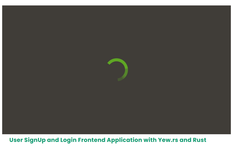
JWT Authentication in Rust using Axum Framework

May 28, 2023 0 Comments 13

Are you interested in building a secure authentication system for your Rust web application? Look no further than the Axum framework and JSON Web Tokens (JWTs)! Axum is a fast and scalable Rust web framework that provides a reliable and efficient platform for developing microservices and APIs.

To keep things simple, we'll implement the JWT using the HS256 algorithm and store data in a PostgreSQL database using SQLX.

The HS256 algorithm is widely used and considered secure when implemented correctly. However, since it uses the same secret key to both sign and verify the JWT, anyone who gains access to the secret key can generate and validate JWTs. This can make it more vulnerable to attacks if the secret key is compromised.



User SignUp and Login Frontend Application with Yew.rs and Rust

In an upcoming article, we'll take things to the next level and implement the RS256 algorithm. This involves using a public-private key pair to sign and verify JWTs, which adds an extra layer of security. We'll also incorporate Redis as a server session to easily revoke JWTs when needed. So stay tuned for that!

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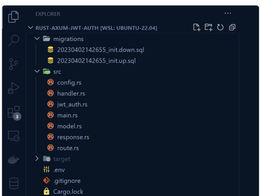
Set Up and Test the Rust Axum JWT Authentication Project

1. You can get the Rust Axum JWT authentication project from its GitHub repository at **https://github.com/wpcodevo/rust-axum-jwt-auth**. Simply download or clone the project and open the source code in your preferred IDE or text editor.
2. Start a PostgreSQL server in a Docker container by executing the command `docker-compose up -d` in the root directory's terminal.
3. Install the **SQLX CLI** tool by running `cargo install sqlx-cli` . Use the command `sqlx migrate run` to apply the PostgreSQL database's "up" migration script.
4. Start the Axum HTTP server by running the command `cargo run` in the terminal. This will install the necessary crates and launch the server.
5. To test the Axum JWT authentication flow, import the `Rust HS256 JWT.postman_collection.json` file into Postman or the Thunder Client extension in Visual Studio Code. This file contains pre-defined HTTP requests for each of the API endpoints, allowing you to quickly test the application without manually creating the request bodies and URLs.

Setup the Rust Axum Project

To give you a better idea of how your project will look like as you follow along with this tutorial, take a look at the screenshot below. It illustrates the folder and file organization that you will end up with once you've completed all the steps outlined in this article. This overview will help you keep track of your progress and ensure that your project is properly structured.



Let's get started by creating a new directory to store our project's source code. Navigate to a directory of your choice using your terminal and enter the following commands:

```
mkdir rust-axum-jwt-auth
cd rust-axum-jwt-auth
cargo init
```

This will create a new folder named `rust-axum-jwt-auth` and initialize a Rust project in that directory.

Once you've initialized the project, you can open it in your preferred code editor. From there, you can launch the integrated terminal and install all the dependencies needed for the project by running the following commands:

```
cargo add axum
cargo add axum-extra -F cookie
cargo add time
cargo add tokio -F full
cargo add tower-http -F "cors"
cargo add serde_json
cargo add serde -F derive
cargo add chrono -F serde
cargo add dotenv
cargo add uuid -F "serde v4"
cargo add sqlx -F "runtime-async-std-native-tls postgres chrono uuid"
cargo add jsonwebtoken
cargo add argon2
cargo add rand_core --features "std"
```

- `axum` – A fast and scalable Rust web framework for building microservices and APIs.
- `axum-extra` – A collection of additional components and utilities for the Axum web framework, including middleware and filters.
- `time` – A library for working with dates, times, and durations.
- `tokio` – A runtime for writing asynchronous, event-driven applications.
- `tower-http` – A set of composable middleware components for building HTTP servers and clients.
- `serde_json` – A crate for fast and efficient JSON serialization and deserialization.
- `serde` – A framework for serializing and deserializing Rust data structures into various formats.
- `chrono` – A date and time library for working with dates, times, and time zones.
- `dotenv` – A library for loading environment variables from a `.env` file.
- `uuid` – A crate for generating, parsing, and formatting UUIDs.
- `sqlx` – A crate for database access that supports asynchronous I/O and provides a type-safe API for working with databases.
- `jsonwebtoken` – A crate for creating and verifying JWTs.
- `argon2` – A crate for password hashing using the Argon2 algorithm.
- `rand_core` – A crate for generating random numbers.

