  }
```

auth.service.ts

```
export class AuthService {

  private authenticated = new BehaviorSubject<boolean>(false);
  public isAuthenticated$ = this.authenticated.asObservable();

  private _profile: any = null;

  public get profile() {
    return this._profile;
  }

  constructor(private profileService: ProfileService, private router: Router) {
  }

  checkAuthentication(): void {
    this.profileService.getProfile().subscribe({
      next: (user) => {
        this._profile = user;
        this.authenticated.next(true);
      },
      error: (error: HttpErrorResponse) => {
        if (error.status === 404) {
          // Profile not found → try creating it
          this.profileService.createProfile().subscribe({
            next: (createdUser) => {
              this._profile = createdUser;
              this.authenticated.next(true);
              this.router.navigate(['/']); // redirect to home after profile creation
            },
            error: (err) => {
              this._profile = null;
              this.authenticated.next(false);
              console.error('❌ Failed to create profile', err);
              this.router.navigate(['/']); // still redirect to home
            }
          });
        } else {
          this._profile = null;
          this.authenticated.next(false);
          console.error('❌ Failed to load profile', error);
        }
      }
    });
  }
}
```

auth.guard.ts

```
export const AuthGuard: CanActivateFn = () => {
  const authService = inject(AuthService);

  return authService.isAuthenticated$.pipe(
    map(isAuth => {
      if (!isAuth) {
        window.location.href = LOGIN_URL;
        return false;
      }
      return true;
    })

};
```

role.guard.ts

```
export const RoleGurad: CanActivateFn = (route, state) => {
  const authService = inject(AuthService);
  const router = inject(Router);
  const snackBar = inject(MatSnackBar);

  const allowedRoles: string[] = route.data['roles'] || [];
  const userRole = authService.profile?.role;

  if (!userRole || !allowedRoles.includes(userRole)) {
    snackBar.open('🚫 You are not authorized to access this page.', 'Dismiss', {
      duration: 5000,
      verticalPosition: 'top',
      panelClass: 'mat-mdc-snack-bar-warn'
    });

    router.navigate(['/']);
    return false;
  }

  return true;
}
```

app.interceptor.ts

```
@Injectable()
export class AppInterceptor implements HttpInterceptor {
  private snackBar = inject(MatSnackBar);
  private router = inject(Router);

  intercept(req: HttpRequest<any>, next: HttpHandler): Observable<HttpEvent<any>> {
    return next.handle(req).pipe(
      catchError((error: HttpErrorResponse) => {
        if (error.status === 401) {
          // ✅ This for logged in user who does not have profile
          this.snackBar.open('🚫 You do not have profile on our site.', 'Dismiss', {
            duration: 5000,
            verticalPosition: 'top',
            panelClass: 'mat-mdc-snack-bar-warn'
          });
          // ✅ No profile. Go to dashboard page
          this.router.navigate(['']);
        } else if (error.status === 403) {
          // ✅ Not authorized – show snackbar
          this.snackBar.open('🚫 You are not authorized to access this resource.', 'Dismiss', {
            duration: 5000,
            verticalPosition: 'top',
            panelClass: 'mat-mdc-snack-bar-warn'
          });
          // ✅ No profile. Go to dashboard page
          this.router.navigate(['']);
        }

        return throwError(() => error);
      })

  }
}
```

user-profile.component (Shared by profile and admin)

```
export class UserProfileComponent implements OnInit, OnDestroy {

  private route = inject(ActivatedRoute);
  private router = inject(Router);
  private profileService = inject(ProfileService);
  private adminService = inject(UserAdminService);
  private notification = inject(NotificationService);
  private dateAdapter = inject(DateAdapter<Date>);

  private destroy$ = new Subject<void>();
  private profileData: any;

  userId?: number;
  isEditMode: boolean = false;

  form!: FormGroup;

  ngOnInit(): void {
    this.dateAdapter.setLocale('en-CA'); // ensures yyyy-MM-dd format

    this.userId = Number(this.route.snapshot.paramMap.get('id'));
    this.route.paramMap.subscribe(params => {
      const id = params.get('id');
      if (id) {
        // Fetch user's profile by admin
        this.loadUser(+id);
      } else {
        // Load self profile
        this.loadSelf();
      }
    });
  }

  loadUser(id: number): void {
    this.adminService.getUserById(id)
      .pipe(takeUntil(this.destroy$))
      .subscribe({
        next: user => {
          this.profileData = user;
          this.form = new User(user).toForm();
        },
        error: () => {
          this.notification.error('Failed to load user information');
          this.router.navigate(['/admin/users']);
        }
      });
  }

