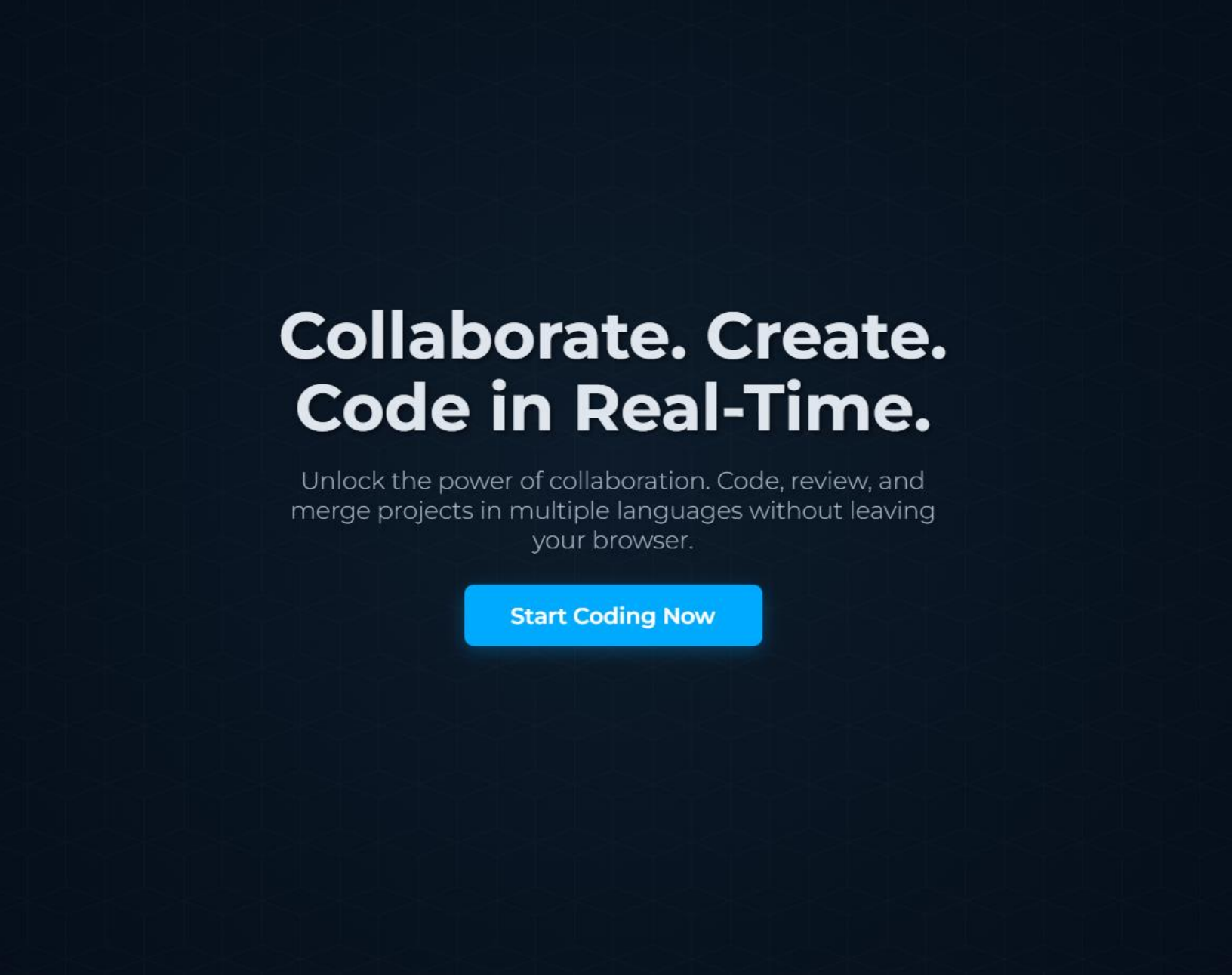

Software Engineering and DevOps – spring 2024

Prepared By Abdullah Ayman

Atypon Final Project

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TECHNOLOGIES USED IN OUR COLLABORATIVE CODE EDITOR

JAVA

SPRING BOOT

SPRING SECURITY

REACT.JS

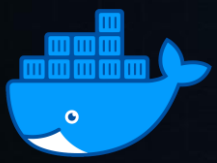
JAVASCRIPT

CSS

MYSQL

MONGODB

GitHub



Docker

AWS

GitHub Actions

OAuth 2.0

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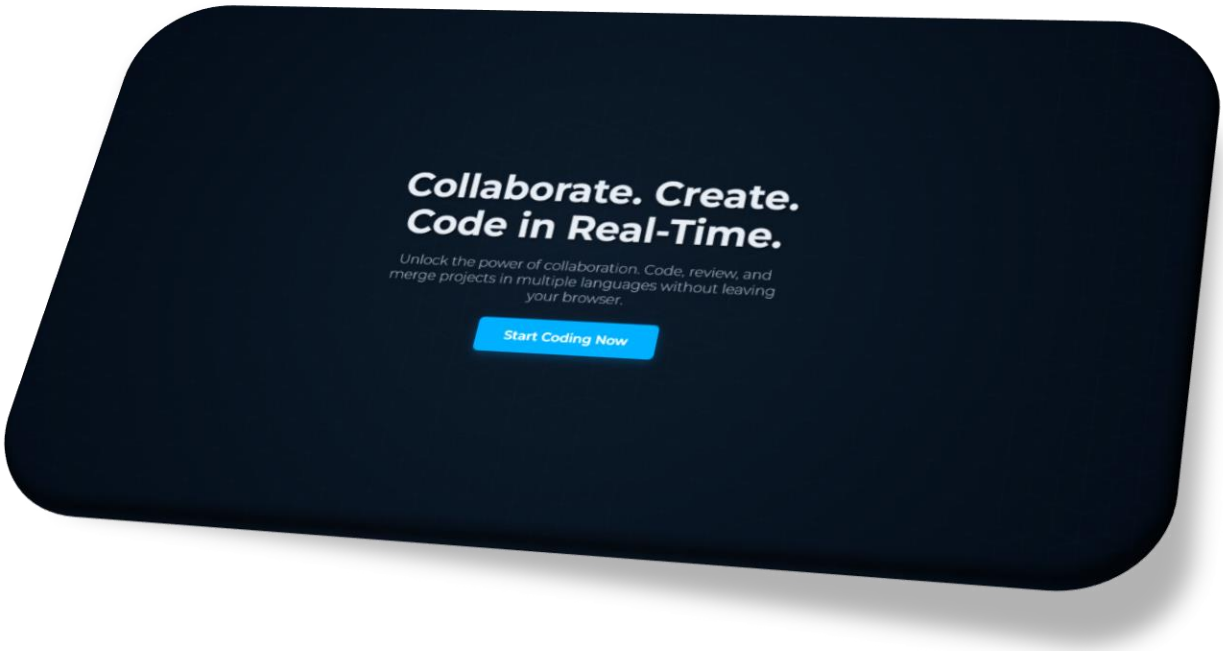
Introduction

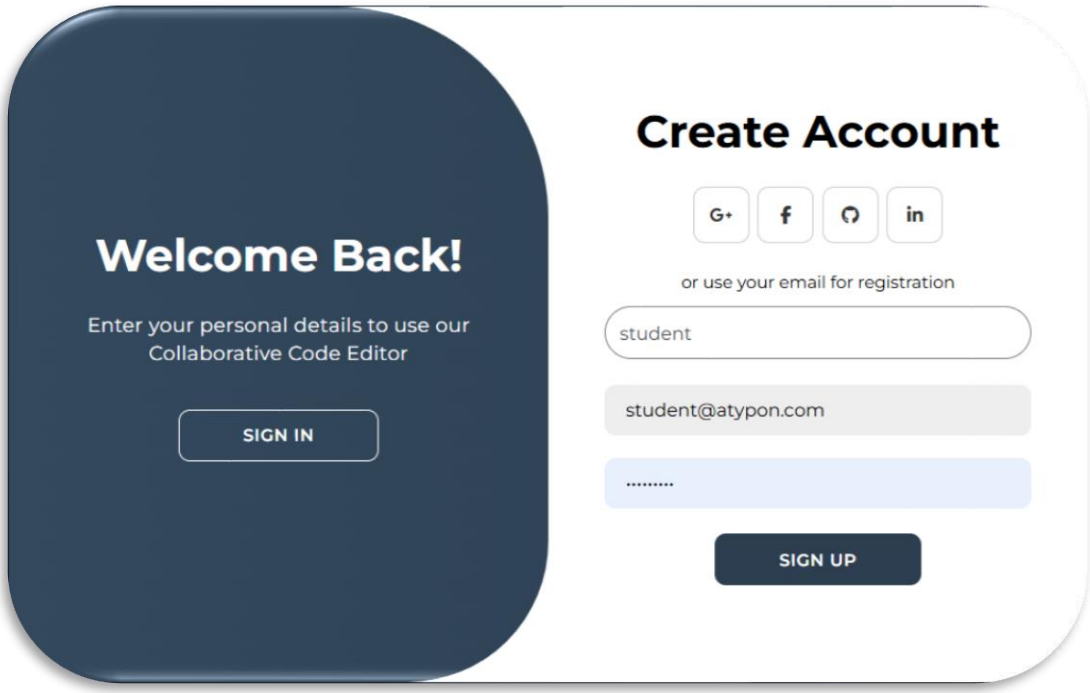


This report outlines the development of a Collaborative Code Editor, a web application that empowers multiple users to write, edit, and execute code together in real-time, regardless of their physical location. It supports real-time communication using WebSockets, version control, and various user roles such as Owner, Viewer, and Collaborator, each with distinct responsibilities. It also incorporates essential features such as code execution in multiple programming languages, robust file management, and real-time updates.

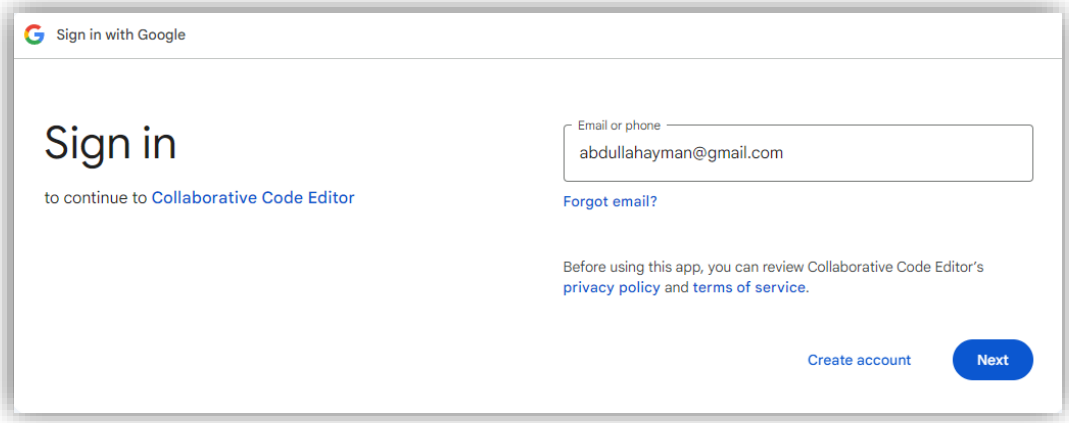
In this report, we will cover:

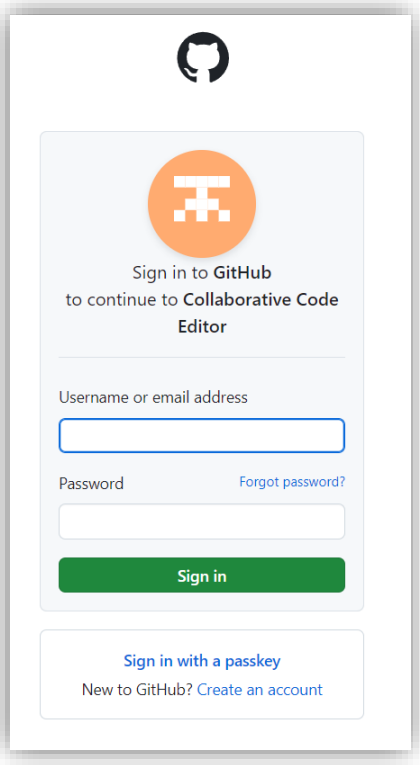
- **System Design & Architecture:** The architecture decisions, including security, data schema design, and communication protocols.
- **Clean Code:** How the project adheres to best practices for writing clear, readable, and maintainable code.
- **Effective Java:** How principles from Effective Java were applied to improve performance and reliability.
- **SOLID Principles:** How the code structure follows the key principles of software design.
- **Design Patterns:** The use of common patterns that enhance flexibility and maintainability.
- **Multithreading:** How we handled concurrency to support multiple users editing files simultaneously, ensuring data consistency.
- **DevOps Practices:** The use of Docker, AWS, and CI/CD pipelines for deployment and scaling the application.

Web Application Overview

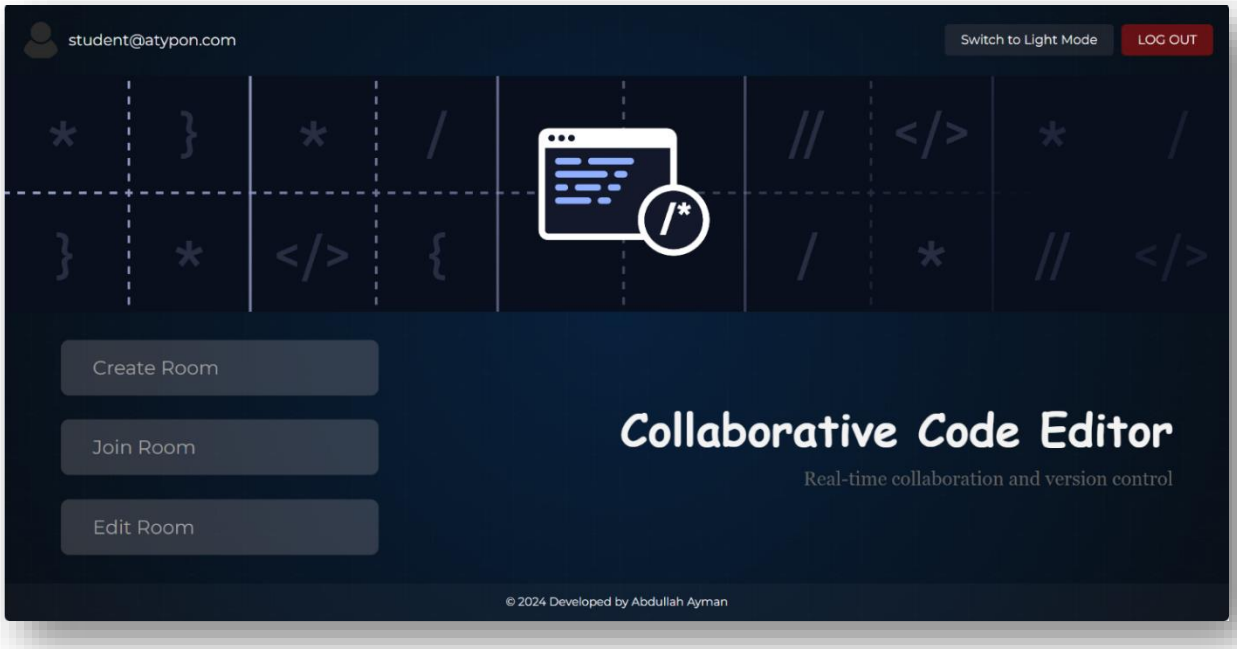


Before you get started with our collaborative code editor, you'll first encounter the login form. Our platform allows you to sign up for a new account or conveniently log in using your existing accounts from GitHub, Facebook, Google, or LinkedIn. Once you've successfully authenticated, you'll have full access to the powerful features of the collaborative code editor.





2.1 User Roles and Permissions



Once authorized, users can access the platform's features. Depending on their role—Owner, Collaborator, or Viewer—they can create, join, or manage rooms and projects, as outlined in the table below. Each role comes with specific permissions to enhance collaboration.