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Please note that Rust is an evolving language, and some of the crates used in this project may introduce breaking changes by the time you read this article. If you encounter any issues, please revert to the versions provided in the `Cargo.toml` file below.

Additionally, feel free to leave a comment detailing any problems you encounter, and I will update the article and source code accordingly to help others who may face the same issue.

Cargo.toml

```
[package]
name = "rust-axum-jwt-auth"
version = "0.1.0"
edition = "2021"

# See more keys and their definitions at https://doc.rust-lang.org/cargo/refe

[dependencies]
argon2 = "0.5.0"
axum = "0.6.12"
axum-extra = { version = "0.7.2", features = ["cookie"] }
chrono = { version = "0.4.24", features = ["serde"] }
dotenv = "0.15.0"
jsonwebtoken = "8.3.0"
rand_core = { version = "0.6.4", features = ["std"] }
serde = { version = "1.0.159", features = ["derive"] }
serde_json = "1.0.96"
sqlx = { version = "0.6.3", features = ["runtime-async-std-native-tls", "post
time = "0.3.20"
tokio = { version = "1.27.0", features = ["full"] }
tower-http = { version = "0.4.0", features = ["cors"] }
uuid = { version = "1.3.0", features = ["serde", "v4"] }
```

Before we dive into the authentication process, let's set up a basic Axum server that has one endpoint. This endpoint will return a simple JSON object when a GET request is made to `/api/healthchecker`. This is just a warm-up exercise to get you familiar with Axum.

Open the `main.rs` file in the '**src**' directory and replace the existing code with the following snippet.

src/main.rs

```
use axum::{response::IntoResponse, routing::get, Json, Router};

pub async fn health_checker_handler() -> impl IntoResponse {
    const MESSAGE: &str = "JWT Authentication in Rust using Axum, Postgres, an

    let json_response = serde_json::json!({
        "status": "success",
        "message": MESSAGE
    });

    Json(json_response)
}

#[tokio::main]
async fn main() {
    let app = Router::new().route("/api/healthchecker", get(health_checker_ha

    println!("🚀 Server started successfully");
    axum::Server::bind(&"0.0.0.0:8000".parse().unwrap())
        .serve(app.into_make_service())
        .wait
        .unwrap();
}
```

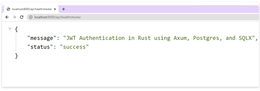
With the Axum server set up, we're ready to test it out. Running `cargo run` every time you make changes to the source code can be time-consuming and tedious. Fortunately, there's a solution: `cargo-watch`. This tool automatically builds your project whenever it detects changes in the source code, similar to Nodemon in Node.js.

To install **cargo-watch**, run the following command:

```
cargo install cargo-watch
```

Now that `cargo-watch` is installed, you can use it to start the Axum server by running the command `cargo watch -q -c -w src/ -x run`. This command sets up `cargo-watch` to automatically build and run your project whenever changes are detected in the `src` directory. This way, you don't have to manually run the `cargo run` command every time you make changes to your code.

With the Axum server running, you can now test it out by making a **GET** request to `http://localhost:8000/api/healthchecker` to see the JSON object response.



Setup the PostgreSQL and pgAdmin Servers

Let's set up PostgreSQL and pgAdmin servers with Docker so that we can easily run the Postgres database and use pgAdmin's GUI to access and manage the database. To get started, we need to create a `docker-compose.yml` file and add the following Docker Compose configurations.

docker-compose.yml

```
version: "3"
services:
  postgres:
    image: postgres:latest
    container_name: postgres
    ports:
      - "6500:5432"
    volumes:
      - progresDB:/var/lib/postgresql/data
    env_file:
      - ./.env
  pgAdmin:
    image: dpage/pgadmin4
    container_name: pgAdmin
    env_file:
      - ./.env
    ports:
      - "5050:80"
volumes:
  progresDB:
```

When you examine the Docker Compose configurations above, you may notice that we haven't specified the credentials required to build the Postgres and pgAdmin images.