  loadSelf(): void {
    this.profileService.getProfile()
      .pipe(takeUntil(this.destroy$))
      .subscribe({
        next: profile => {
          this.profileData = profile;
          this.form = new User(profile).toForm();
        },
        error: () => {
          this.notification.error('Failed to load profile');
          this.router.navigate(['/admin/users']);
        }
      });
  }

  submit(): void {
    this.form.markAllAsTouched();
    if (this.form.valid) {
      const profile = new User().toModel(this.form);
      const payload = {
        ...profile,
        dateOfBirth: profile.dateOfBirth ? format(profile.dateOfBirth, 'yyyy-MM-dd') : null
      };

      if (this.userId) {
        this.adminService.updateUserByAdmin(this.userId, payload).subscribe({
          next: profile => {
            this.profileData = profile;
            this.toggleEdit();
            this.notification.success('User information updated successfully');
          },
          error: err => this.notification.error('Failed to update profile')
        })
      } else {
        this.profileService.updateProfile(payload).subscribe({
          next: profile => {
            this.profileData = profile;
            this.toggleEdit();
            this.notification.success('Profile updated successfully');
          },
          error: err => this.notification.error('Failed to update profile')
        })
      }
    }
  }

  toggleEdit() {
    if (this.isEditMode) {
      this.form = new User(this.profileData).toForm();
    }
    this.isEditMode = !this.isEditMode;
  }

  cancelEdit() {
    this.form.markAsPristine();
    this.isEditMode = false;
    this.form.patchValue(this.profileData); // Restore previous values
  }

  ngOnDestroy(): void {
    this.destroy$.next();
    this.destroy$.complete();
  }
```

```
<div class="container mt-4">
  <h2 class="mb-4">User Profile</h2>

  <div *ngIf="!isEditMode">
    <div class="row mb-3">
      <div class="col-md-12 mt-2"><strong>OKTA ID:</strong> {{ oktaUserId?.value }}</div>
      <div class="col-md-6 mt-2"><strong>First Name:</strong> {{ firstName?.value }}</div>
      <div class="col-md-6 mt-2"><strong>Last Name:</strong> {{ lastName?.value }}</div>
      <div class="col-md-6 mt-2"><strong>Email:</strong> {{ email?.value }}</div>
      <div class="col-md-6 mt-2"><strong>Date of Birth:</strong> {{ dateOfBirth?.value | date:'yyyy-MM-dd'
}}</div>
      <div class="col-md-6 mt-2"><strong>Gender:</strong>
         <ng-container [ngSwitch]="gender?.value">
            <span *ngSwitchCase="'M'">Male</span>
            <span *ngSwitchCase="'F'">Female</span>
            <span *ngSwitchDefault>Other</span>
          </ng-container>
        </div>
      <div class="col-md-6 mt-2 mb-2  "><strong>Role:</strong> {{ role?.value }}</div>
    </div>
    <button mat-raised-button color="primary" (click)="toggleEdit()">Edit</button>
  </div>

  <form *ngIf="isEditMode" [formGroup]="form" (ngSubmit)="submit()" class="row g-3">
    <div class="col-md-6">
      <mat-form-field appearance="outline" class="w-100">
        <mat-label>First Name</mat-label>
        <input matInput formControlName="firstName" required />
        <mat-error *ngIf="form.get('firstName')?.hasError('required')">First Name is required</mat-error>
      </mat-form-field>
    </div>

    <div class="col-md-6">
      <mat-form-field appearance="outline" class="w-100">
        <mat-label>Last Name</mat-label>
        <input matInput formControlName="lastName" required />
        <mat-error *ngIf="form.get('lastName')?.hasError('required')">Last Name is required</mat-error>
      </mat-form-field>
    </div>

    <div class="col-md-6">
      <mat-form-field appearance="outline" class="w-100">
        <mat-label>Email</mat-label>
        <input matInput formControlName="email" required />
        <mat-error *ngIf="form.get('email')?.hasError('required')">Email is required</mat-error>
      </mat-form-field>
    </div>

    <div class="col-md-6">
      <mat-form-field appearance="outline" class="w-100">
        <mat-label>Date of Birth</mat-label>
        <input matInput [matDatepicker]="picker" formControlName="dateOfBirth">
        <mat-datepicker-toggle matSuffix [for]="picker"></mat-datepicker-toggle>
        <mat-datepicker #picker></mat-datepicker>
      </mat-form-field>
    </div>