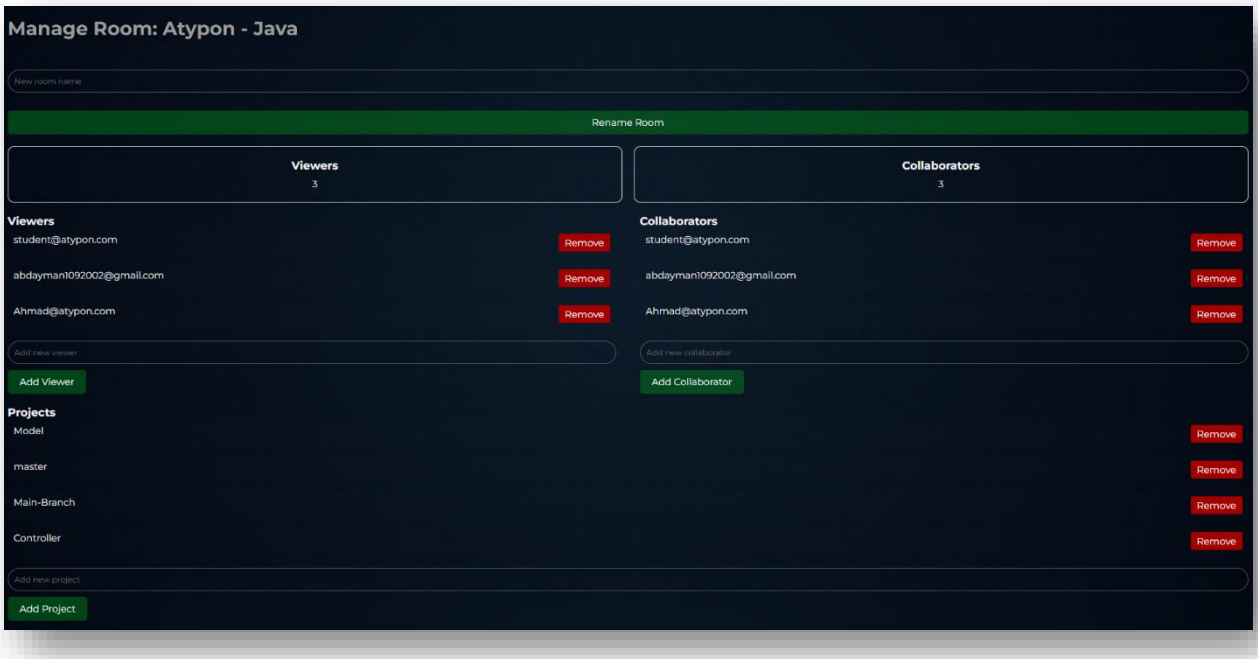
ROLE	PERMISSIONS	RESPONSIBILITIES
OWNER	Create room, add/remove projects, rename/remove room	Full control of the room, project management, adding/removing users
COLLABORATOR	Edit files, manage versions, PULL, PUSH, MERGE, RUN and DOWNLOAD version files and projects	Contribute to project files, handle version control, and real time editing.
VIEWER	View project, assist collaborators, view logs, run the codes	Monitor project progress, view code complexity, help collaborators

2.2 Owner: Responsibilities

Once you create a room as an Owner, you are given full control over the room's management and its members.

Hit what you want from your own room’s dashboard then you can manage it.

2.2 Owner: Responsibilities



Owner Abilities in the Collaborative Code Editor

- Add New Members: This typically involves sending an invitation link or directly adding the member's email address through a user interface.

- Remove Members: The Owner can select members from a list and choose an option to remove them, which revokes their access to the room.

- Rename the Room: This usually involves entering a new name in a designated field within the settings of the room.

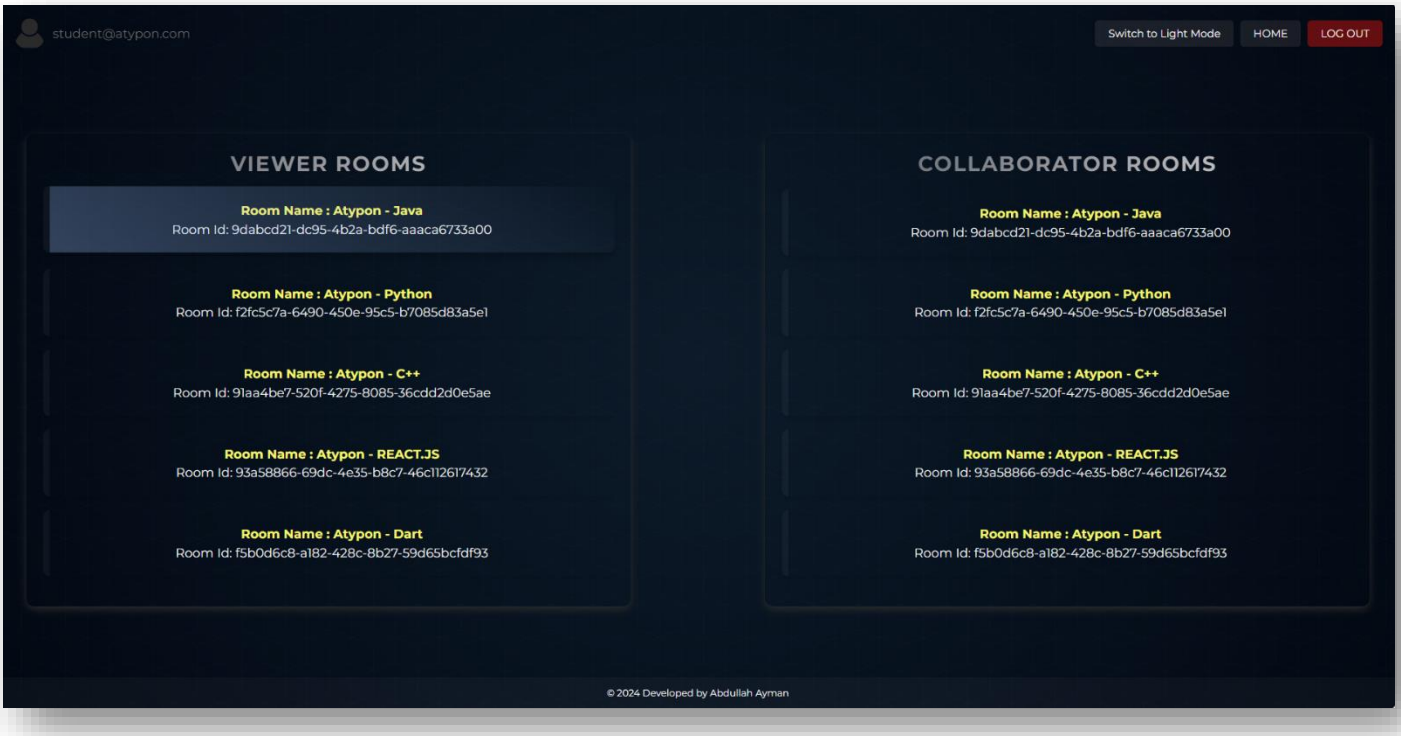
- Download Projects and Logs: This is often facilitated through a download button that packages the project files and logs into a downloadable format (e.g., ZIP file).

- Manage Projects: This involves a user interface where Owners can create new project entries, edit details, or delete projects as needed.

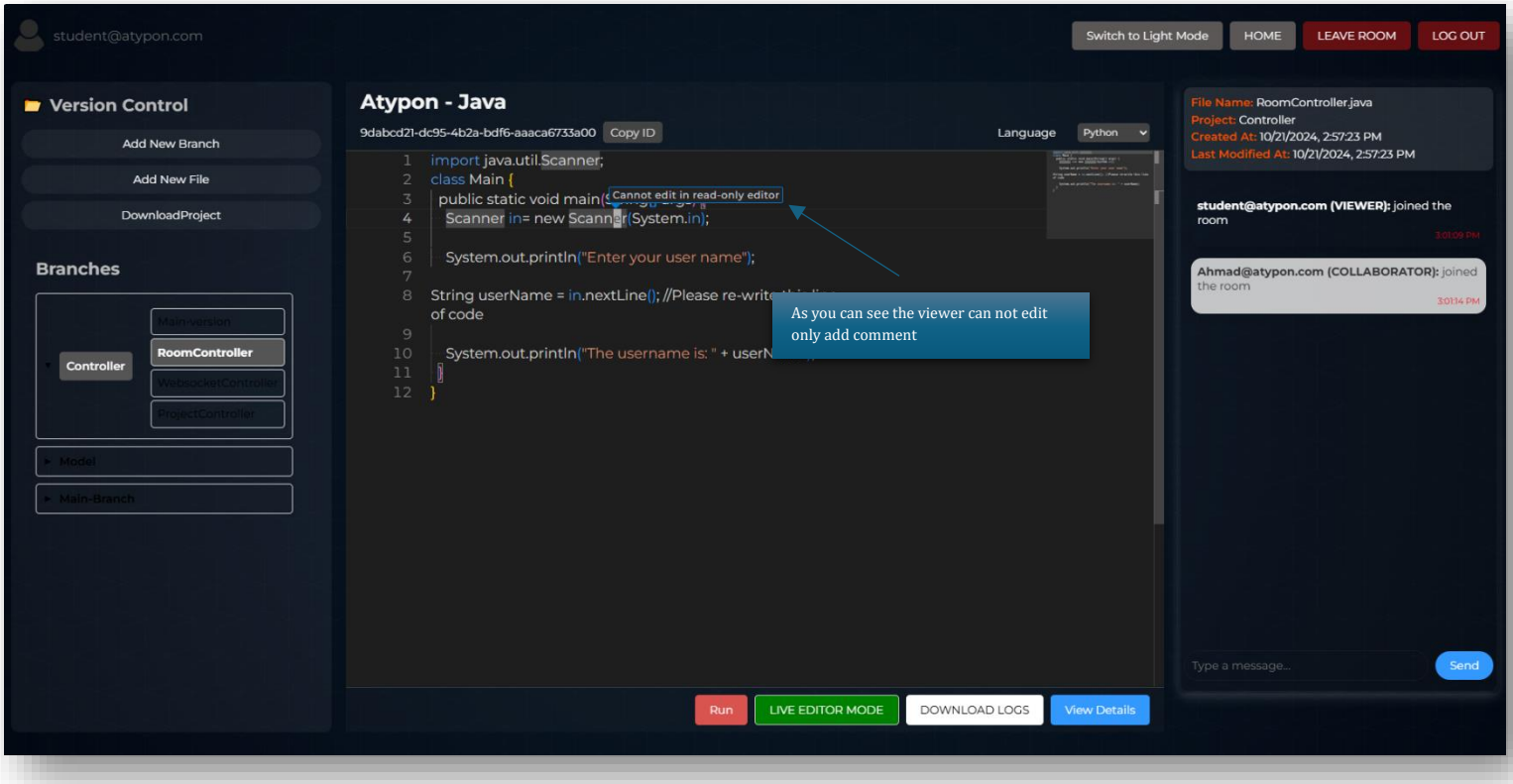
Note

it's important to mention that some of the room control functionality has not yet been implemented in the frontend (like download logs, projects and remove the room). Future enhancements will focus on completing these controls and developing a more creative dashboard to improve user experience.

2.3 Viewer: Viewing, Logs and Assessment



Viewers, once they join a room, they can engage with the project by accessing the latest code, adding comments, and reviewing important metrics. This functionality not only enhances collaboration but also ensures that Viewers can contribute effectively to the overall project quality.



2.3 Viewer: Viewing, Logs and Assessment

Viewer Features:

- **Joining the Room:**

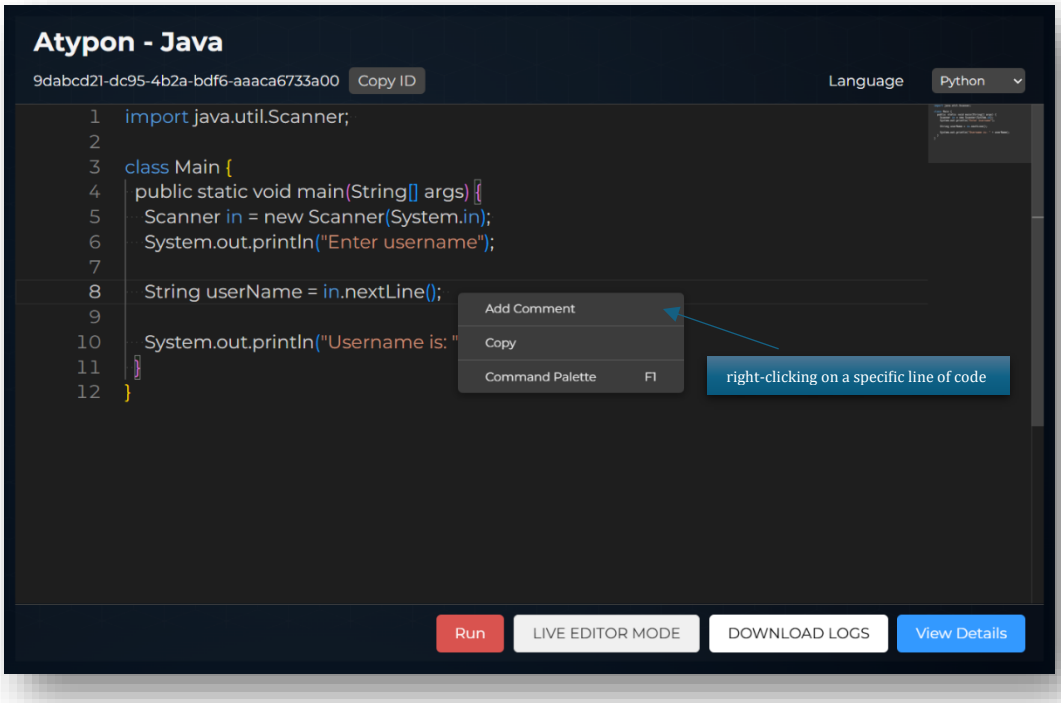
  Action: When a Viewer joins the room, a message is logged to indicate their entry.

  Process: The system automatically records this event in the logs file, providing a history of room activity.

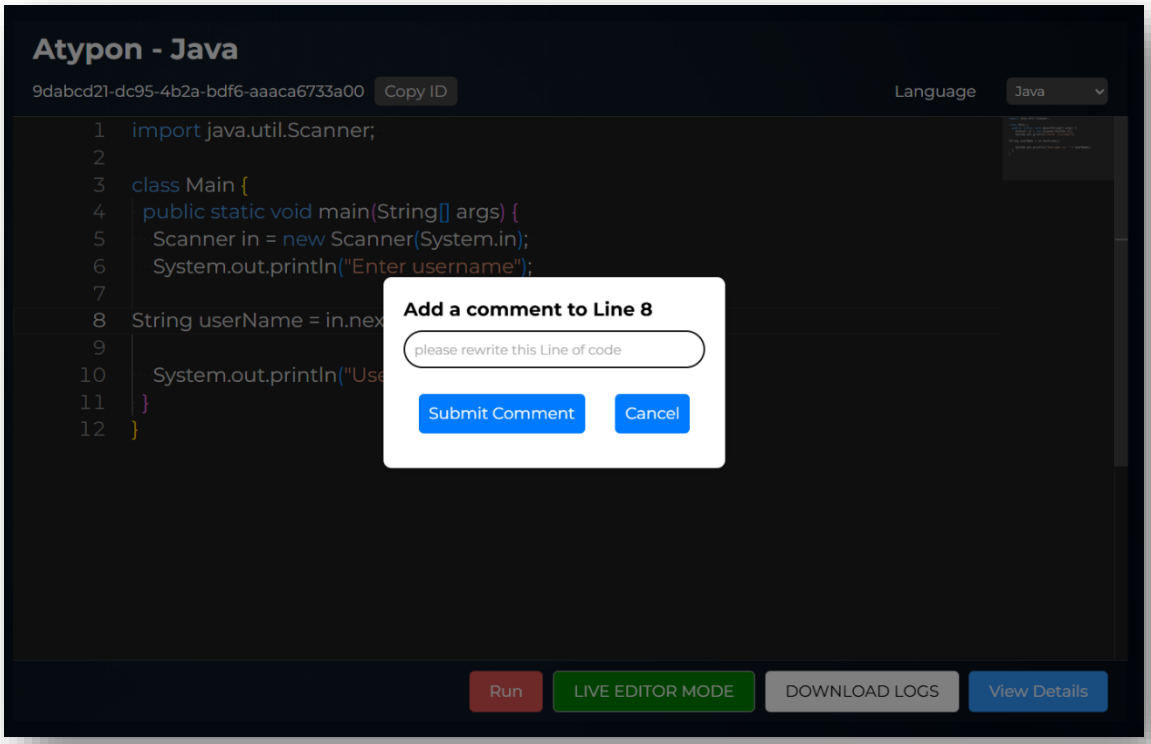
- **Adding Comments:**

  Action: Viewers can provide feedback or notes directly in the code by adding comments.