Instead, we've directed Docker Compose to a `.env` file that will contain these credentials. To ensure that Docker Compose can access the credentials, create a new file called `.env` in the root directory and add the necessary environment variables to it.

.env

```
POSTGRES_HOST=127.0.0.1
POSTGRES_PORT=6500
POSTGRES_USER=admin
POSTGRES_PASSWORD=password123
POSTGRES_DB=rust_hs256

DATABASE_URL=postgresql://admin:password123@localhost:6500/rust_hs256?schema=p

PGADMIN_DEFAULT_EMAIL=admin@admin.com
PGADMIN_DEFAULT_PASSWORD=password123

JWT_SECRET=my_ultra_secure_secret
JWT_EXPIRED_IN=60m
JWT_MAXAGE=60
```

We included the JWT secret, the expiration time, and the token max-age in the `.env` file, which we'll cover in a later section. However, since there are only three variables, we decided to include them here.

Once you have set up the `.env` file with the required credentials, you can start the PostgreSQL and pgAdmin servers by running the command `docker-compose up -d`. This will launch the two servers in their own Docker containers.

If at any point you wish to stop the running containers, simply run the command `docker-compose down`.

Load the Environment Variables

As we build our project, we need a way to access the environment variables from the `.env` file without having to retrieve them in every file that needs them. To achieve this, we'll create a utility function that can be called during project initialization.

To get started, create a file named `config.rs` in the '**src**' directory and include the following code.

src/config.rs

```
#[derive(Debug, Clone)]
pub struct Config {
    pub database_url: String,
    pub jwt_secret: String,
    pub jwt_expires_in: String,
    pub jwt_maxage: i32,
}

impl Config {
    pub fn init() -> Config {
        let database_url = std::env::var("DATABASE_URL").expect("DATABASE_URL
        let jwt_secret = std::env::var("JWT_SECRET").expect("JWT_SECRET must
        let jwt_expires_in = std::env::var("JWT_EXPIRED_IN").expect("JWT_EXPI
        let jwt_maxage = std::env::var("JWT_MAXAGE").expect("JWT_MAXAGE must
        Config {
            database_url,
            jwt_secret,
            jwt_expires_in,
            jwt_maxage: jwt_maxage.parse::<i32>().unwrap(),
        }
    }
}
```

By centralizing the retrieval of environment variables in a utility function, our codebase becomes more organized and maintainable. This approach saves us from having to clutter every file that needs access to the environment variables with the same repetitive code.

Create and Push the Database Migrations

Let's move on to the database migration process. This involves generating migration scripts and defining the necessary SQL queries in the migration file, followed by applying the '**up**' migration script to the database. To begin, you need to install the `sqlx-cli` tool by running the following command:

```
cargo install sqlx-cli
```

Once you've installed `sqlx-cli`, you can generate the migration files by running the command `sqlx migrate add -r init` in your terminal. This will create a '**migrations**' folder in the root directory of your project, and within that folder, you'll find the '**up**' and '**down**' migration files. You can use a different name instead of '**init**' after the `-r` flag, but it's common practice to use '**init**' since it's the first migration.

Now navigate to the '**migrations**' folder and open the '**up**' migration file. Here, you can add the necessary SQL queries for this migration.

migrations/20230402142655_init.up.sql

```
-- Add up migration script here

CREATE EXTENSION IF NOT EXISTS "uuid-ossp";

CREATE TABLE
    "users" (
        id UUID NOT NULL PRIMARY KEY DEFAULT (uuid_generate_v4()),
        name VARCHAR(100) NOT NULL,
        email VARCHAR(255) NOT NULL UNIQUE,
        photo VARCHAR NOT NULL DEFAULT 'default.png',
        verified BOOLEAN NOT NULL DEFAULT FALSE,
        password VARCHAR(100) NOT NULL,
        role VARCHAR(50) NOT NULL DEFAULT 'user',
        created_at TIMESTAMP
        WITH
            TIME ZONE DEFAULT NOW(),
        updated_at TIMESTAMP
        WITH
            TIME ZONE DEFAULT NOW()
    );

CREATE INDEX users_email_idx ON users (email);
```