    <div class="col-md-6">
      <mat-form-field appearance="outline" class="w-100">
        <mat-label>Gender</mat-label>
        <mat-select formControlName="gender" required>
```

```
          <mat-option value="M">Male</mat-option>
          <mat-option value="F">Female</mat-option>
          <mat-option value="OTH">Prefer Not to Say</mat-option>
        </mat-select>
        <mat-error *ngIf="form.get('gender')?.hasError('required')">Gender is required</mat-error>
      </mat-form-field>
    </div>

    <div class="col-md-6">
      <mat-form-field appearance="outline" class="w-100">
        <mat-label>Role</mat-label>
        <mat-select formControlName="role" required>
          <mat-option value="NONE">None</mat-option>
          <mat-option value="STUDENT">Student</mat-option>
          <mat-option value="TEACHER">Teacher</mat-option>
          <mat-option value="ADMIN">Admin</mat-option>
        </mat-select>
        <mat-error *ngIf="form.get('role')?.hasError('required')">Role is required</mat-error>
      </mat-form-field>
    </div>

    <div class="col-12 d-flex justify-content-start gap-2">
      <button mat-raised-button color="primary" type="submit" [disabled]="form.invalid">Save</button>
      <button mat-raised-button type="button" (click)="cancelEdit()">Cancel</button>
    </div>
  </form>
</div>
```

Create a service to handling message displaying

```
export class NotificationService {

  constructor(private snackBar: MatSnackBar) {}

  success(message: string): void {
    this.snackBar.open(`✅ ${message}`, 'Dismiss', {
      duration: 3000,
      verticalPosition: 'top',
      panelClass: ['mat-mdc-snack-bar-success']
    });
  }

  error(message: string): void {
    this.snackBar.open(`🚫 ${message}`, 'Dismiss', {
      duration: 5000,
      verticalPosition: 'top',
      panelClass: ['mat-mdc-snack-bar-error']
    });
  }

  warning(message: string): void {
    this.snackBar.open(`⚠️ ${message}`, 'Dismiss', {
      duration: 5000,
      verticalPosition: 'top',
      panelClass: ['mat-mdc-snack-bar-warn']
    });
  }

  info(message: string): void {
    this.snackBar.open(`ℹ️ ${message}`, 'Dismiss', {
      duration: 4000,
      verticalPosition: 'top',
      panelClass: ['mat-mdc-snack-bar-info']
    });
  }
}
```

Handling Date Format Issues

1. Submit in Format of yyyy-MM-dd

Currently the dateOfBirth sent from UI does not match the format required by REST API which is yyyy-MM-dd. Fix it as below

- Install **date-fns**

```
npm i date-fns
```

- Convert in submit()

```
const profile = new UserForm().toModel(this.form);
const payload = {
  ...profile,
  dateOfBirth: profile.dateOfBirth ? format(profile.dateOfBirth, 'yyyy-MM-dd') : null
};
```

2. Display Format in the DatePicker

✅ Step 1: Configure Global Date Format

```
import { MAT_DATE_FORMATS } from '@angular/material/core';

export const APP_DATE_FORMATS = {
  parse: {
    dateInput: 'YYYY-MM-DD',
  },
  display: {
    dateInput: 'YYYY-MM-DD',
    monthYearLabel: 'MMM YYYY',
    dateA11yLabel: 'LL',
    monthYearA11yLabel: 'MMMM YYYY',
  }
};

export const DateFormatProvider = {
  provide: MAT_DATE_FORMATS,
  useValue: APP_DATE_FORMATS,
};
```

✅ Step 2: Register the Provider in app.config.ts

```
export const appConfig: ApplicationConfig = {
  providers: [
    ... ...
    DateFormatProvider
  ],
};
```

3. Wrong Date Displayed in DatePicker

> new Date('yyyy-MM-dd') results in a date that is **one day earlier**
>
> After fetched dateOfBirth from REST API in format yyyy-MM-dd, when use new Date(dateOfBirth), it alwsys results in the date that is one day earlier.

Reason:

When you pass a date string like '2024-10-01' to new Date(), JavaScript interprets it as **midnight UTC** (i.e., 2024-10-01T00:00:00.000Z). Then it converts that to **local time**, which could be **the previous day** if your time zone is behind UTC.

Solution:

Parse the date string using a **library that treats it as a local date**, such as **date-fns**

user-from.model.ts