  Process: By right-clicking on a specific line of code, Viewers access a menu with various features, including the option to "add comment." This allows them to insert comments on any line, fostering clear communication.

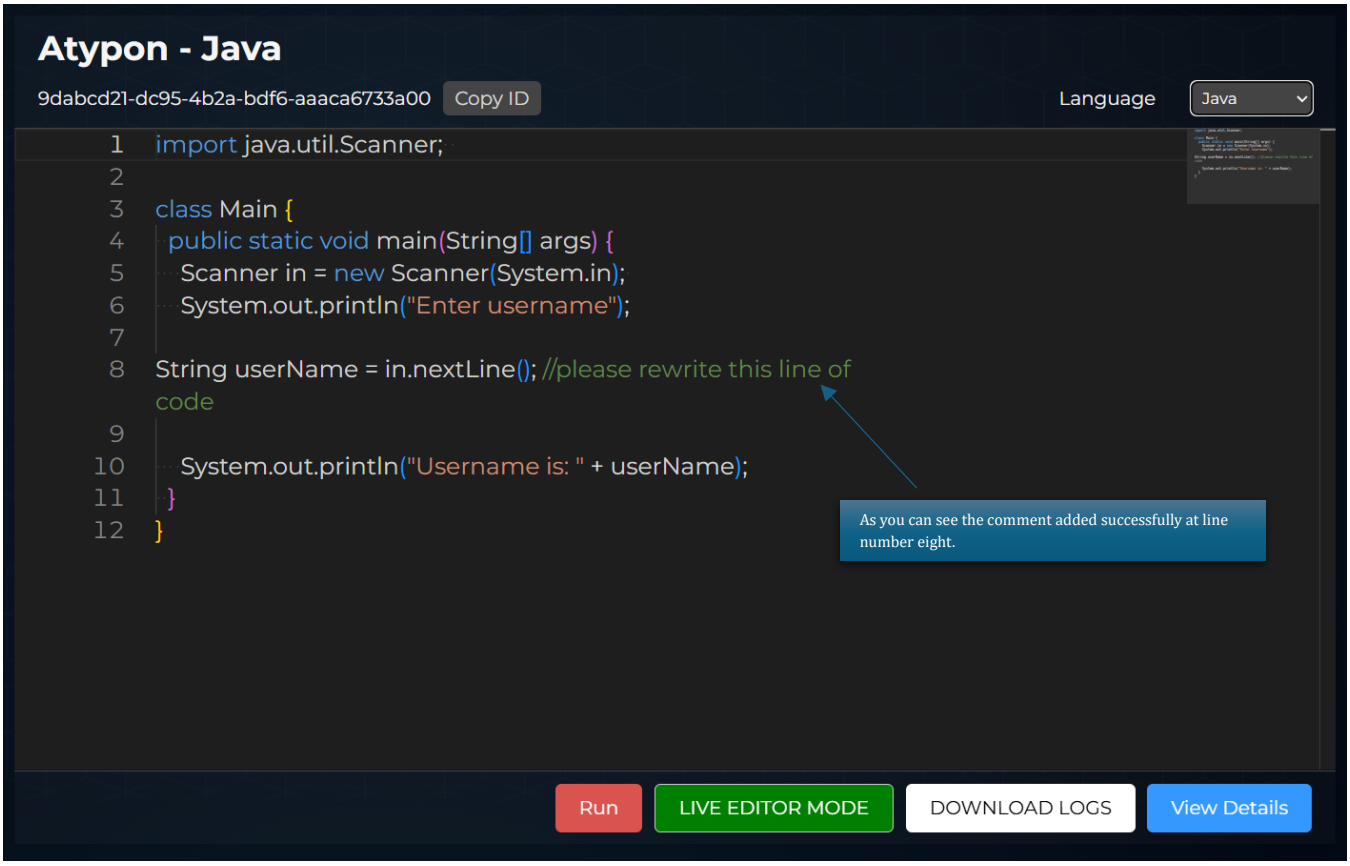


2.3 Viewer: Viewing, Logs and Assessment



Note

it's important to mention that, make sure press LIVE EDITOR MODE Button to allow you to add comments in live mode.

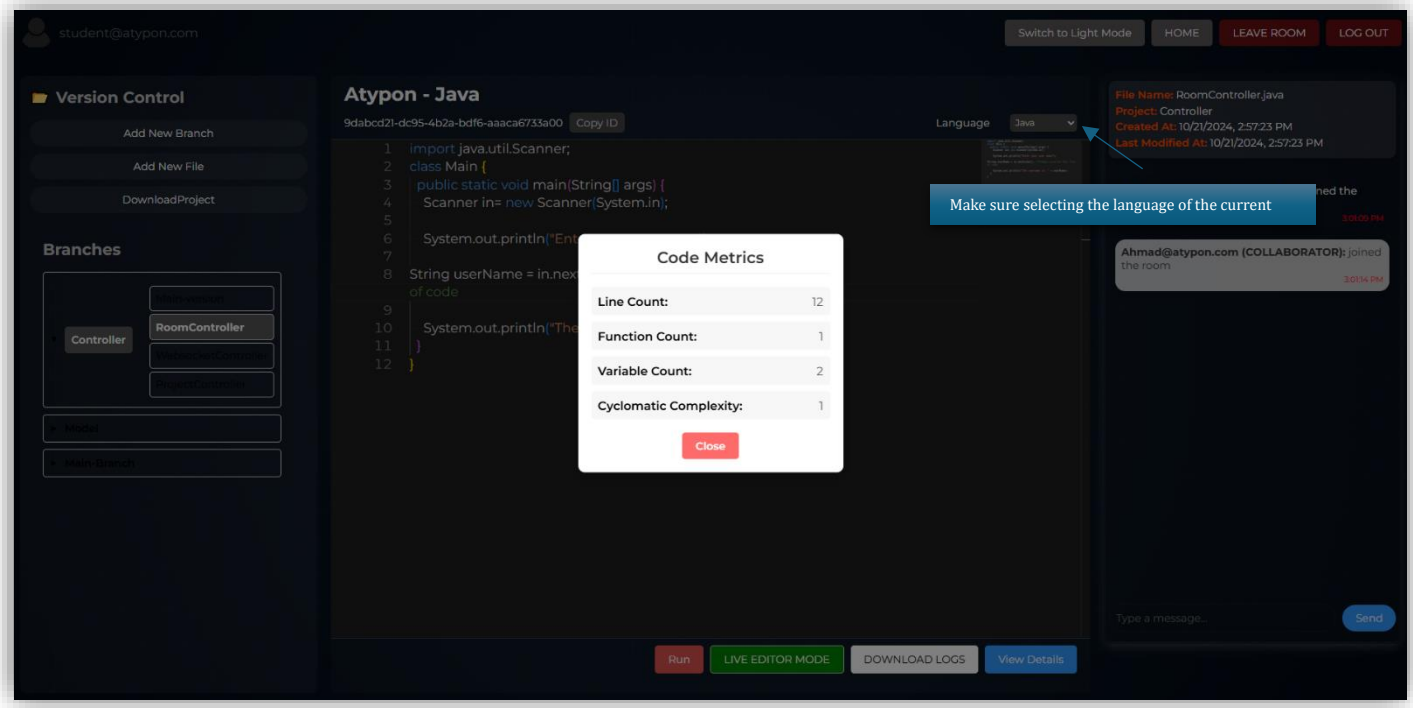


2.3 Viewer: Viewing, Logs and Assessment

- **Displaying Code Metrics:**

  Action: Viewers can assess the code quality and complexity.

  Process: The system displays metrics such as the number of lines, functions, variables, and the cyclomatic complexity. This information aids Viewers in evaluating the contributions of Collaborators and understanding the code structure (for now this feature is allowed only to java and python).

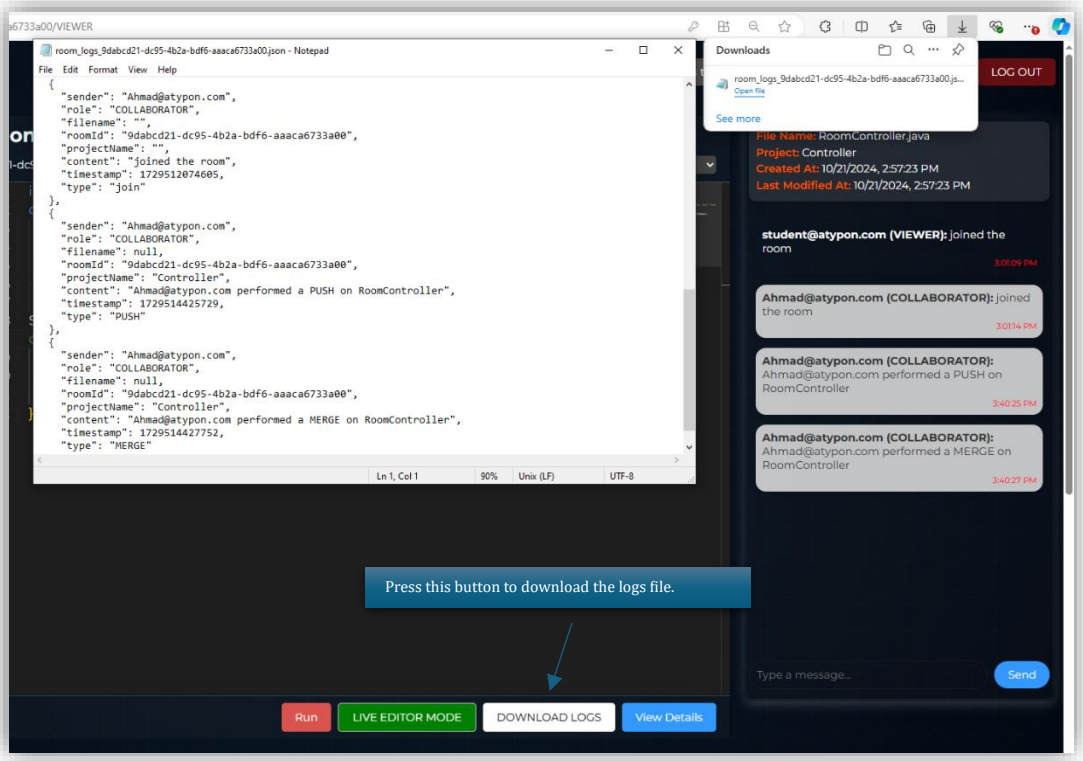


- **Downloading Logs:**

  Action: Viewers can download a log file that contains detailed information about project activity.

  Process: This log file includes data on who pushed or merged files, as well as who joined or left the room. Such logs are essential for tracking changes and contributions.

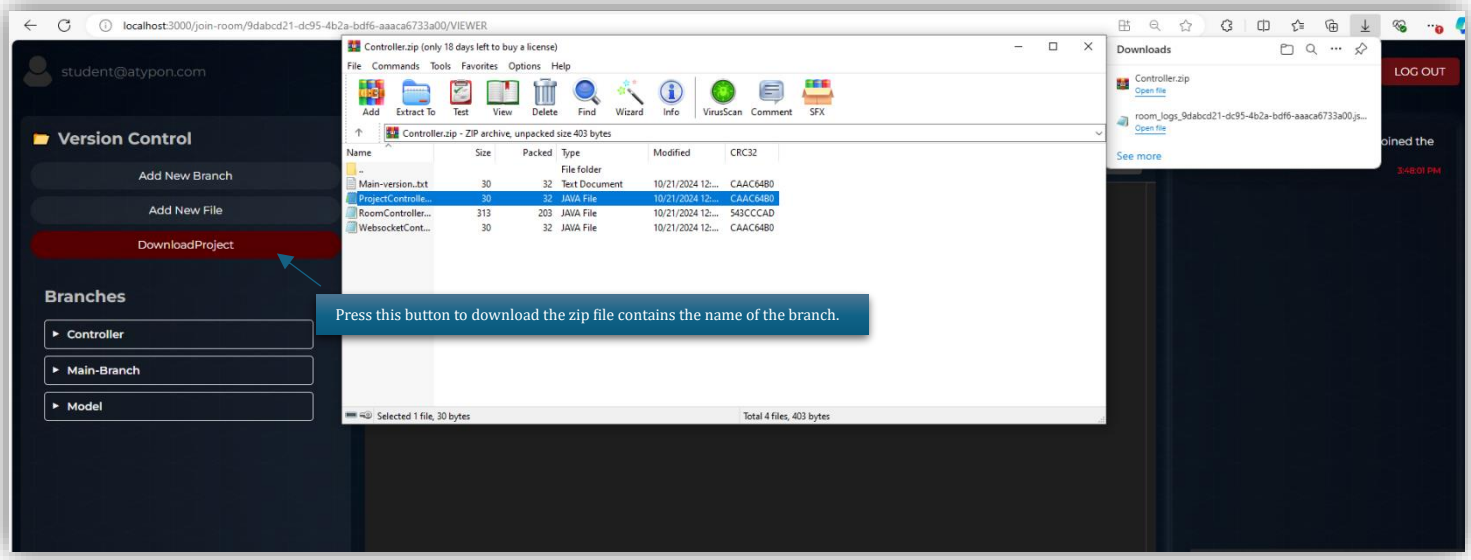
2.3 Viewer: Viewing, Logs and Assessment



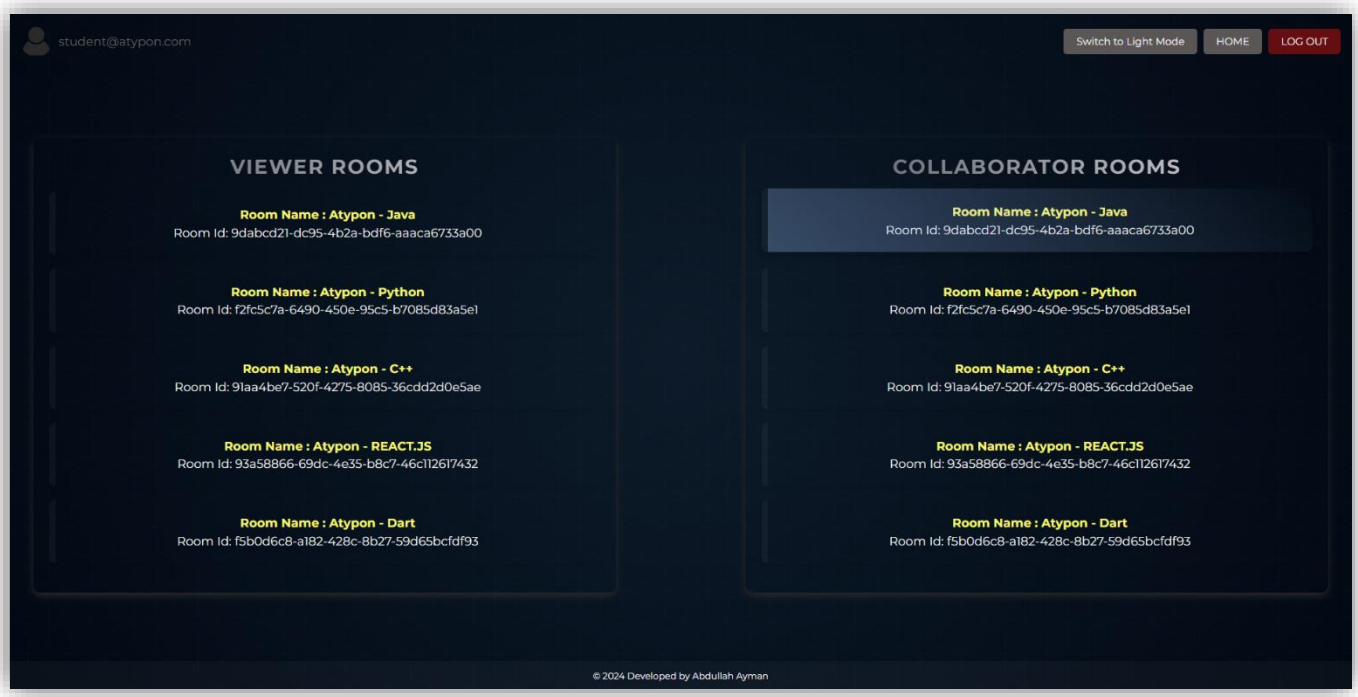
- **Downloading Branches:**

  Action: Viewers have the option to download any branch of the project.