To make sure we can undo the changes made by the '**up**' migration file, we need to add the appropriate SQL code to the corresponding '**down**' migration file. To do this, go to the '**migrations**' folder and find the '**down**' migration file that corresponds to the '**up**' migration file. Then, add the following SQL code to it:

migrations/20230402142655_init.down.sql

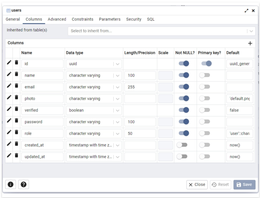
```
-- Add down migration script here

DROP TABLE IF EXISTS "users";
```

Now that we have defined the SQL queries for both the 'up' and 'down' migration files, we can apply the 'up' migration script to the database by running the command `sqlx migrate run` in the terminal. This will establish a connection to the Postgres database using the database connection URL provided in the `.env` file and apply the migration script.

It's worth noting that this approach helps to keep our database schema changes organized and trackable over time. If at any point you want to undo the changes made by the migration script, you can run the `sqlx migrate revert` command, which will execute the corresponding '**down**' migration file.

After completing the setup steps, you can access pgAdmin by visiting `http://localhost:5050/` and authenticate using the credentials provided in the **.env** file. Next, connect to the Postgres server using the login details from the `.env` file. To find the IP address of the PostgreSQL container, simply run the command `docker inspect postgres`.

Once you have successfully connected to the PostgreSQL server, navigate to the tables section of the `rust_b256` database in pgAdmin to view the `users` table that was created by SQLX-CLI during the migration process.



Connect the App to the PostgreSQL Database

Now that the Postgres database schema is in-sync with the codebase, the next step is to connect the Axum server to the running Postgres server. This will involve using the `Config::init()` function to load the environment variables from the `.env` file and create 10 connection pools to the PostgreSQL server using SQLX and the database connection URL.

To achieve this, you can open the `src/main.rs` file and replace its content with the following code.

src/main.rs

```
mod config;
use std::sync::Arc;

use axum::{response::IntoResponse, routing::get, Json, Router};
use config::Config;
use dotenv::dotenv;

use sqlx::{postgres::PgPoolOptions, Pool, Postgres};

pub struct AppState {
    db: Pool<Postgres>,
    env: Config,
}

#[tokio::main]
async fn main() {
    dotenv().ok();

    let config = Config::init();

    let pool = match PgPoolOptions::new()
        .max_connections(10)
        .connect(&config.database_url)
        .await
    {
        Ok(pool) => {
            println!("🚀Connection to the database is successful!");
            pool
        }
        Err(err) => {
            println!("🔥 Failed to connect to the database: {:?}", err);
            std::process::exit(1);
        }
    };

    let app = Router::new()
```

In the code above, we initialized the `Config` struct using the `Config::init()` method, which loads environment variables from the `.env` file. Then, we used the `PgPoolOptions` method from the SQLX crate to create a pool of 10 connections to the Postgres server.

Finally, we used the `Arc` smart pointer to share the state of the `AppState` struct across multiple threads. The `AppState` struct contains the database connection pool and the `Config` struct.

Define the SQLX Database Model

Let's now create the SQLX database model. We'll start by defining a struct that represents the `users` table in the PostgreSQL database. The struct will have fields that match the columns of the table. To map query results to the struct, we'll implement the `sqlx::FromRow` trait.

To get started, create a new file called `model.rs` in the `src` directory and add the following structs:

src/model.rs

```
use chrono::prelude::*;
use serde::{Deserialize, Serialize};

#[allow(non_snake_case)]
#[derive(Debug, Deserialize, sqlx::FromRow, Serialize, Clone)]
pub struct User {
    pub id: uuid::Uuid,
    pub name: String,
    pub email: String,
    pub password: String,
    pub role: String,
    pub photo: String,
    pub verified: bool,
    #[serde(rename = "createdAt")]
    pub created_at: Option<DateTime<Utc>>,
    #[serde(rename = "updatedAt")]
    pub updated_at: Option<DateTime<Utc>>,
}

#[derive(Debug, Serialize, Deserialize)]
pub struct TokenClaims {
    pub sub: String,
    pub iat: usize,
    pub exp: usize,
}

#[derive(Debug, Deserialize)]
pub struct RegisterUserSchema {
    pub name: String,
    pub email: String,
    pub password: String,
}

#[derive(Debug, Deserialize)]
pub struct LoginUserSchema {
    pub email: String,
```

The above code introduces three different structs. `User` is the

The above code introduces three data structures - `TokenClaims` , `RegisterUserSchema` , and `LoginUserSchema` - alongside the SQLX database model struct. Although these structs should ideally be defined in a separate file, we've kept them in the `model.rs` file for the sake of simplicity.