```
toForm() {
  return new FormGroup({
    ... ...,
    dateOfBirth: new FormControl(this.toDate(this.dateOfBirth), Validators.required)
  })
}

toDate(dateOfBirth: any) {
  if (!dateOfBirth) {
    return null;
  }
  const parts = dateOfBirth.split('-');
  return new Date(+parts[0], +parts[1] - 1, +parts[2]);
}
```

4.2 Separate 2 Front End Applications

4.2.1 Overview

The implementation in 6.1 has only one Angular application which include features for both user management and course management. Now to do the POC of separate FE applications, we are going to split the current Angular application course-ap into to applications:

- user-app: User Management App
  - Configured with own OKTA client Id and redirect URL
  - Redirects to user management dashboard after login, which is the redirect URL on OKTA for User Management App
- course-app: Course Management App
  - Configured with own OKTA client Id and redirect URL
  - Redirects to course management dashboard after login, which is the redirect URL on OKTA for Course Management App
- OKTA
  - Single ORG

Target:

- 2 separately deployed Angular applications
- SSO between apps still works
- Backend cross-app communication still works
- Able to redirect to a specified page in the other application other than default page (Dashboard)

4.2.2. Implementation

4.2.2.1 Front End

Step 1: Create a Workspace with Multiple Projects

The current **course-app** is a **single-project** Angular app, first convert it into a workspace that **supports multiple apps and libraries**.

```
cd D:\workspace\sso-demo\sso-okta-app-authorization\frontend
ng new fe-workspace --create-application=false
cd fe-workspace
```

Add the existing course-app

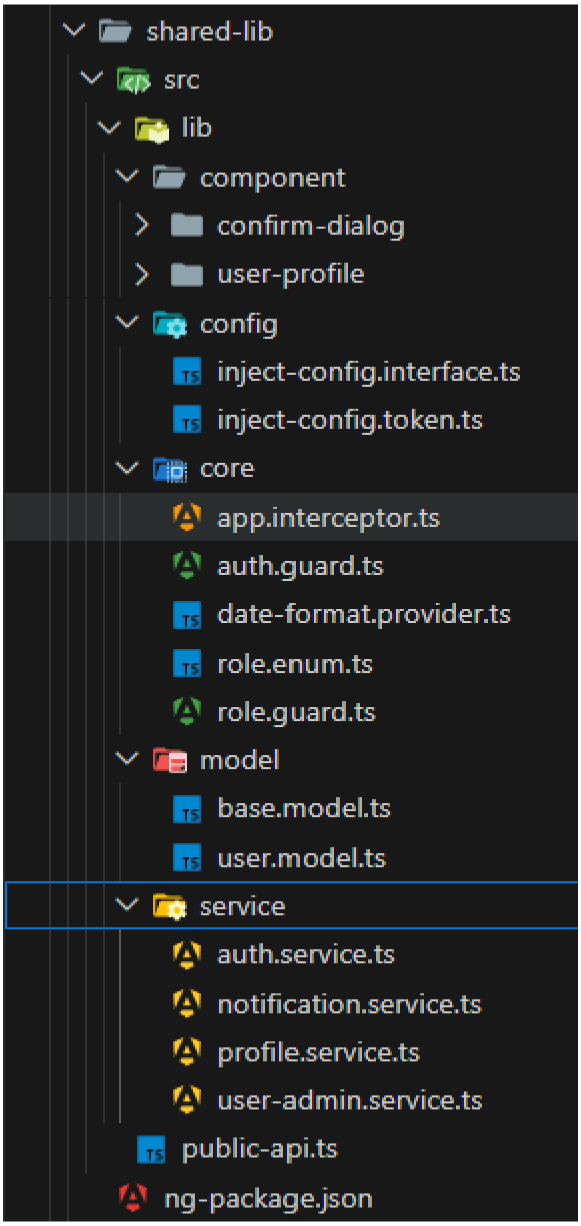
```
ng generate application course-app
```

Step 2: Create user-app and shared-lib