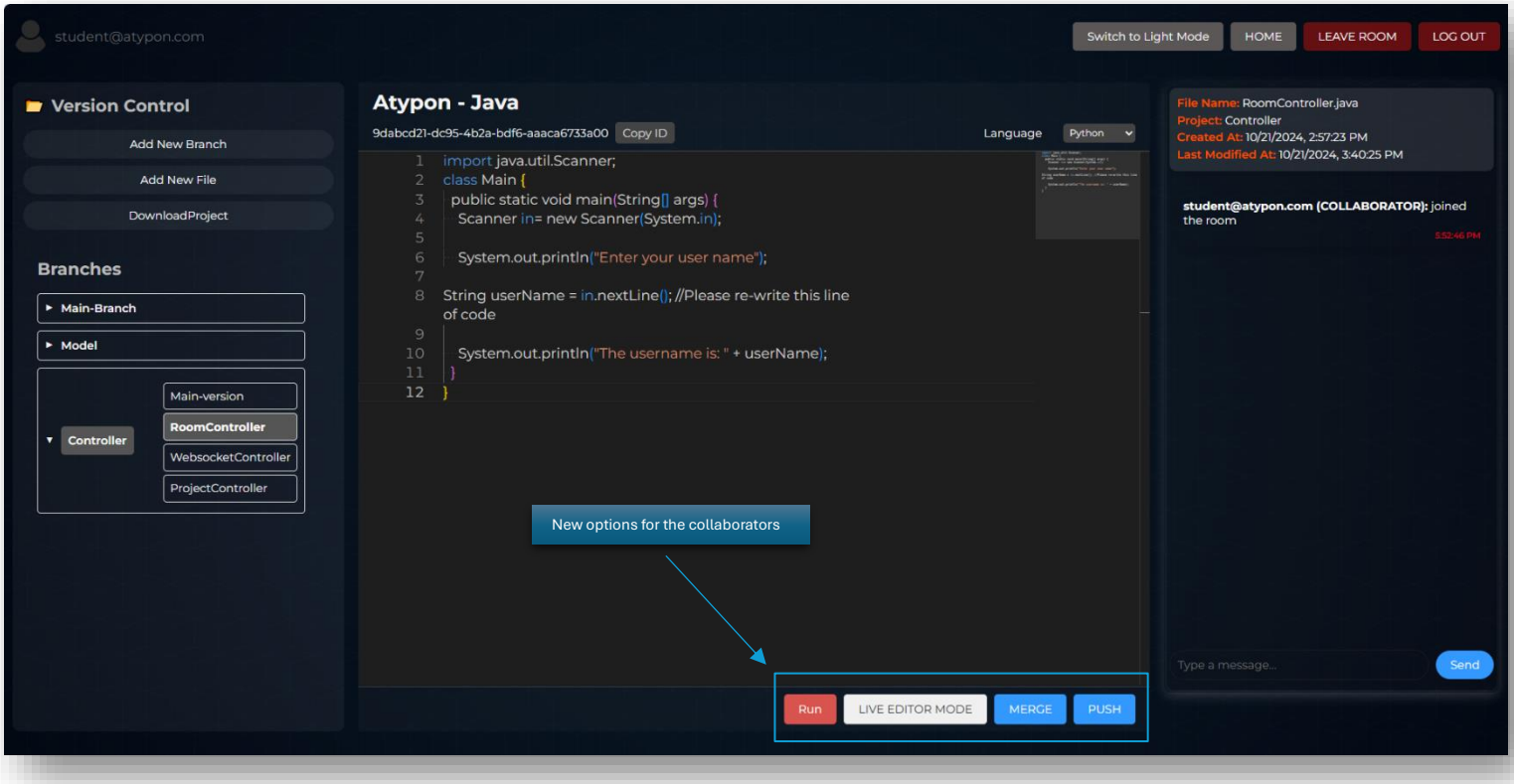
  Process: This feature enables them to access specific versions of the code for local review or testing.



2.4 Collaborator: Editing, Versioning



Collaborators, once they join a room, they can engage with the project by accessing the latest code, Collaborators play a key role in the code editing process, actively contributing to project development in real time. Download, PUSH and merge then handling everything from writing code to resolving conflict. This functionality enhances collaboration, enabling multiple contributors to work efficiently within a shared environment.



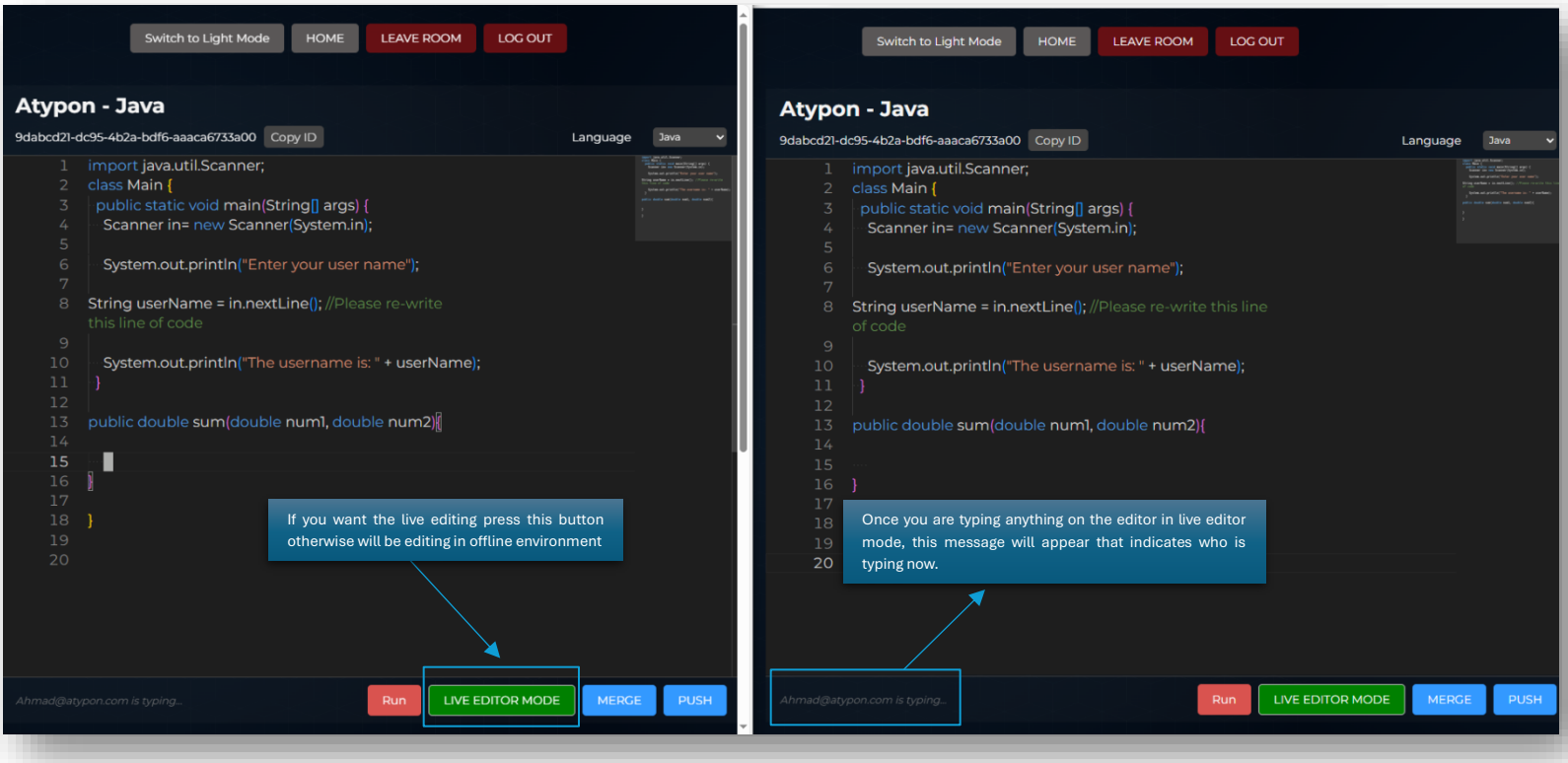
2.4 Collaborator: Editing, Versioning

Collaborator Features:

➢ Joining the Room and Live Editing:

Action: Once a Collaborator joins the room and selects a branch and file, they can immediately begin editing the code in real time.

Process: Any changes made by the Collaborator are instantly reflected in the editor, allowing other Collaborators to see updates live.

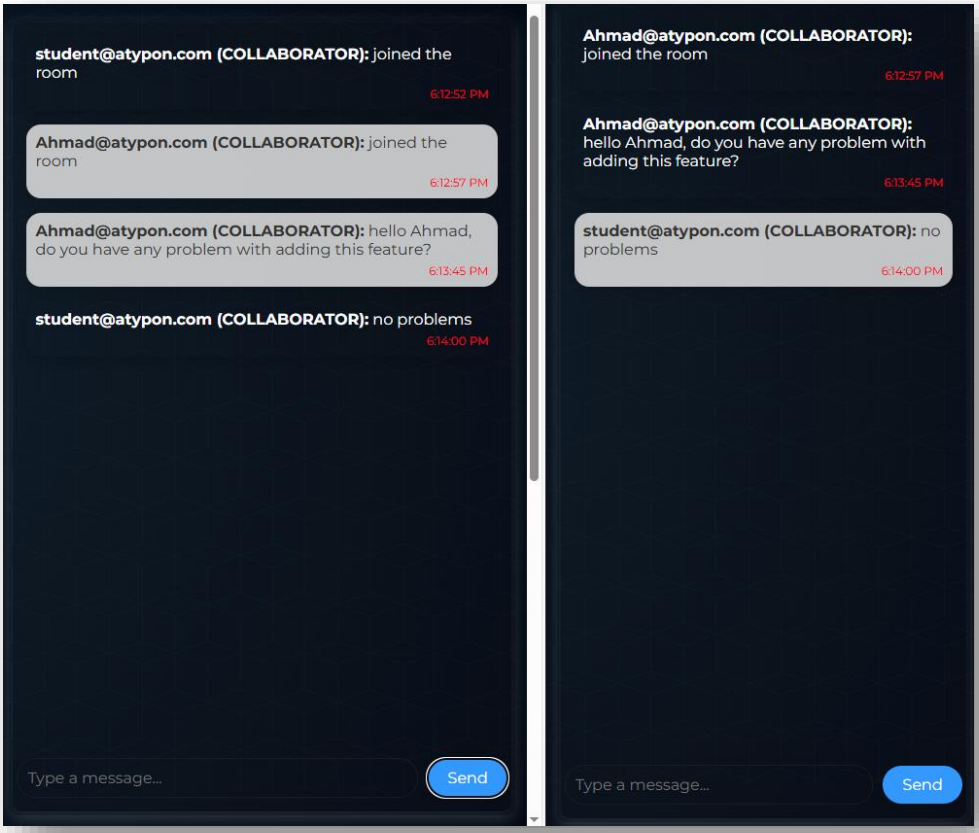


➢ Live Chat and Discussion:

Action: Collaborators can engage in live discussions with other members using the chat box on the right side of the page.

Process: This feature facilitates communication and decision-making, ensuring that Collaborators stay aligned while working on the code.

2.4 Collaborator: Editing, Versioning



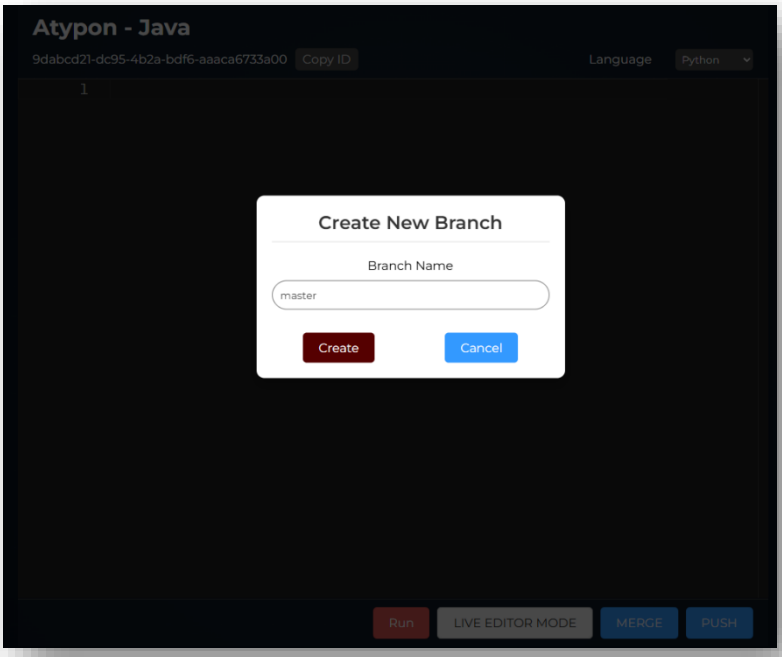
- **Version Control (GitHub-like):**

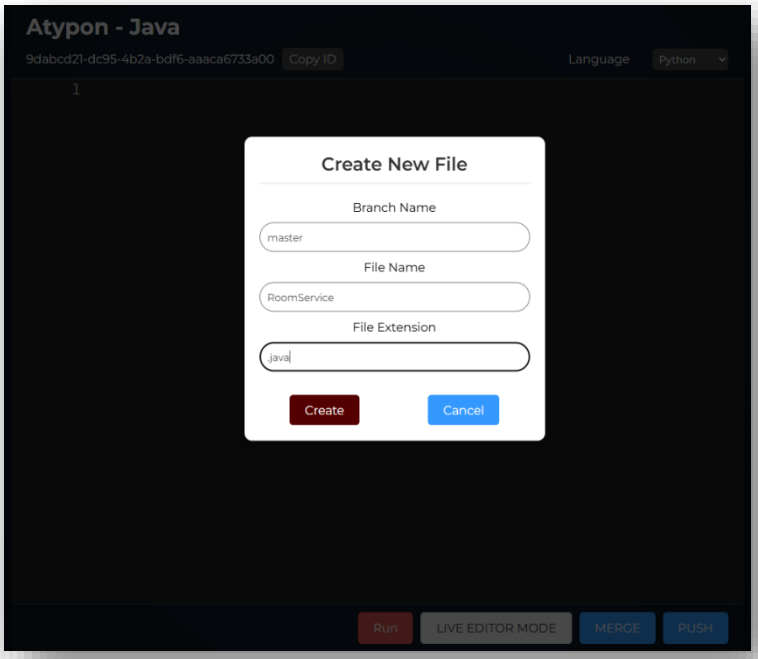
  Action: Collaborators have full version control functionality similar to GitHub.

  Key Processes:

  - **Creating Files:** Collaborators can create new files by clicking “Create File”**.**
  - **Creating Branches:** New branches can be created by clicking “Create project”**.**
  - **Merging Code (MERGE):** Collaborators can merge the live-edited code, which will replace the persistent version stored in the database. If conflicts arise, they must be resolved manually within the editor.
  - **Handling Conflicts** (PUSH it after handling): After addressing any code conflicts, the Collaborator must press **"PUSH"** to update the database with the new changes. This ensures that the final version is saved and reflected across the project.
  - **Downloading Branches:** download branches in a ZIP file for offline review or backup.