The `TokenClaims` struct allows us to construct the JWT claim when signing tokens, while the `RegisterUserSchema` struct allows us to deserialize the request body during the account registration process to ensure the user provides the correct data types. Similarly, the `LoginUserSchema` struct lets us deserialize the request body during the account login process.

Define the Response Structures

When designing APIs, it's generally best to filter the data in the JSON response in order to exclude any sensitive fields like hashed passwords, credit card numbers, and so on.

To accomplish this, we'll create a separate struct that includes only the fields we want to send to the user, rather than sending the SQLX database model directly. Later on, we'll create a helper function that uses this struct to filter the results returned by SQLX and remove any sensitive fields.

To get started, create a new file called `response.rs` in the `src` directory and define the following structs:

src/response.rs

```
use chrono::prelude::*;
use serde::Serialize;

#[allow(non_snake_case)]
#[derive(Debug, Serialize)]
pub struct FilteredUser {
    pub id: String,
    pub name: String,
    pub email: String,
    pub role: String,
    pub photo: String,
    pub verified: bool,
    pub createdAt: DateTime<Utc>,
    pub updatedAt: DateTime<Utc>,
}

#[derive(Serialize, Debug)]
pub struct UserData {
    pub user: FilteredUser,
}

#[derive(Serialize, Debug)]
pub struct UserResponse {
    pub status: String,
    pub data: UserData,
}
```

Create the Axum JWT Authentication Middleware

At this point, we are ready to start implementing the authentication aspect of our project. To achieve this, we'll create a middleware for JWT authentication using Axum. This middleware will ensure that only users with valid JWTs can access subsequent route handlers.

The middleware's main responsibility is to authenticate incoming requests by checking for a valid JSON Web Token (JWT) in either a cookie or the Authorization header of the request. It takes four arguments:

1. `cookie_jar` : The cookie jar extracted from the request.
2. `State(data)` : The application state, which is an `Arc` of an `AppState` struct.
3. `req` : The HTTP request being authenticated.
4. `next` : The next middleware or handler in the chain, which is executed if authentication is successful.

The middleware first tries to get the JWT from the cookie jar. If it's not present, it checks the Authorization header for the token. If the middleware can't find a JWT in either location, it returns an error response with a 401 Unauthorized status code.

src/jwt_auth.rs

```
use std::sync::Arc;

use axum::{
    extract::State,
    http::{header, Request, StatusCode},
    middleware::Next,
    response::IntoResponse,
    Json,
};

use axum_extra::extract::cookie::CookieJar;
use jsonwebtoken::{decode, DecodingKey, Validation};
use serde::Serialize;

use crate::{
    model::{TokenClaims, User},
    AppState,
};

#[derive(Debug, Serialize)]
pub struct ErrorResponse {
    pub status: &'static str,
    pub message: String,
}

pub async fn auth(cookie_jar: CookieJar,
    State(data): State<Arc<AppState>>,
    mut req: Request<B>,
    next: Next<B>,
) -> Result<impl IntoResponse, (StatusCode, Json<ErrorResponse>)> {
    let token = cookie_jar
        .get("token")
        .map(|cookie| cookie.value().to_string())
        .or_else(|| {
            req.headers()
                .get(header::AUTHORIZATION)
                .auth_bearer()
                .
```

If a valid JWT is found, the middleware function uses the `jsonwebtoken` library and the application's JWT secret to decode it. If decoding is successful, the function extracts the user ID from the JWT's subject field and looks up the corresponding user in the database using the `sqlx` library. This step ensures that the user belonging to the token still exists in the database.

If the user is found in the database, the middleware stores the user record in the request's extensions so that subsequent middleware or handlers can access it. If the user is not found, the middleware returns an error response with a 401 Unauthorized status code.