```
ng generate application user-app
ng generate library shared-lib
```

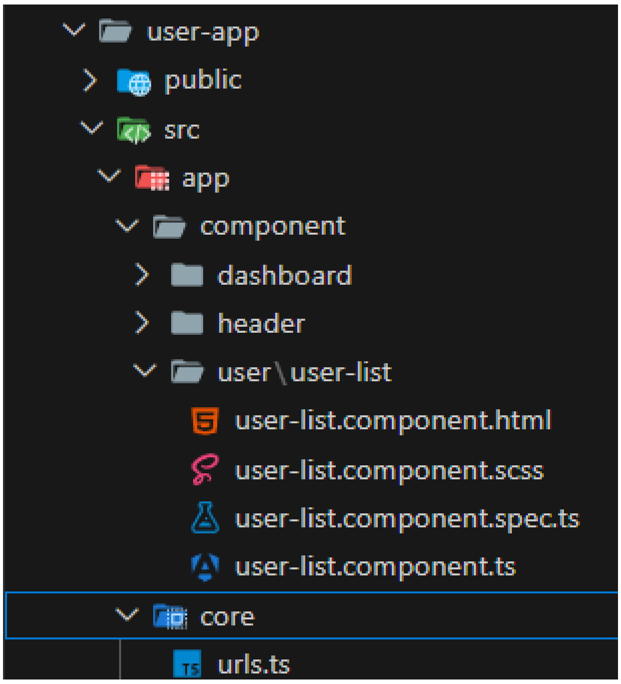
Step 3: Move Shared Code to shared-lib

To update when finalize



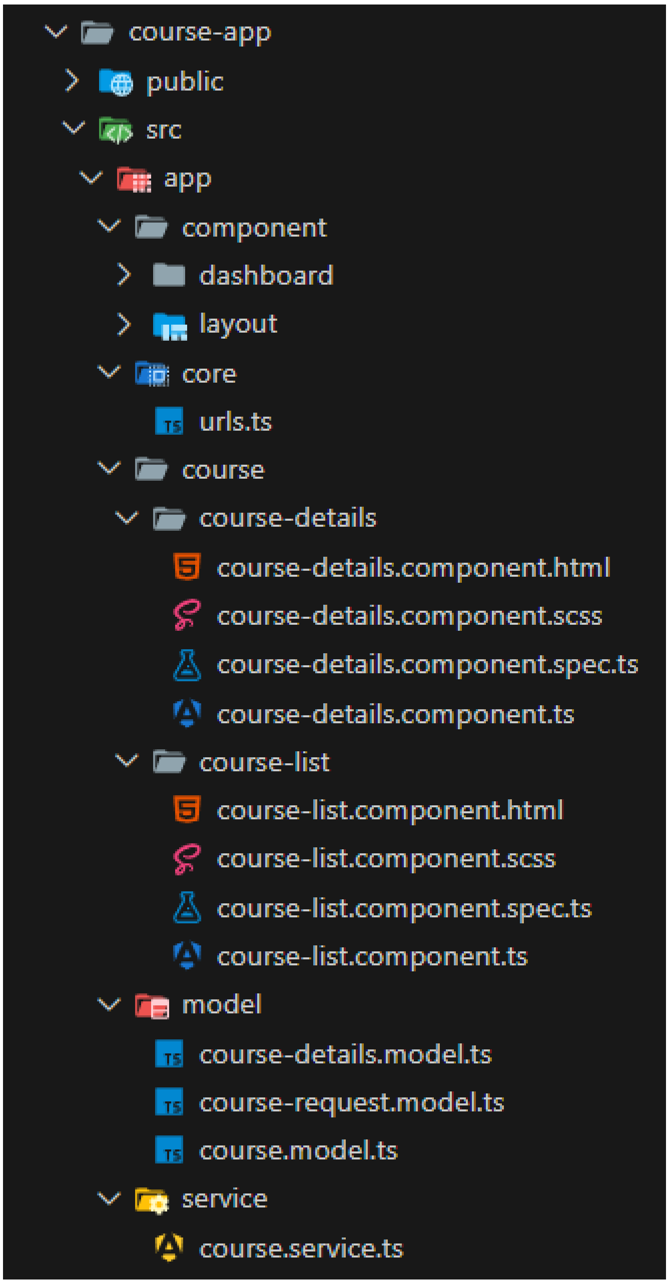
```
shared-lib
  src
    lib
      component
        confirm-dialog
        user-profile
      config
        inject-config.interface.ts
        inject-config.token.ts
      core
        app.interceptor.ts
        auth.guard.ts
        date-format.provider.ts
        role.enum.ts
        role.guard.ts
      model
        base.model.ts
        user.model.ts
      service
        auth.service.ts
        notification.service.ts
        profile.service.ts
        user-admin.service.ts
    public-api.ts
  ng-package.json
```

Step 4: Move User-Related Features to user-app