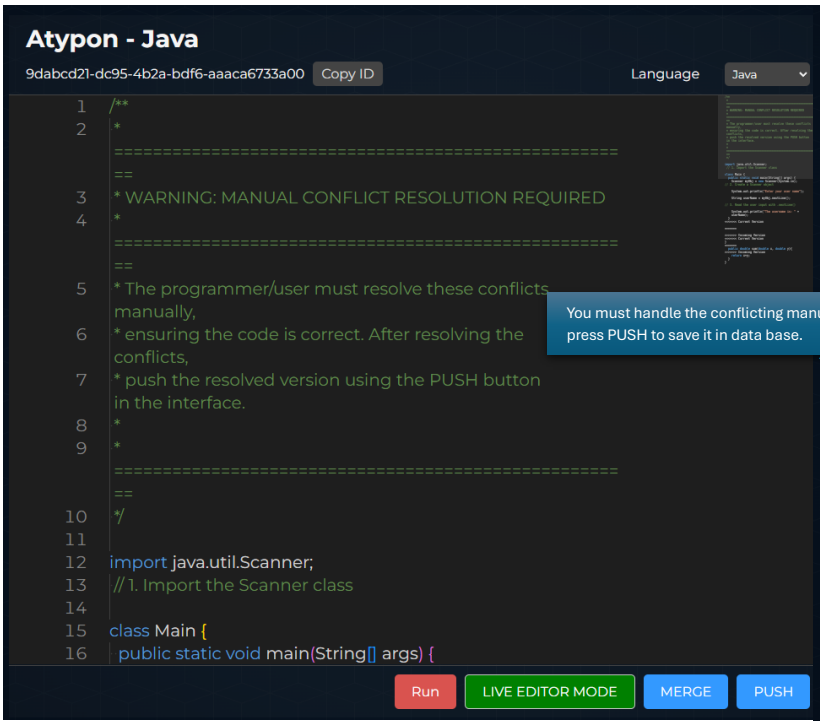
2.4 Collaborator: Editing, Versioning

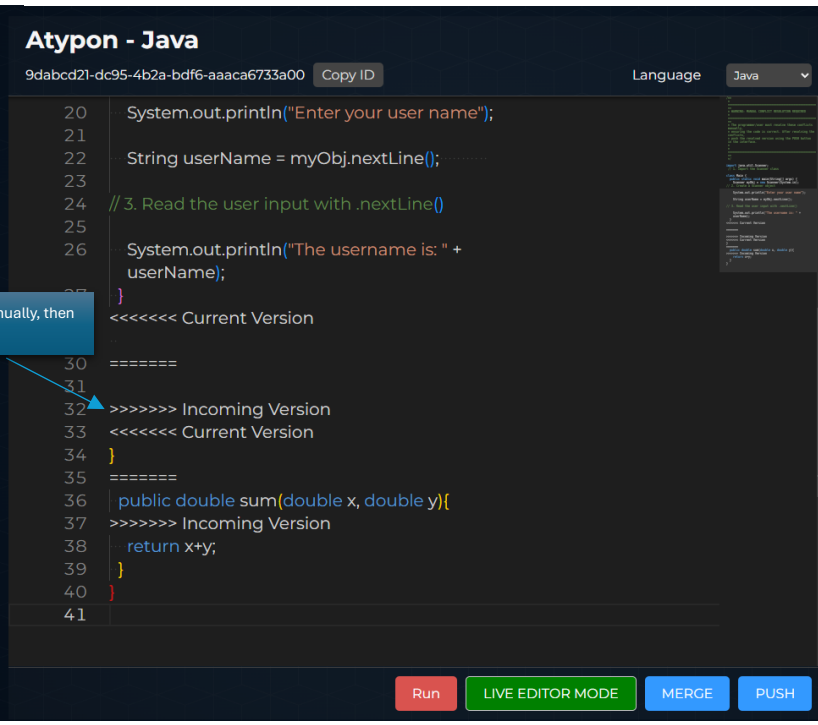




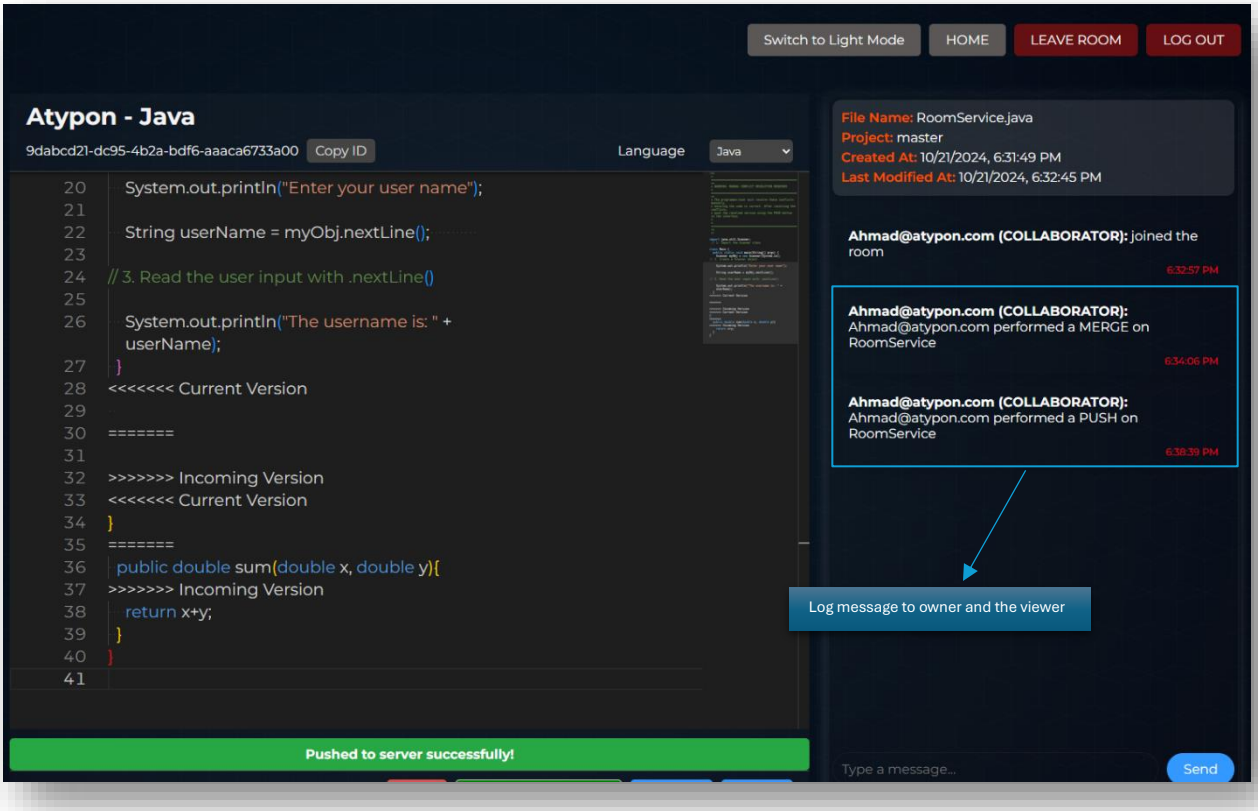
Note

it's important to mention that, for simplicity I have developed like this in the future work I want to make it in more details and features.





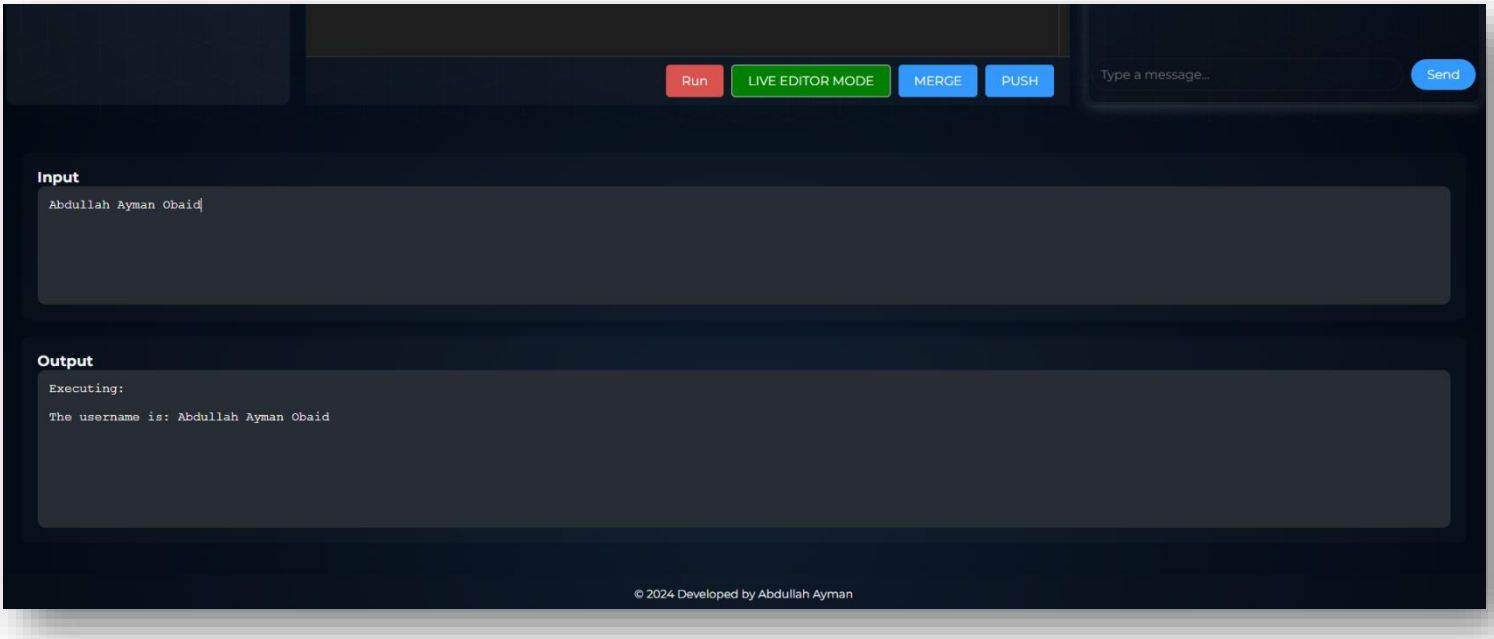
2.4 Collaborator: Editing, Versioning



- **Running Code:**

  Action: Collaborators could run the code directly in the editor.

  Process: The interface provides an input area where Collaborators can enter data, and an output area where the results of the code execution are displayed.



2.4 Collaborator: Editing, Versioning

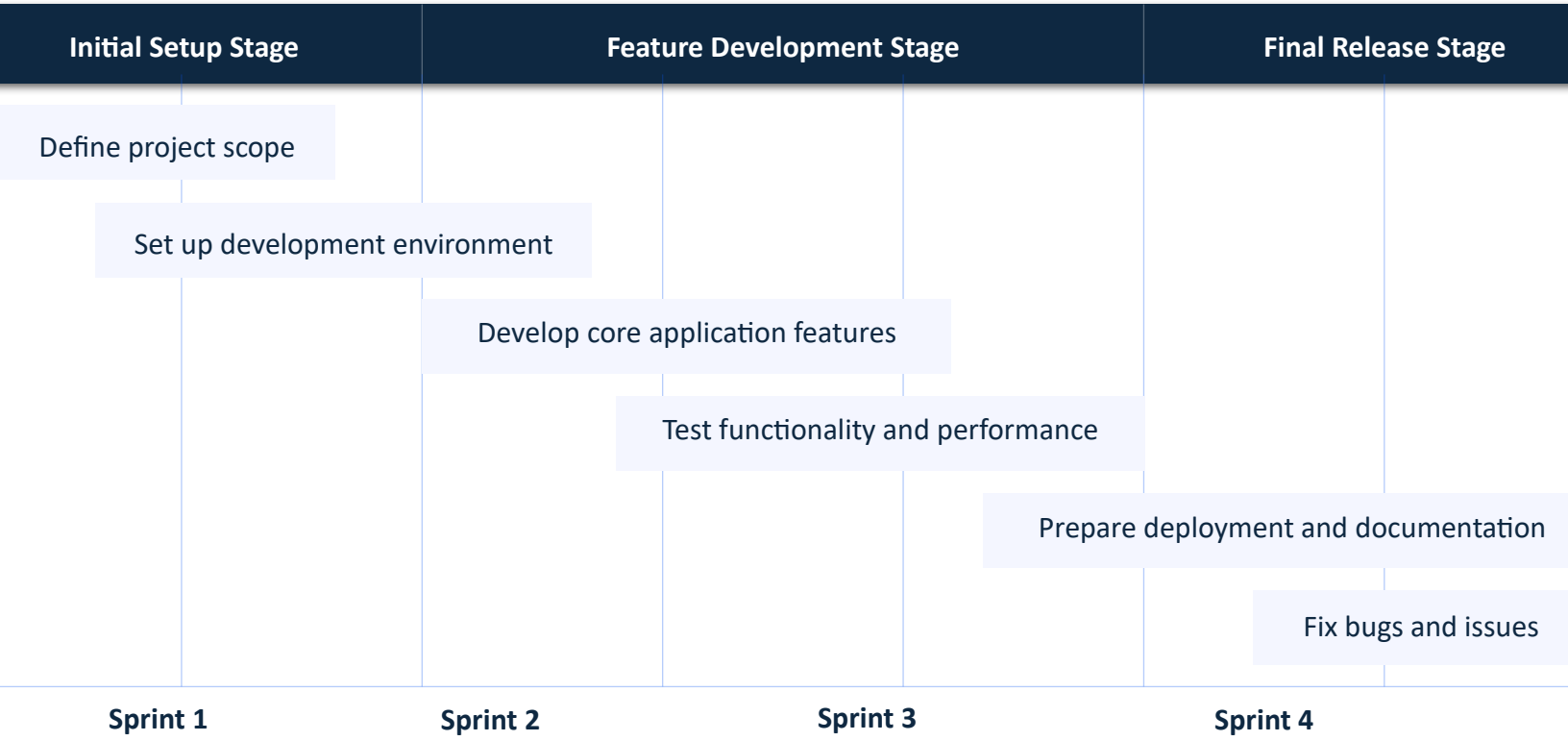
Note

it's important to mention that our editor has different functionalities that make developer's life easier, these features like those ones in VS Editor.

System Design and Architecture

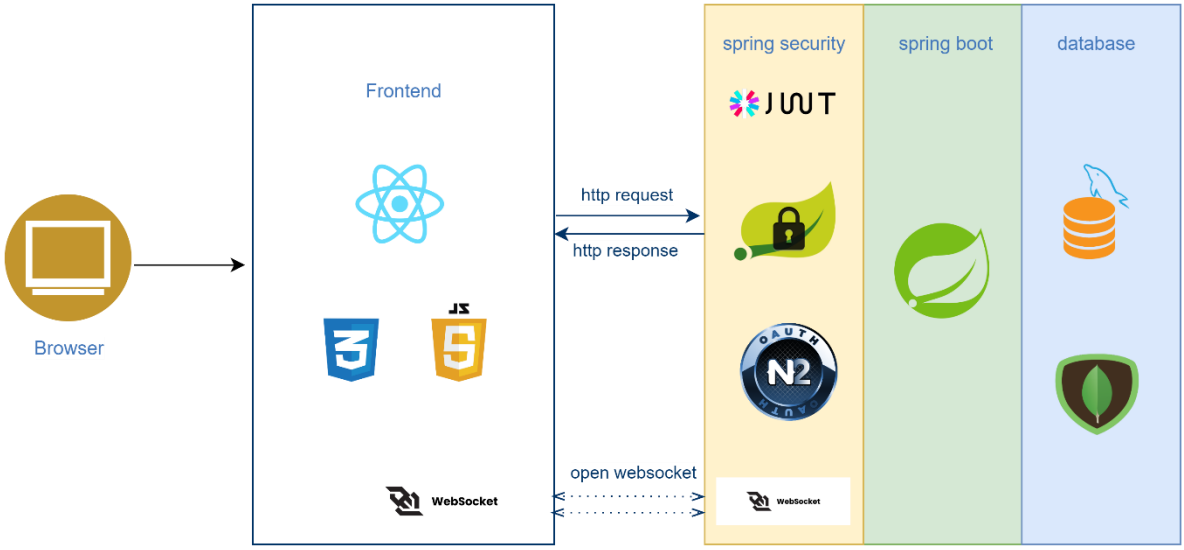
Before starting any software project, it's essential to plan effectively, and Agile methodology provides the framework to do so in a structured yet flexible manner. Our project will be divided into four **one-week sprints**, each focused on delivering key features incrementally. This short sprint cycle allows for frequent feedback. By organizing the work into manageable, focused sprints, we ensure consistent progress.

3.1 Agile project roadmap



OVERVIEW This Agile project focuses on delivering a robust software solution in three key stages: initial setup, feature development, and final release. Over four weeks, I will define the project scope, develop core features, test performance, fix bugs, and prepare for deployment, ensuring timely and efficient delivery.