If any errors occur during the authentication process, the middleware returns an error response with a 500 Internal Server Error status code and an appropriate error message.

Implement the JWT Authentication in Axum

Now that we have implemented the JWT middleware, it is time to move on to creating route handlers for user registration, login, and logout. Additionally, we will demonstrate how the authorization process works by creating an Axum route handler that will return the user's profile information. This route handler will be secured by the previously implemented JWT middleware to ensure that only authorized users can access it.

To get started, we will create a new `handler.rs` file in the `src` directory and add the necessary crates and dependencies to it.

src/handler.rs

```
use std::sync::Arc;

use argon2::{password_hash::SaltString, Argon2, PasswordHash, PasswordHasher,
use axum::{
    extract::State,
    http::{header, Response, StatusCode},
    response::IntoResponse,
    Extension, Json,
};
use axum_extra::extract::cookie::{Cookie, SameSite};
use jsonwebtoken::{encode, EncodingKey, Header};
use rand_core::OsRng;
use serde_json::json;

use crate::{
    model::{LoginUserSchema, RegisterUserSchema, TokenClaims, User},
    response::FilteredUser,
    AppState,
};
```

To further enhance security, we'll create a utility function that uses the `FilteredUser` struct to filter sensitive fields from the user data retrieved from the database. This function will be defined in `handler.rs` and can be placed at the bottom of the file, as the route handlers will be defined above it in the next steps.

src/handler.rs

```
fn filter_user_record(user: &User) -> FilteredUser {
    FilteredUser {
        id: user.id.to_string(),
        email: user.email.to_owned(),
        name: user.name.to_owned(),
        photo: user.photo.to_owned(),
        role: user.role.to_owned(),
        verified: user.verified,
        createdAt: user.created_at.unwrap(),
        updatedAt: user.updated_at.unwrap(),
    }
}
```

Axum User Registration Handler

To register new users, we'll create an Axum route handler called `register_user_handler` that takes two arguments: `State(data)` , which is a state object that contains the **AppState**, and `Json(body)` , which is the request body in a `RegisterUserSchema` object format.

When registering a new user, we want to ensure that there are no duplicate email addresses in the database. To do this, the `register_user_handler` function first checks if a user with the email provided in the request body already exists in the database. If a user with that email address is found, the function will return an HTTP status code of 409 along with an error message.

If the email is not found in the database, the function will generate a random salt string and hash the user's plain-text password using the Argon2 algorithm. The function will then use SQLX to perform an INSERT query to add the new user to the database. Once the user has been successfully created, the function will return the new user's data in a JSON response.

src/handler.rs

```
pub async fn register_user_handler(
    State(data): State<Arc<AppState>>,
    Json(body): Json<RegisterUserSchema>,
) -> Result<impl IntoResponse, (StatusCode, Json<serde_json::Value>)> {
    let user_exists: Option<bool> =
        sqlx::query_scalar("SELECT EXISTS(SELECT 1 FROM users WHERE email =
            .bind(body.email.to_owned().to_ascii_lowercase())
            .fetch_one(&data.db)
            .
```

```
        if exists {
            let error_response = serde_json::json!({
                "status": "fail",
                "message": "User with that email already exists",
            });
            return Err((StatusCode::CONFLICT, Json(error_response)));
        }
    }

    let salt = SaltString::generate(&mut OsRng);
    let hashed_password = Argon2::default()
        .hash_password(body.password.as_bytes(), &salt)
        .map_err(|e| {
            let error_response = serde_json::json!({
                "status": "fail",
                "message": format!("Error while hashing password: {}", e),
            });
```

However, if there is an error with the database or the password hashing, the `register_user_handler` function will return an HTTP status code of 500 along with an error message in the response.

Axum User Login Handler

In order to allow registered users to sign into the API, we need to create a route function called **login_user_handler** that will be invoked when a **POST** request is made to the `/api/auth/login` endpoint.

First, the function queries the database using the `sqlx` crate to retrieve the user associated with the email provided in the request body. If no user is found, the function will return an error response with the message "**Invalid email or password**".

If a user is found, the function then validates the password using the Argon2 algorithm. If the password is invalid, the function will return an error response with the message "**Invalid email or password**".