```
user-app
  public
  src
    app
      component
        dashboard
        header
        user\user-list
          user-list.component.html
          user-list.component.scss
          user-list.component.spec.ts
          user-list.component.ts
      core
        urls.ts
```

Step 5: Move Course-Related Features to course-app



```
course-app
  public
  src
    app
      component
        dashboard
        layout
      core
        urls.ts
      course
        course-details
          course-details.component.html
          course-details.component.scss
          course-details.component.spec.ts
          course-details.component.ts
        course-list
          course-list.component.html
          course-list.component.scss
          course-list.component.spec.ts
          course-list.component.ts
      model
        course-details.model.ts
        course-request.model.ts
        course.model.ts
      service
        course.service.ts
```

Step 6: Import shared-lib in Both Apps

Make sure **fe-workspace/tsconfig.json** includes the path alias for the library:

```
"paths": {
  "shared-lib": ["projects/shared-lib/src/public-api"]
}
```

and **tsconfig.app.json** in both user-app and course-app extends from it:

```
{
  "extends": "../../tsconfig.json",
  ... ...
}
```

Step 7: Import shared-lib in Both Apps

- Ensure both course-app and user-app have **independent routing**
- Each can have its own **proxy.conf.json** to call backend APIs through the gateway

Step 8: External Configuration Injection

1. **Define an Interface for Config Data**

```
export interface SharedLibConfig {
  loginUrl: string;
  profileApiUrl: string;
  usersApiUrl: string;
}
```

2. **Create an Injection Token**

```
import { InjectionToken } from '@angular/core';
import { SharedLibConfig } from './shared-lib-config.interface';

export const SHARED_LIB_CONFIG = new InjectionToken<SharedLibConfig>('SharedLibConfig');
```

3. **Inject It into a Service or Component in the shared-lib, e.g. use it in AuthGuard**

```
import { inject } from '@angular/core';
import { CanActivateFn } from '@angular/router';
import { tap } from 'rxjs/operators';
import { AuthService } from '../service/auth.service';
import { SHARED_LIB_CONFIG } from '../config/shared-lib-config.token';
import { SharedLibConfig } from '../config/shared-lib-config.interface';

export const AuthGuard: CanActivateFn = () => {

  const sharedLibConfig: SharedLibConfig = inject(SHARED_LIB_CONFIG);
  const authService = inject(AuthService);

  return authService.checkAuthentication().pipe(
    tap(isAuthenticated => {
      if (!isAuthenticated) {
        window.location.href = sharedLibConfig.loginUrl;
      }
    })

};
```

4. **Provide It from the Host App**

```
import { routes } from './app.routes';
import { AppInterceptor, DateFormatProvider, SHARED_LIB_CONFIG, SharedLibConfig } from 'shared-lib';
import { URL_LOGIN, URL_PROFILE_API, URL_USERS_API } from './core/urls';

const sharedLibConfig: SharedLibConfig = {
  loginUrl: URL_LOGIN,
  profileApiUrl: URL_PROFILE_API,
  usersApiUrl: URL_USERS_API
}

export const appConfig: ApplicationConfig = {
  providers: [provideZoneChangeDetection({ eventCoalescing: true }),
    provideHttpClient(withInterceptorsFromDi()), // ✅ This fixes HttpClient injection
    ... ...
    // Inject config to the shared lib
    { provide: SHARED_LIB_CONFIG, useValue: sharedLibConfig }
  ]
};
```

Step 9: Ensure Run Auth Check Before Load Page when Switch to Another App

> **Issue**: When switch to a page other than default page in the other application, it always land to default page Dashboard.

✅ What's Happening

When you switch from **user-app** to **course-app**, the following sequence happens:

1. Your browser navigates to http://localhost:4201/courses.
2. Angular app initializes.
3. Angular route guard runs for /courses → uses AuthService.isAuthenticated$.
4. **BUT:** checkAuthentication() hasn't completed yet (or hasn't even started).
5. So the guard treats the user as **unauthenticated** → **redirects to home or dashboard.**
6. Meanwhile, **checkAuthentication**() runs and confirms authentication — but it's **too late**.

✅ Why This Happens

It's calling checkAuthentication() in AppComponent.ngOnInit(), which:

- Is **not guaranteed to complete before routing starts**
- Doesn't synchronously block the route guard

✅ Clean Solution

Modify your AuthGuard to:

- **Call checkAuthentication() directly** inside canActivate() (**see above updated code**)
- Wait for the result (Observable<boolean>

- Only allow navigation **after** the async check finishes

auth.service.ts: change to return Observable<boolean>