3.2 Overview of System Architecture



- **Client-Side (Frontend):**
  - **WebSocket for Real-Time Collaboration:** Upon accessing a room, a WebSocket connection is opened between the frontend and the server. This connection supports real-time code editing, live updates, and chat functionality among Collaborators.
  - **User Authentication:** The login process initiates when a user enters their credentials (username and password or OAuth provider), which are sent to the backend via an HTTP request.
- **Backend (Server-Side):**
  - **Spring Boot (Java):** The server is built using the Spring Boot framework.
  - **Authentication Flow:**
    - **Spring Security (OAuth 2.0, JWT).**
    - **JWT Token for Authorization.**
    - **Role-Based Access Control (RBAC).**
- **Database Layer:**
  - **MongoDB (NoSQL)** for File Versions and Code Updates.
  - **MySQL (Relational)** for Room and Project Management.
- **WebSocket Communication:**
  - **Real-Time Code Editing:**
  - **Live Chat.**

3.3 Database Design

In this section, I will explain the schema design choices for both MySQL and MongoDB, along with the challenges encountered, and propose diagram suggestions to illustrate the structure. The database design of the collaborative code editor integrates both relational and non-relational databases, making use of MySQL for structured relationships **(users, rooms, projects)** and MongoDB for unstructured, high-volume **data (file versions, real-time code updates, logs)**. This hybrid database approach ensures a balance between the structured data relationships and flexible, dynamic data storage for file versioning and collaboration.

1. **MySQL Schema Design:**
   The relational database in MySQL is used to manage users, rooms, projects, and their relationships. Each entity has its own table with structured relationships to represent ownership, project management, and membership roles.

   Key Entities in MySQL:
   - **User:** Represents users in the system, each having a unique username, email, and role (e.g., USER, ADMIN). A user can have different memberships in various rooms.

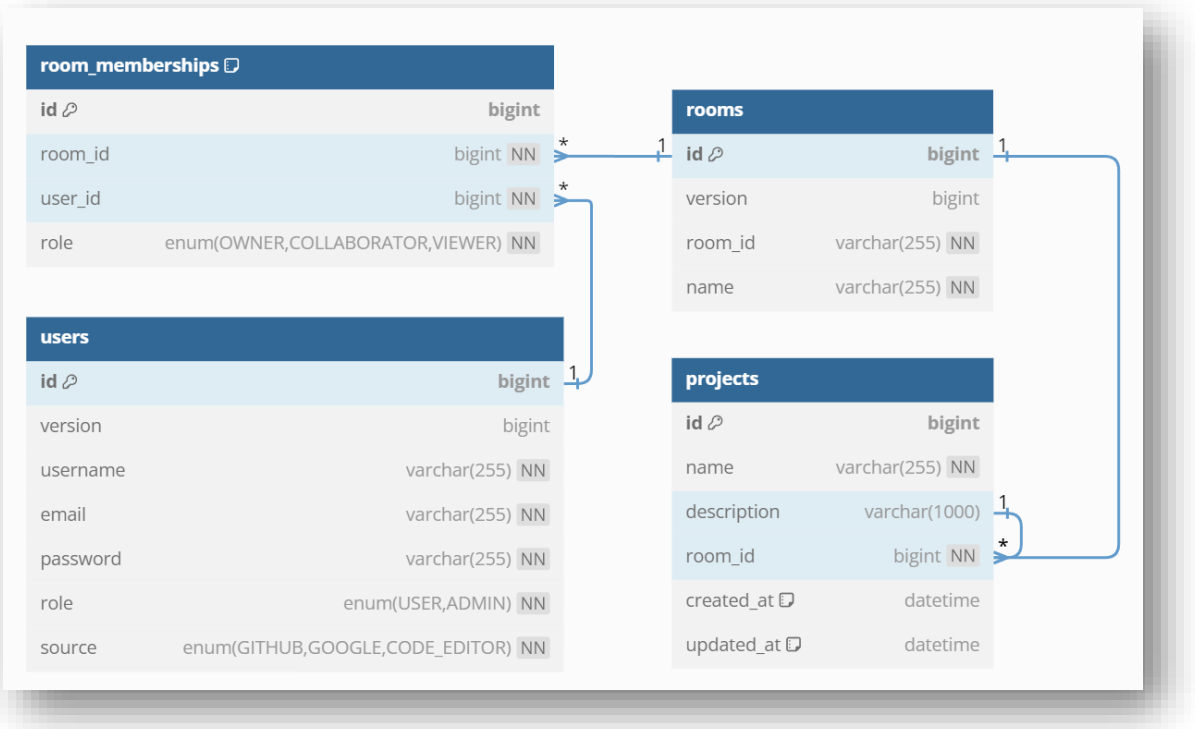
   - **Room:** Each room is a collaborative space where projects are managed. Rooms are associated with multiple users through the RoomMembership table, defining their roles (Owner, Collaborator, Viewer).

   - **Project:** Each room contains multiple projects. Projects have a relationship with a room and store details such as name, description, and timestamps (createdAt, updatedAt).

   - **RoomMembership:** This table handles the many-to-many relationship between users and rooms, allowing users to join multiple rooms with specific roles **(Owner, Collaborator, Viewer).**

3.3 Database Design

❖ **Schema Diagram for MySQL:** In this diagram, tables like User, Room, Project, and RoomMembership represented with relationships:



2. **MongoDB Schema Design:**

MongoDB is used for dynamic, high-volume data, such as file versions, real-time code updates, and chat logs. The flexibility of MongoDB allows storing various file versions and real-time code changes efficiently.

Key Collections in MongoDB:

- **File:** Stores information about individual file versions. Each document stores details such as filename, roomId, projectName, content, creation and modification timestamps, and file extension.

- **CodeUpdate:** This collection stores real-time code updates during live editing. It tracks which user made changes, which file and project were affected, the line number, and the specific changes made.

- **Project:** Each room contains multiple projects. Projects have a relationship with a room and store details such as name, description, and timestamps (createdAt, updatedAt).

- **MessageLog:** Stores logs of messages sent in the chat, tracking the sender, role, filename, room, and project. This helps in keeping a detailed history of collaboration activities.

3.3 Database Design

❖ **Design Considerations and Problems Faced:**

- **Cascading in Relational Models:** One issue encountered was managing cascading operations between rooms and users. To prevent unwanted deletions when removing a room, a **RoomMembership** entity was introduced to **separate concerns between rooms and users.**

- **File Updates in MongoDB:** Updating documents in MongoDB with dynamic content, especially file updates, proved challenging. The requirement to pass the entire document for updates **does not align with clean code principles**, leading to a more verbose update logic compared to MySQL's simpler save operation.

```
@Modifying
@Update(update = "{ 'filename' : ?0, 'projectName' : ?1, 'roomId' : ?2, 'content' : ?3, 'createdAt' :
@Query(value = "{ 'filename' : ?0, 'projectName' : ?1, 'roomId' : ?2}")
@Lock(LockModeType.PESSIMISTIC_WRITE)
void upsertFileContent(@Param("filename") String filename,
                       @Param("projectName") String projectName,
                       @Param("roomId") String roomId,
                       @Param("content") String content,
                       @Param("createdAt") Long createdAt,
                       @Param("lastModifiedAt") Long lastModifiedAt,
                       @Param("extension") String extension);
```

3.4 Security Design

In this section, I will explain the security architecture of the collaborative code editor project:

1. **General Technologies Used:** For the security design in this project, I employed the following technologies to ensure secure authentication and access control:

   - **OAuth 2.0** for third-party authentication with GitHub and Google.
   - **JWT (JSON Web Tokens)** for token-based authentication to maintain stateless sessions between the front end and back end.
   - **Role-Based Access Control (RBAC)** to manage permissions for three user roles: Owner, Collaborator, and Viewer.
   - **Spring Security** to handle HTTP requests, authentication, and authorization.
   - **BCrypt** for password hashing and storage, ensuring secure user credentials.

2. **Custom Sign-Up Implementation:** The system supports its own user registration process alongside OAuth 2.0. In the custom sign-up process, users provide their email, username, and password. These are validated using specific criteria before being stored in the database.

   Sign-Up Workflow:

   - The password must meet certain security standards, such as having a minimum length of 8 characters, containing uppercase and lowercase letters, digits, and special characters.

   - **Email Validator:** Ensures that the email format is valid.

3.4 Security Design

- **Password Validator:** Checks if the password is secure enough, avoiding common passwords, and not allowing personal information (username or email) within the password.

- The password is hashed using **BCrypt** for security, ensuring no plaintext passwords are saved in the database.

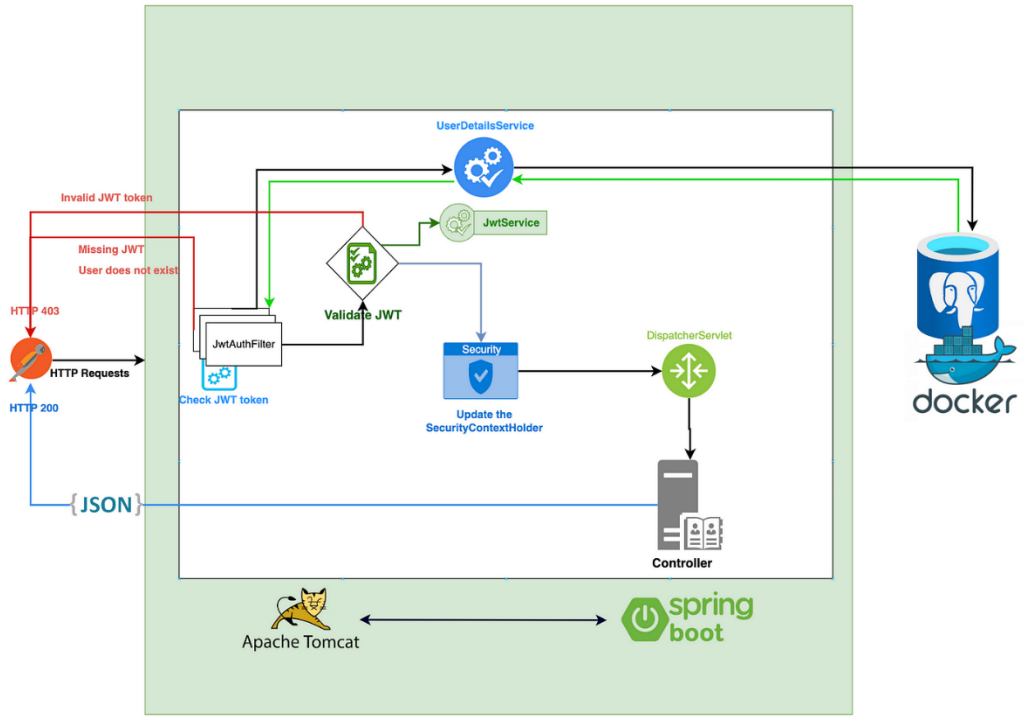
```java
public class PasswordValidator {

    private static final int MIN_LENGTH = 8;
    private static final List<String> COMMON_PASSWORDS = Arrays.asList("password", "123456", "qwerty", "admin");

    public static void validatePassword(String password, String username, String email) {
    // custom ...
    }

    private static boolean containsUpperCase(String password) {
        return password.chars().anyMatch(Character::isUpperCase);
    }

    private static boolean containsLowerCase(String password) {
        return password.chars().anyMatch(Character::isLowerCase);
    }

    private static boolean containsDigit(String password) {
        return password.chars().anyMatch(Character::isDigit);
    }

    private static boolean containsSpecialCharacter(String password) {
        return password.chars().anyMatch(ch → "!@#$%^&*()_+{}[]|:;<>,.?/~`-=".indexOf(ch) ⩾ 0);
    }
}
```

```java
public class EmailValidator {

    private static final String EMAIL_REGEX = "^[A-Za-z0-9+_•—]+@[A-Za-z0-9•—]+$";

    private static final Pattern EMAIL_PATTERN = Pattern.compile(EMAIL_REGEX);

    public static void validateEmail(String email) {
        if (email == null || !EMAIL_PATTERN.matcher(email).matches()) {
            throw new IllegalArgumentException("Invalid email format");
        }
    }
}
```

```java
@Override
@Transactional
public void createUser(User user) {

    EmailValidator.validateEmail(user.getEmail());
    PasswordValidator.validatePassword(user.getPassword(), user.getUsername(), user.getEmail());

    if (userRepository.findOneByEmail(user.getEmail()).isPresent()) {
        throw new IllegalArgumentException("User with this email already exists.");
    }

    user.setPassword(encoder.encode(user.getPassword()));

    try {
        userRepository.save(user);
    } catch (Exception e) {
        throw new RuntimeException("Failed to create user", e);
    }
}
```

3.4 Security Design

3. **JWT-Based Authentication Flow:** Once a user logs in using their credentials, a JWT token is generated and returned to the front end. This token is used for all future API requests, enabling stateless authentication between the client and server.



JWT Authentication Workflow:

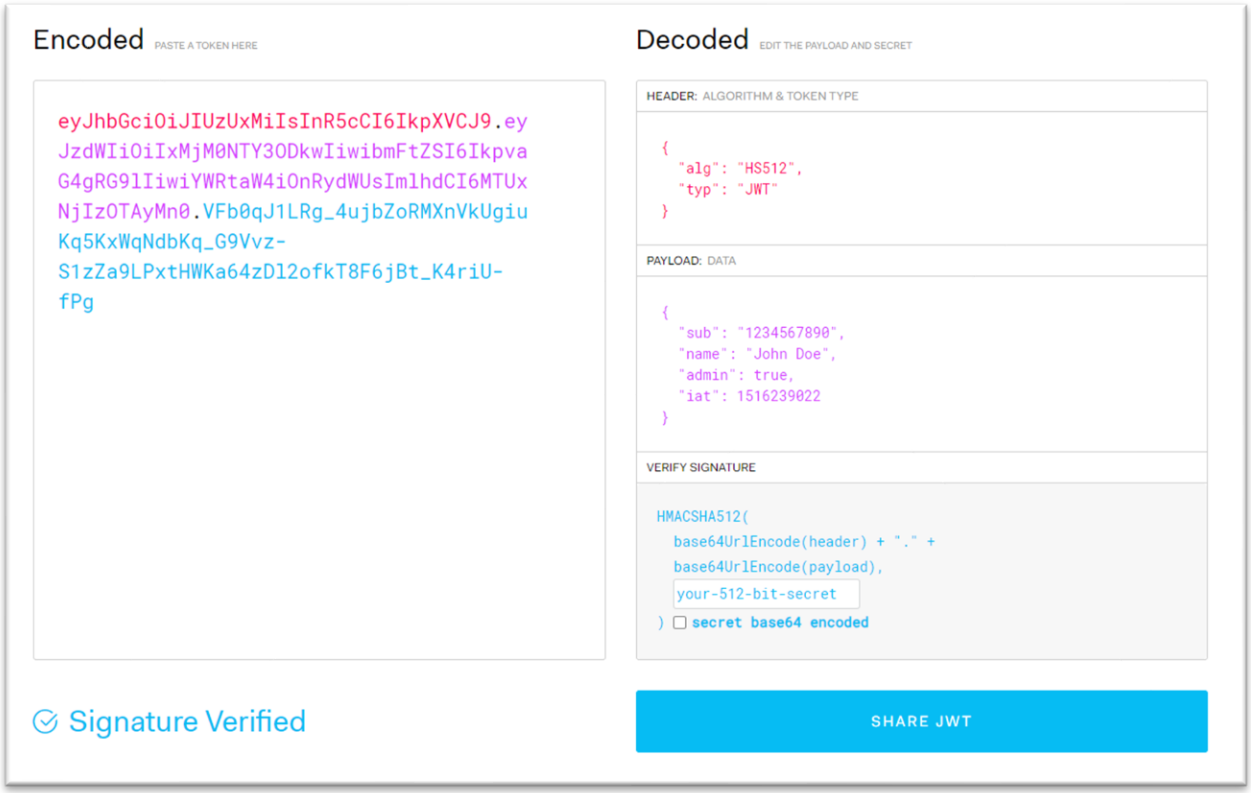
- The user provides login credentials (email and password) via a /sign-in endpoint.
- The AuthenticationService verifies the credentials using Spring Security's AuthenticationManager and returns a JWT upon successful verification.
- The JWT is generated using the user's email and an expiration time (10 hours in this case).
- The JWT is then sent back to the front end and stored (typically in the browser's local storage).
- For any future API requests, the JWT is included in the request's Authorization header (Bearer <token>).
- The back end validates the JWT and processes the request if the token is valid.

```java
public String verify(LoginRequest loginRequest) {
    Authentication authentication = authenticateUser(loginRequest);
    return jwtUtil.generateToken(authentication);
}
```