However, if the password is valid, the function generates a JSON Web Token (JWT) that contains the user's ID, an expiration time, and an issue time. The token is then signed using the `encode()` function from the `jsonwebtoken` crate and sent to the client in a response body, along with a cookie containing the token.

src/handler.rs

```
pub async fn login_user_handler(
    State(data): State<Arc<AppState>>,
    Json(body): Json<LoginUserSchema>,
) -> Result<impl IntoResponse, (StatusCode, Json<serde_json::Value>) {
    let user = sqlx::query_as!(
        User,
        "SELECT * FROM users WHERE email = $1",
        body.email.to_ascii_lowercase()
    )
    .fetch_optional(&data.db)
    .await?
    .map_err(|e| {
        let error_response = serde_json::json!({
            "status": "error",
            "message": format!("Database error: {}", e),
        });
        (StatusCode::INTERNAL_SERVER_ERROR, Json(error_response))
    })?
    .ok_or_else(|| {
        let error_response = serde_json::json!({
            "status": "fail",
            "message": "Invalid email or password",
        });
        (StatusCode::BAD_REQUEST, Json(error_response))
    })?;

    let is_valid = match PasswordHash::new(&user.password) {
        Ok(parsed_hash) => Argon2::default()
            .verify_password(body.password.as_bytes(), &parsed_hash)
            .map_or(false, |_| true),
        Err(_) => false,
    };

    if !is_valid {
        let error_response = serde_json::json!({
```

Finally, the function returns an Axum `Result` type. If the request is successful, the function will return a successful response containing the token and cookie. If the request is unsuccessful, the function will return an error response with a status code and a message explaining the cause of the error.

Axum User Logout Handler

Now that we have a function to sign users into the API, we'll create a corresponding function to sign them out. This new function, called **logout_handler**, will be invoked when a **GET** request is sent to `/api/auth/logout`.

When `logout_handler` is called, it creates a cookie named "**token**" with no value and sets its expiration time to a negative value, effectively removing the existing cookie from the user's browser.

Finally, the function constructs a success response containing a JSON object and the empty cookie.

src/handler.rs

```
pub async fn logout_handler() -> Result<impl IntoResponse, (StatusCode, Json<
    let cookie = Cookie::build("token", "")
        .path("/")
        .max_age(time::Duration::hours(-1))
        .same_site(SameSite::Lax)
        .http_only(true)
        .finish();

    let mut response = Response::new(json!{"status": "success"}).to_string()
    response
        .headers_mut()
        .insert(header::SET_COOKIE, cookie.to_string().parse().unwrap());
    Ok(response)
}
```

Axum Handler to Fetch Logged-in User

We'll now create an Axum route handler that will return the authenticated user's profile information when a GET request is made to the `/api/users/me` endpoint. To protect this route function, we'll apply the JWT middleware guard, which means that only users with a valid JWT will be able to access it.

When a user with a valid JWT accesses this endpoint, the JWT authentication middleware will add the user's record to the request's extensions. Then, the `get_me_handler` function will retrieve the user's record from the extension, filter out any sensitive data using the `filter_user_record` function, and return the remaining non-sensitive data in a JSON response to the client.

src/handler.rs

```
pub async fn get_me_handler(
    Extension(user): Extension<User>,
) -> Result<impl IntoResponse, (StatusCode, Json<serde_json::Value>) {
    let json_response = serde_json::json!({
        "status": "success",
        "data": serde_json::json!({
            "user": filter_user_record(&user)
        })
    });

    Ok(Json(json_response))
}
```

The Complete Code for the Axum Handlers

src/handler.rs

```
use std::sync::Arc;

use argon2::{password_hash::SaltString, Argon2, PasswordHash, PasswordHasher
use axum::{
    extract::State,
    http::{header, Response, StatusCode},
    response::IntoResponse,
    Extension, Json,
};
use axum_extra::extract::cookie::{Cookie, SameSite};
use jsonwebtoken::{encode, EncodingKey, Header};
use rand_core::OsRng;
use serde_json::json;

use crate::{
    model::{LoginUserSchema, RegisterUserSchema, TokenClaims, User},
    response::FilteredUser,
    AppState,
};

pub async fn health_checker_handler() -> impl IntoResponse {
    const MESSAGE: &str = "JWT Authentication in Rust using Axum, Postgres,

    let json_response = serde_json::json!({
        "status": "success",
        "message": MESSAGE
    });

    Json(json_response)
}

pub async fn register_user_handler(
    State(data): State<Arc<AppState>>,
    Json(body): Json<RegisterUserSchema>,
) -> Result<impl IntoResponse, (StatusCode, Json<serde_json::Value>) {
```