```
export class AuthService {

  private authenticated = new BehaviorSubject<boolean>(false);
  public isAuthenticated$ = this.authenticated.asObservable();

  private _profile!: User | null;

  public get profile() {
    return this._profile;
  }

  constructor(private profileService: ProfileService) {}

  private checkInProgress$: Observable<boolean> | null = null;

  checkAuthentication(): Observable<boolean> {
    // ✅ If already authenticated, return true immediately
    if (this.authenticated.value === true) {
      return of(true);
    }

    // ✅ If already checking, return the same observable
    if (this.checkInProgress$) {
      return this.checkInProgress$;
    }

    // 🔄 Otherwise, perform check and cache it
    const check$ = this.profileService.getProfile().pipe(
      tap(user => {
        this._profile = user;
        this.authenticated.next(true);
      }),
      map(() => true),
      catchError((error: HttpErrorResponse) => {
        if (error.status === 404) {
          // Try creating profile
          return this.profileService.createProfile().pipe(
            tap(createdUser => {
              this._profile = createdUser;
              this.authenticated.next(true);
            }),
            map(() => true),
              catchError(err => {
              console.error('❌ Failed to create profile', err);
              this._profile = null;
              this.authenticated.next(false);
              return of(false);
            })

        } else {
          console.error('❌ Failed to load profile', error);
          this._profile = null;
          this.authenticated.next(false);
          return of(false);
        }
      }),
      finalize(() => {
        // 🚫 Clear cache after first run completes
        this.checkInProgress$ = null;
      }),
      shareReplay(1) // 🔁 Reuse the result for all subscribers
    this.checkInProgress$ = check$;
    return check$;
  }
}
```

Call authService.checkAuthentication() manually in header.component

Also, call the REST API "/custome-login/{client}?redirectTo=" for redirecting to specified page

```
  isAuthenticated$ = this.authService.isAuthenticated$;

  ngOnInit(): void {
    this.authService.checkAuthentication()
      .pipe(takeUntil(this.destroy$))
      .subscribe();
  }

  redirectToCourseApp(targetPath: string): string {
    const encodedRedirectTo = encodeURIComponent(targetPath);
    return `http://localhost:9001/custom-login/course-app?redirectTo=${encodedRedirectTo}`;
  }
```

Remove **authService.checkAuthentication()** in app.component.

Step 10: Misc Changes

- Add necessary dependencies in package.json

```
"@angular/cdk": "^19.0.0",
"@angular/material": "^19.2.17",
"bootstrap": "^5.3.6",
"date-fns": "^4.1.0",
```

- Add link resource for icons in index.html of both applications

```
  <link href="https://fonts.googleapis.com/icon?family=Material+Icons" rel="stylesheet" />
```

- export necessary artifacts in public-api.ts

```
/*
 * Public API Surface of shared-lib
 */

export * from './lib/model/base.model';
export * from './lib/model/user.model';

export * from './lib/component/confirm-dialog/confirm-dialog.component';
... ...
```

4.2.2.2 Backend

To support SSO between two **separately hosted Angular apps (on ports 4200 and 4201)** with two **backend OKTA clients (user-app and course-app)**, you must ensure that after logging into user-app (http://localhost:4200), you should be able to access course-app (http://localhost:4201) **without** logging in again — and vice versa.

4.2.2.2.1 Update api-gateway SecurityConfig to support multiple clients

application.xml of **api-gateway**

```
client:
  redirect-url:
    user-app: http://localhost:4200
    course-app: http://localhost:4201
```

SecurityConfig.java

```
@Configuration
@EnableWebFluxSecurity
public class SecurityConfig {

    @Value("${client.redirect-url.user-app:}")
    private String userAppRedirectUrl;

    @Value("${client.redirect-url.course-app:}")
    private String courseAppRedirectUrl;