3.4 Security Design

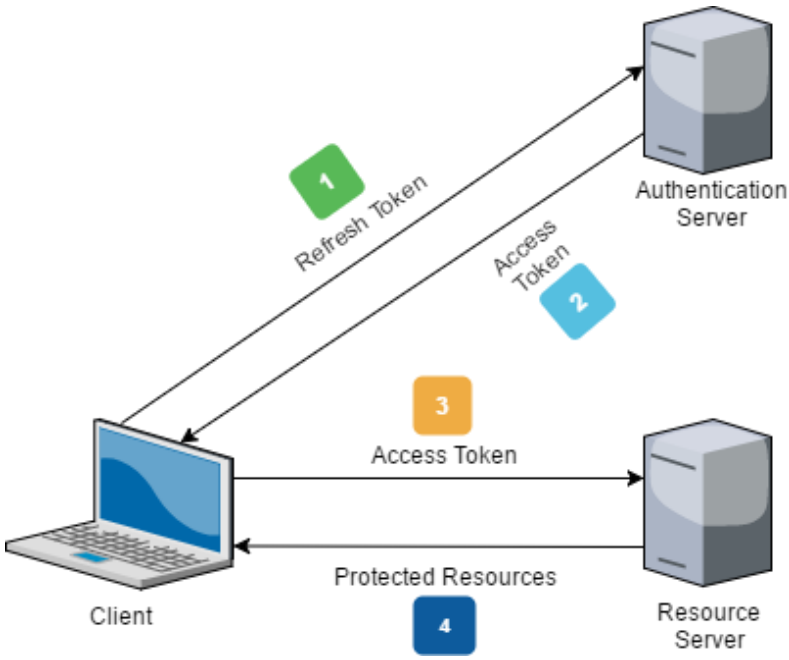
- The token contains information like the user's email, issued time, and expiration, and it's signed using a **HMAC SHA-512** algorithm.

```java
@Component
public class JwtUtil {

    private final SecretKey SECRET_KEY = Keys.secretKeyFor(SignatureAlgorithm.HS512);
    private final UserDetailsService userDetailsService;
    private static final long TOKEN_VALIDITY = 1000 * 60 * 60 * 10; // 10 hours

    public JwtUtil(UserDetailsService userDetailsService) {
        this.userDetailsService = userDetailsService;
    }

    public String generateToken(Authentication authentication) {
        String email = getEmail(authentication);

        return Jwts.builder()
                .setSubject(email)
                .setIssuedAt(new Date())
                .setExpiration(new Date(System.currentTimeMillis() + TOKEN_VALIDITY))
                .signWith(SECRET_KEY)
                .compact();
    }
```



3.4 Security Design

4. **OAuth 2.0 Authentication Flow:** In addition to custom sign-in, the system integrates OAuth 2.0 to allow users to authenticate via third-party providers like Google and GitHub.



OAuth 2.0 Workflow:

- When a user selects Google or GitHub login, they are redirected to the respective provider's OAuth authorization page.
- The authorization code is exchanged for an access token from Google or GitHub.
- The access token is used to retrieve user details (e.g., email, username) from the OAuth provider
- If the user exists in the system, they are authenticated and a JWT token is generated for the session.
- If the user is new, a new account is created in the system.

JWT Token with OAuth:

- After successful OAuth login, a new JWT token is generated for the user and sent back to the front end for future authenticated requests, just as it would be for a regular login.

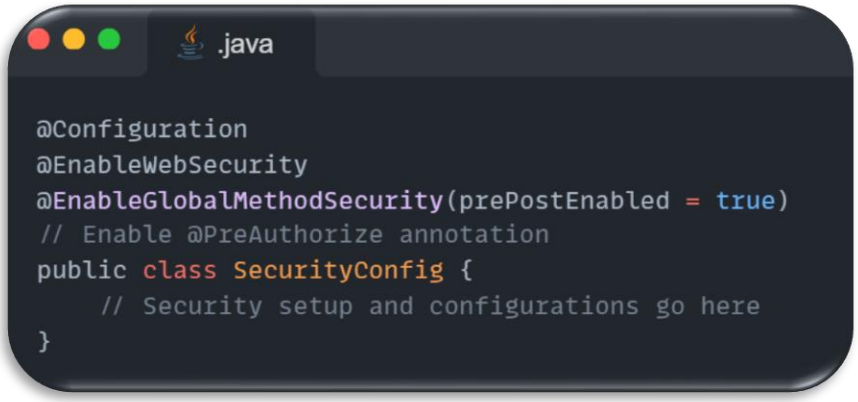
```java
@Override
public void onAuthenticationSuccess(HttpServletRequest request, HttpServletResponse response
    if (authentication instanceof OAuth2AuthenticationToken oauthToken) {
        String registrationId = oauthToken.getAuthorizedClientRegistrationId();
        if ("google".equalsIgnoreCase(registrationId)) {
            handleGoogleLogin(oauthToken.getPrincipal());
        } else if ("github".equalsIgnoreCase(registrationId)) {
            handleGitHubLogin(oauthToken.getPrincipal());
        }
    }
    String jwtToken = generateJwtToken(authentication);
    response.sendRedirect("http://localhost:3000/oauth2/redirect?token=" + jwtToken);
}
```

3.4 Security Design

5. **Role-Based Access Control:** In this project, Role-Based Access Control (RBAC) has **three roles** in the system: **Owner, Collaborator, and Viewer**. These roles define what actions a user can perform within a room, such as editing files, managing projects, or simply viewing content.

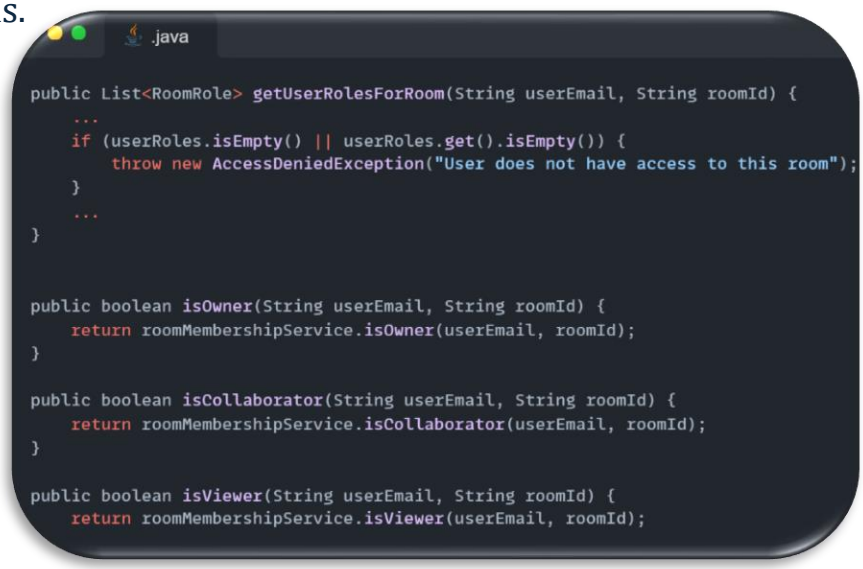
Security Configuration

- The security configuration enables global method security, allowing us to use annotations like @PreAuthorize to control access at the method level.



```java
@Configuration
@EnableWebSecurity
@EnableGlobalMethodSecurity(prePostEnabled = true)
// Enable @PreAuthorize annotation
public class SecurityConfig {
    // Security setup and configurations go here
}
```

Role Checks in the Service Layer: In the service layer, the **RoomSecurityService** interacts with the **RoomMembershipService** to determine the roles of users within rooms.



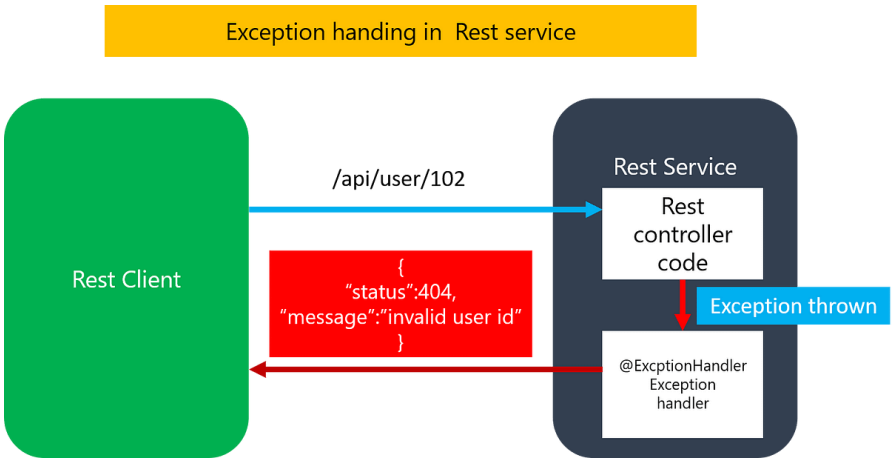
```java
public List<RoomRole> getUserRolesForRoom(String userEmail, String roomId) {
    ...
    if (userRoles.isEmpty() || userRoles.get().isEmpty()) {
        throw new AccessDeniedException("User does not have access to this room");
    }
    ...
}


public boolean isOwner(String userEmail, String roomId) {
    return roomMembershipService.isOwner(userEmail, roomId);
}

public boolean isCollaborator(String userEmail, String roomId) {
    return roomMembershipService.isCollaborator(userEmail, roomId);
}

public boolean isViewer(String userEmail, String roomId) {
    return roomMembershipService.isViewer(userEmail, roomId);
```

Room Access Control

The key access methods are protected using @PreAuthorize annotations. These annotations check the user's role in the room before allowing access to certain

```java
@PreAuthorize("@roomSecurityService.canViewRoom(principal.username, #roomId)")
@PostMapping("/join-room/{roomId}")
public ResponseEntity<String> joinRoom(@PathVariable("roomId") String roomId,
    return ResponseEntity.ok("Room");
}
```

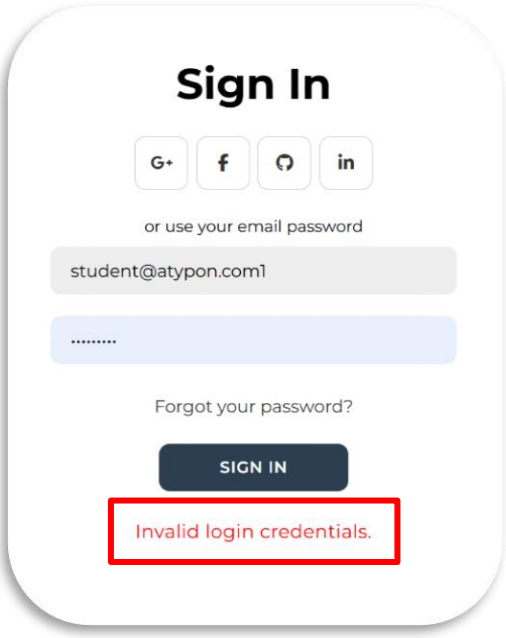
3.5 Exception Handling Design

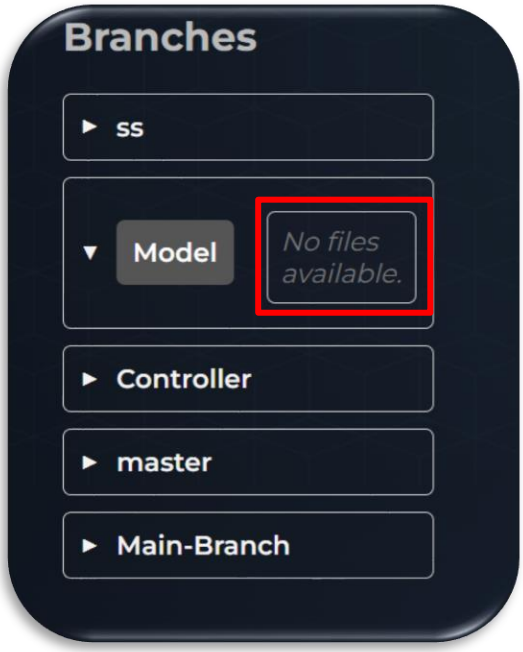


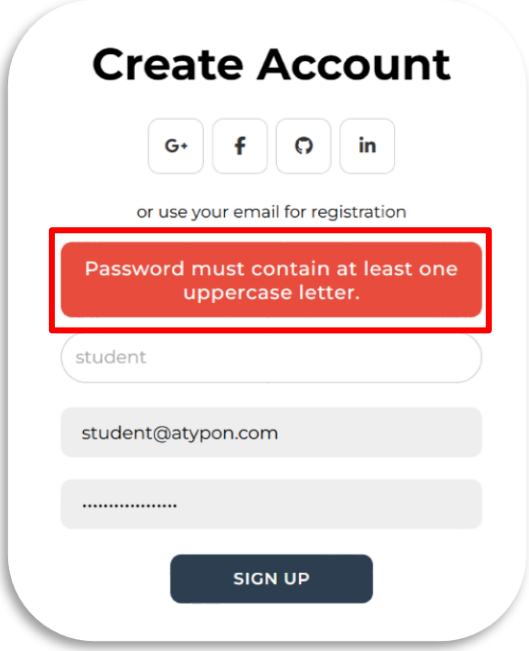
In my project, I've implemented a centralized exception handling mechanism using **@RestControllerAdvice** and a **GlobalExceptionHandler** class. This approach enables consistent and organized handling of exceptions that may arise throughout the application. By using this design, exceptions are handled in a clean, maintainable manner.

Exception Types: The system handles multiple types of exceptions:

- **User-Related Exceptions**: E.g., UserNotFoundException, InvalidCredentialsException.
- **File and Project Exceptions:** E.g., FileNotFoundException, FileAlreadyExistsException, ProjectNotFoundException.
- **Room Exceptions:** E.g., RoomNotFoundException, RoomCreationException, RoomDeletionException.
- **General Exceptions:** A fallback handler for uncaught exceptions, which returns a generic error message.







3.5 Exception Handling Design

```java
@ExceptionHandler(UserNotFoundException.class)
@ResponseStatus(HttpStatus.NOT_FOUND)
public Map<String, String> handleUserNotFoundException(UserNotFoundException ex) {
    logger.warn("User not found: {}", ex.getMessage(), ex);
    return createErrorResponse("User Not Found", ex.getMessage(), "USER_NOT_FOUND");
}

@ExceptionHandler(RoomCreationException.class)
@ResponseStatus(HttpStatus.BAD_REQUEST)
public Map<String, String> handleRoomCreationException(RoomCreationException ex) {
    logger.error("Room creation failed: {}", ex.getMessage(), ex);
    return createErrorResponse("Room Creation Failed", ex.getMessage(), "ROOM_CREATION_FAILED");
}
```

Logging (LoggerFactory SLF4)

plays a role in allowing the system administrator to trace errors and improve the system. By utilizing SLF4J's LoggerFactory, the GlobalExceptionHandler logs each exception according to its severity:

- **Warnings:** These are for recoverable issues like invalid credentials or failed room updates. These logs help the admin identify areas where the user experience might be improved or where minor issues are occurring.

- **Errors:** Critical problems such as missing resources (e.g., user, project, room not found) or internal server errors are logged as errors.