Create the API Routes

With all the Axum route functions now defined, it's time to create the routes that will call them. Although we could add this logic to the `main.rs` file, it's better to keep our project organized and easy to understand by creating a separate file for routes. We'll call this file `route.rs` which we'll create in the `src` directory.

Here's the code that defines our routes. Although it's worth mentioning that it could be refactored by creating a common route prefix for all the routes since they all start with `/api`, but for simplicity's sake, we'll leave it as is.

src/route.rs

```
use std::sync::Arc;

use axum::{
    middleware,
    routing::{get, post},
    Router,
};

use crate::{
    handler::{
        get_me_handler, health_checker_handler, login_user_handler, logout_
        register_user_handler,
    },
    jwt_auth::auth,
    AppState,
};

pub fn create_router(app_state: Arc<AppState>) -> Router {
    Router::new()
        .route("/api/healthchecker", get(health_checker_handler))
        .route("/api/auth/register", post(register_user_handler))
        .route("/api/auth/login", post(login_user_handler))
        .route(
            "/api/auth/logout",
            get(logout_handler)
                .route_layer(middleware::from_fn_with_state(app_state.clone
        )
        .route(
            "/api/users/me",
            get(get_me_handler)
```

```
                .route_layer(middleware::from_fn_with_state(app_state.clone
        )
        .with_state(app_state)
}
```

Register the API Router and Setup CORS

After defining all the routes in the `route.rs` file, we need to register them with the Axum server and enable it to handle requests from the frontend application. To do this, we'll use a component called `CorsLayer` from the `tower-http` crate.

We'll start by creating a `CorsLayer` instance that specifies the origins, HTTP methods, credentials, and headers to allow. Then, we'll create a `Router` instance using the `create_router` function we defined earlier, and pass an `AppState` object that holds our database connection pool and environment configuration.

Lastly, we'll apply the `CorsLayer` to our **Router** instance using the `layer` method, and assign the result to the `app` variable. With this setup, our Axum server is now ready to receive and process incoming requests.

src/main.rs

```
mod config;
mod handler;
mod jwt_auth;
mod model;
mod response;
mod route;

use config::Config;
use std::sync::Arc;

use axum::http::{
    header::{ACCEPT, AUTHORIZATION, CONTENT_TYPE},
    HeaderValue, Method,
};
use dotenv::dotenv;
use route::create_router;
use tower_http::cors::CorsLayer;

use sqlx::{postgres::PgPoolOptions, Pool, Postgres};

pub struct AppState {
    db: Pool<Postgres>,
    env: Config,
}

#[tokio::main]
async fn main() {
    dotenv().ok();

    let config = Config::init();

    let pool = match PgPoolOptions::new()
        .max_connections(10)
        .connect(&config.database_url)
        .await
```

Oops, that was a lot of code! But don't worry, we're almost there. To help you test out the API without having to manually type in the request URLs and bodies, I've prepared a file for you.

You can easily import the `Rust HS256 JWT.postman_collection.json` file from the project's GitHub repository at **https://github.com/wpcodevo/rust-axum-jwt-auth** into either Postman or the Thunder Client VS Code extension. This file contains a set of pre-defined requests that you can use to interact with the Axum server.

Once you have the collection imported, you can quickly test the authentication flow of the API by making requests to it. Happy testing!

Conclusion

That's it! Congratulations on reaching the end of this tutorial. By now, you've acquired a new skill: implementing JSON Web Token authentication in Rust using Axum and SQLX. You've learned how to securely authenticate users, store data in a PostgreSQL database, and build a robust API server. It's a big accomplishment, and you should be proud of yourself.

Keep exploring Rust and Axum, and who knows what exciting projects you'll create next!

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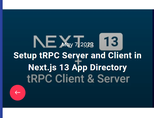

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