    @Bean
    public SecurityWebFilterChain springSecurityFilterChain(
            ServerHttpSecurity http,
            ReactiveClientRegistrationRepository clientRegistrationRepository) {

        return http
                .csrf(ServerHttpSecurity.CsrfSpec::disable)
                .cors(cors -> cors.configurationSource(corsConfigurationSource()))
                .authorizeExchange(exchanges -> exchanges
                        .pathMatchers("/actuator/**", "/public/**").permitAll()
                        .anyExchange().authenticated())
                .oauth2Login(login -> login
                        .authenticationSuccessHandler(redirectToAngular())) // redirects to Angular after login
                .logout(logout -> logout
                        .logoutSuccessHandler(oidcLogoutSuccessHandler(clientRegistrationRepository)))
                .build(); // ✅ TokenRelay is configured via application.yml route filters
    }

    private ServerAuthenticationSuccessHandler redirectToAngular() {
        return (exchange, authentication) -> {
            ServerWebExchange webExchange = exchange.getExchange();

            String defaultRedirect = getClientRedirectUrl((OAuth2AuthenticationToken) authentication);

            return webExchange.getSession().flatMap(session -> {
                String redirectTo = (String) session.getAttributes().get("redirectTo");
                log.info("Redirecting to {}", redirectTo);

                // Clear it from session after use
                session.getAttributes().remove("redirectTo");

                String finalRedirect = (redirectTo != null && !redirectTo.isBlank())
                        ? defaultRedirect + redirectTo
                        : defaultRedirect;

                RedirectServerAuthenticationSuccessHandler handler =
                        new RedirectServerAuthenticationSuccessHandler(finalRedirect);

                return handler.onAuthenticationSuccess(exchange, authentication);
            });
        };
    }

    private ServerLogoutSuccessHandler oidcLogoutSuccessHandler(
            ReactiveClientRegistrationRepository clientRegistrationRepository) {

        return (exchange, authentication) -> {
            String redirectUri = getClientRedirectUrl((OAuth2AuthenticationToken) authentication);

            OidcClientInitiatedServerLogoutSuccessHandler handler =
                    new OidcClientInitiatedServerLogoutSuccessHandler(clientRegistrationRepository);
            handler.setPostLogoutRedirectUri(String.valueOf(URI.create(redirectUri)));

            return handler.onLogoutSuccess(exchange, authentication);
        };
    }

    private String getClientRedirectUrl(OAuth2AuthenticationToken authentication) {
        String client = authentication.getAuthorizedClientRegistrationId();

        return switch (client) {
            case "user-app" -> userAppRedirectUrl;
            case "course-app" -> courseAppRedirectUrl;
            default -> userAppRedirectUrl; // fallback
        };
    }

    @Bean
    public UrlBasedCorsConfigurationSource corsConfigurationSource() {
        CorsConfiguration config = new CorsConfiguration();
        config.setAllowedOrigins(List.of("http://localhost:4200", "http://localhost:4201"));
        config.setAllowedMethods(List.of("GET", "POST", "PUT", "DELETE", "OPTIONS"));
        config.setAllowedHeaders(List.of("*"));
        config.setAllowCredentials(true); // ✅ important for cookies/session-based auth

        UrlBasedCorsConfigurationSource source = new UrlBasedCorsConfigurationSource();
        source.registerCorsConfiguration("/**", config);
        return source;
    }
}
```

4.2.2.2.2 Create a Custom Controller to Initiate Login

To reliably capture redirectTo, we should **not use** the default Spring Security endpoint /oauth2/authorization/{registrationId} directly.

Instead, create your own endpoint (e.g. /custom-login/course-app) that:

1. Reads the redirectTo query param,
2. Stores it in the session,
3. Redirects to the real Spring Security OAuth2 login URL (/oauth2/authorization/course-app).

OAuth2LoginController.java

```java
@RestController
@RequestMapping("/custom-login")
public class OAuth2LoginController {

    @GetMapping("/{client}")
    public Mono<Void> loginWithRedirect(@PathVariable String client,
                                        @RequestParam(required = false) String redirectTo,
                                        ServerWebExchange exchange) {
        return exchange.getSession().flatMap(session -> {
            if (redirectTo != null) {
                session.getAttributes().put("redirectTo", redirectTo);
            }

            String loginUri = "/oauth2/authorization/" + client;

            return Mono.defer(() -> {
                exchange.getResponse().setStatusCode(HttpStatus.FOUND);
                exchange.getResponse().getHeaders().setLocation(URI.create(loginUri));
                return exchange.getResponse().setComplete();
            });
        });
    }
}
```

Use This Controller in the Frontend Links

header.component.ts

```typescript
  redirectToCourseApp(targetPath: string): string {
    const encodedRedirectTo = encodeURIComponent(targetPath);
    return `http://localhost:9001/custom-login/course-app?redirectTo=${encodedRedirectTo}`;
  }
```