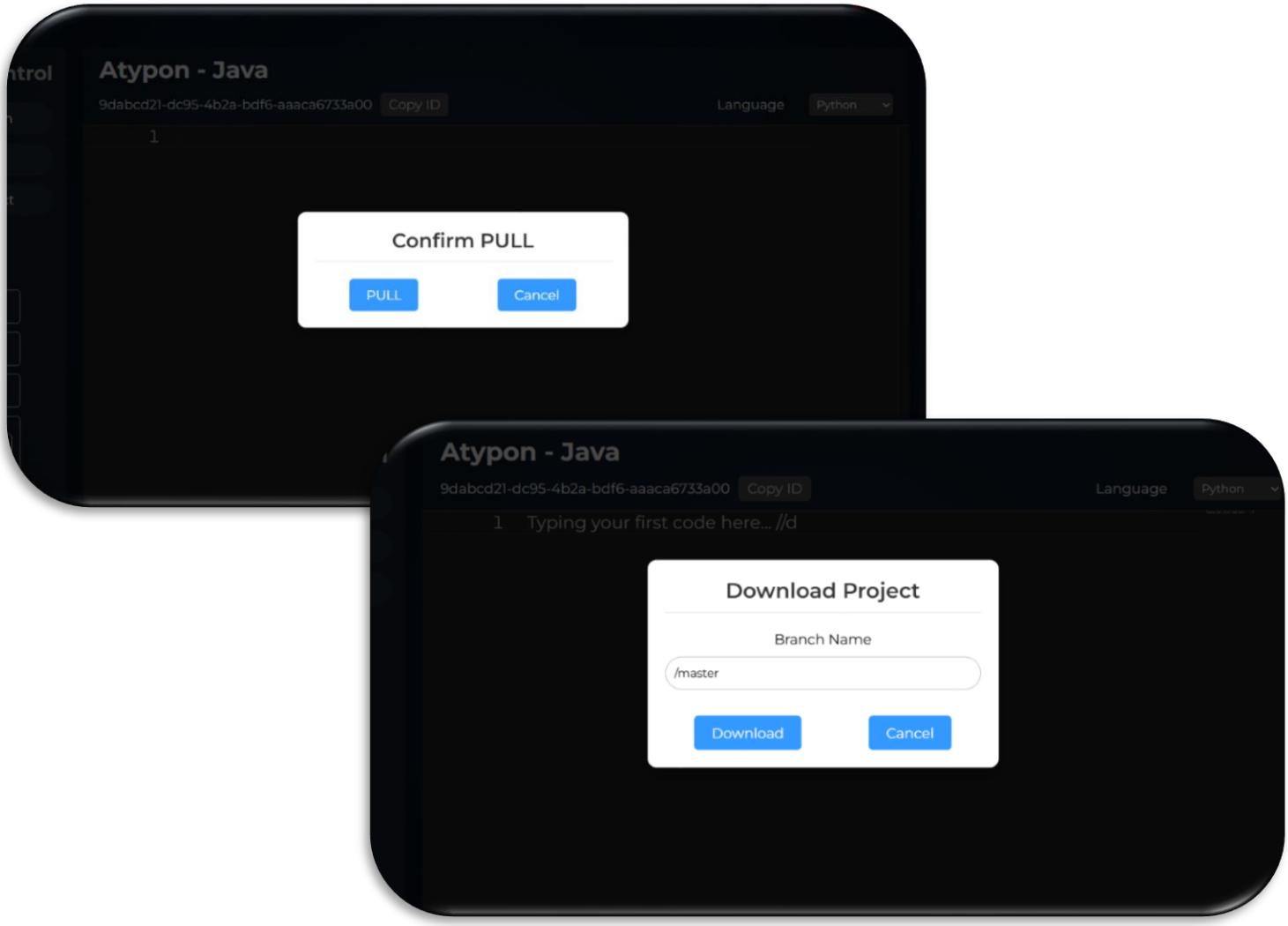
```
2024-10-16T00:46:12.668+03:00 DEBUG 21264 --- [editor] [main] org.hibernate.type.BasicTypeRegistry
2024-10-16T00:46:12.668+03:00 DEBUG 21264 --- [editor] [main] org.hibernate.type.BasicTypeRegistry
2024-10-16T00:46:12.668+03:00 DEBUG 21264 --- [editor] [main] org.hibernate.type.BasicTypeRegistry
2024-10-16T00:46:12.668+03:00 DEBUG 21264 --- [editor] [main] org.hibernate.type.BasicTypeRegistry
2024-10-16T00:46:12.718+03:00  INFO 21264 --- [editor] [main] o.s.o.j.p.SpringPersistenceUnitInfo
2024-10-16T00:46:12.749+03:00  INFO 21264 --- [editor] [main] com.zaxxer.hikari.HikariDataSource
2024-10-16T00:46:14.878+03:00  WARN 21264 --- [editor] [main] o.h.engine.jdbc.spi.SqlExceptionHelper
2024-10-16T00:46:14.878+03:00 ERROR 21264 --- [editor] [main] o.h.engine.jdbc.spi.SqlExceptionHelper

The last packet sent successfully to the server was 0 milliseconds ago. The driver has not received any p
2024-10-16T00:46:14.879+03:00  WARN 21264 --- [editor] [main] o.h.e.j.e.i.JdbcEnvironmentInitiator

org.hibernate.exception.JDBCConnectionException: unable to obtain isolated JDBC connection [Communicatio

The last packet sent successfully to the server was 0 milliseconds ago. The driver has not received any p
    at org.hibernate.exception.internal.SQLStateConversionDelegate.convert(SQLStateConversionDelegate.ja
    at org.hibernate.exception.internal.StandardSQLExceptionConverter.convert(StandardSQLExceptionConv
```

3.6 Version Control Design

In my project, I designed the version control system to mimic GitHub-like version control but with the added feature of real-time editing. The following explains the key functionalities and how they are implemented:

1. **Pulling and Downloading Code**
   - The pull action in my system allows users to pull the code currently being edited in real time. This brings the live version of the code into the editor, enabling collaborators to see and modify it together. However, if a user wishes to **pull an existing version stored in the database**, they can use the **Download** button. The code for downloading the project is handled by ProjectDownloadService:

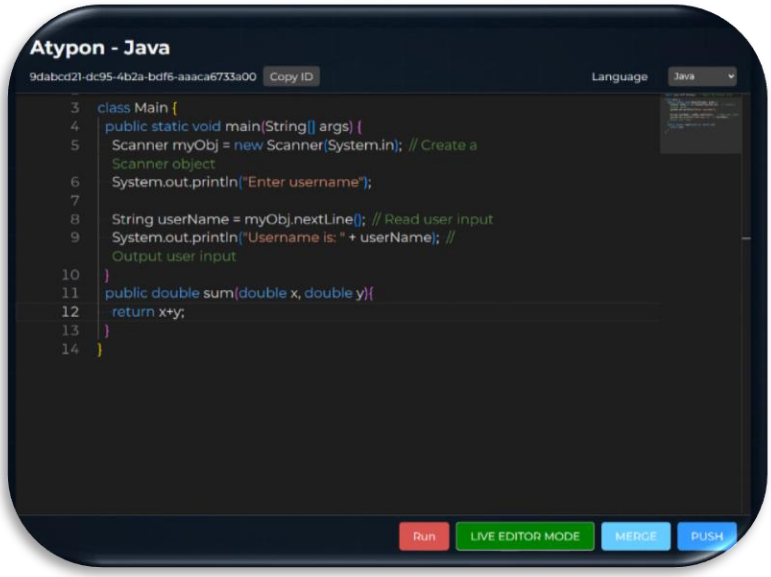
   - The response headers are set to ensure that the files are downloaded as a ZIP. The files are written into the ZIP using a ZipOutputStream, allowing the user to download the entire project in a compressed format.

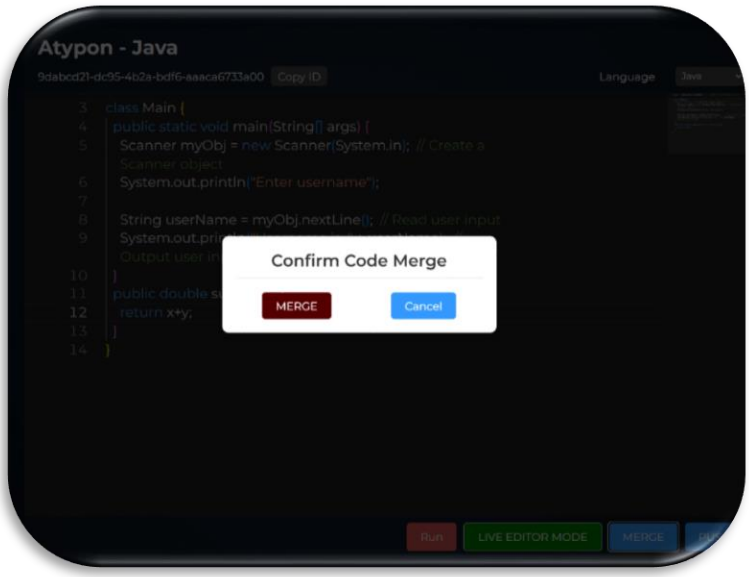


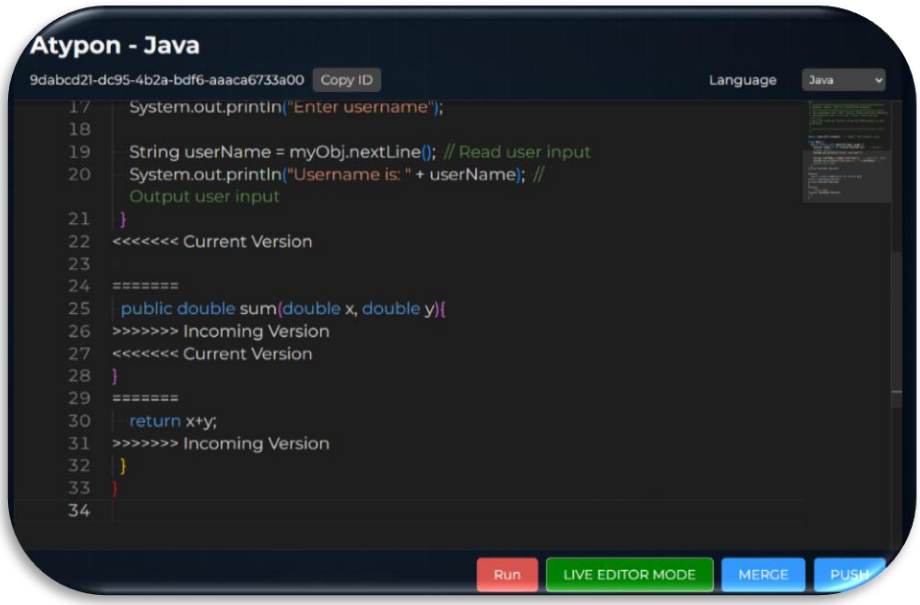
3.6 Version Control Design

4. **Merging Code:**
   The merge functionality in my system compares the code currently being edited in the live editor with the original version stored in the database. If there are conflicts, the system identifies and inserts conflict markers. This requires the user to manually resolve the conflicts before proceeding. The merging process works as follows:

- The original version is retrieved from the database.
- The system compares the lines from the original version with the new version from the editor.
- When there are differences, the system adds conflict markers **(<<<<<<<, =======, >>>>>>>)**, similar to Git, and returns the merged content to the user, who must **manually resolve the conflict.**



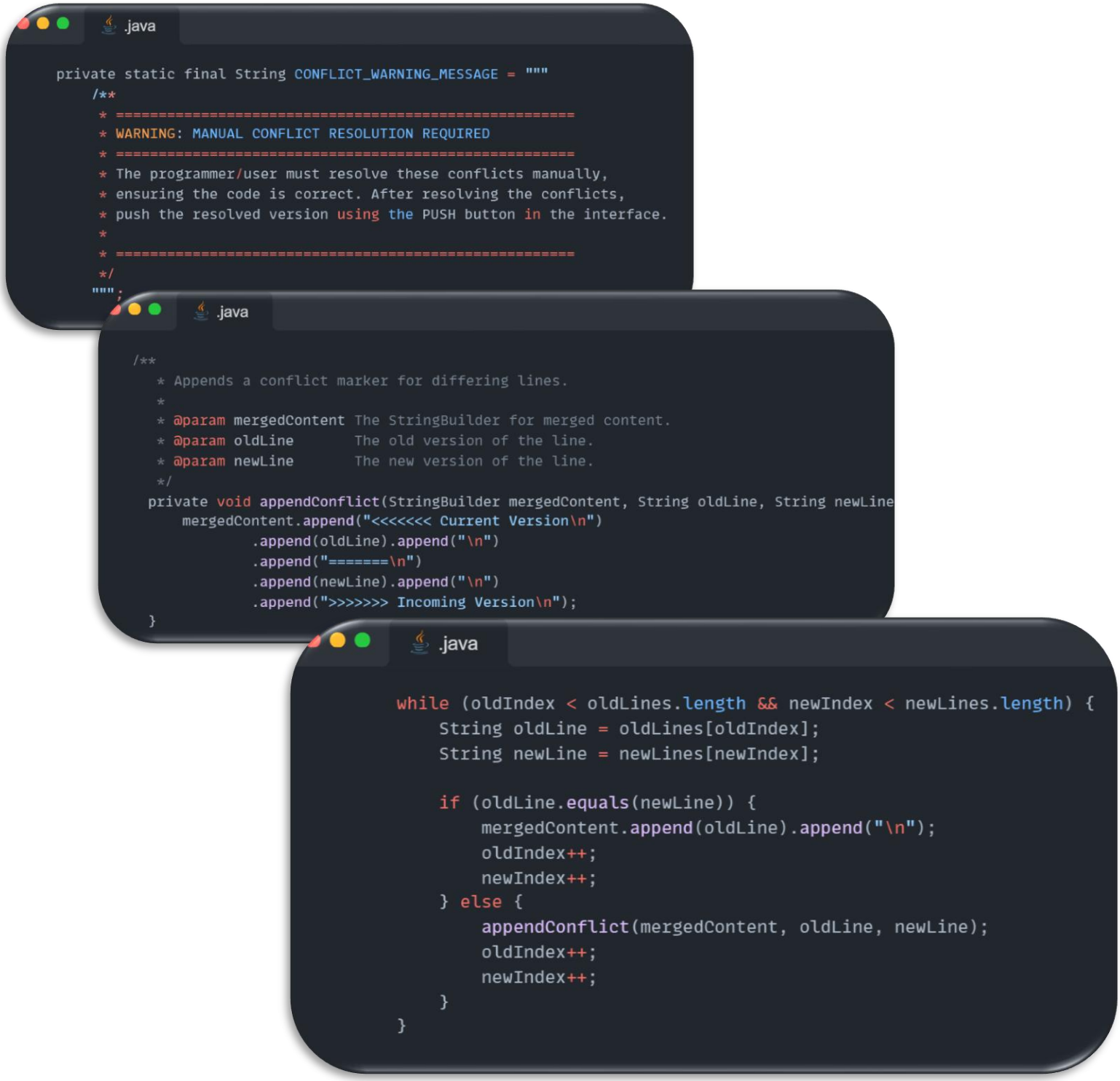




3.6 Version Control Design

Conflict Handling

I implemented a conflict resolution system within the **FileMergeHandler**, which automatically detects and marks conflicting sections of the code.



```java
private static final String CONFLICT_WARNING_MESSAGE = """
    /**
     * ==================================================
     * WARNING: MANUAL CONFLICT RESOLUTION REQUIRED
     * ==================================================
     * The programmer/user must resolve these conflicts manually,
     * ensuring the code is correct. After resolving the conflicts,
     * push the resolved version using the PUSH button in the interface.
     *
     * ==================================================
     */
    """;
```

```java
/**
 * Appends a conflict marker for differing lines.
 *
 * @param mergedContent The StringBuilder for merged content.
 * @param oldLine       The old version of the line.
 * @param newLine       The new version of the line.
 */
private void appendConflict(StringBuilder mergedContent, String oldLine, String newLine
    mergedContent.append("<<<<<<< Current Version\n")
            .append(oldLine).append("\n")
            .append("=======\n")
            .append(newLine).append("\n")
            .append(">>>>>>> Incoming Version\n");
}
```

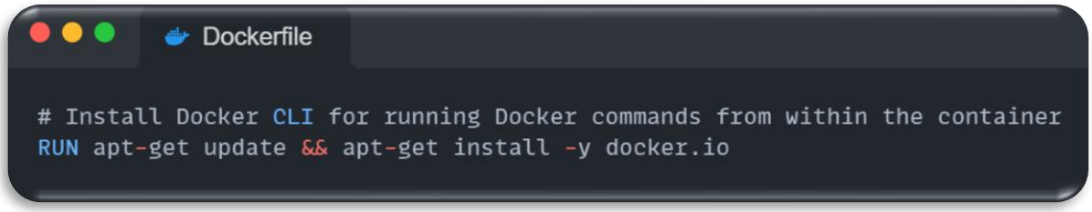
```java
while (oldIndex < oldLines.length && newIndex < newLines.length) {
    String oldLine = oldLines[oldIndex];
    String newLine = newLines[newIndex];

    if (oldLine.equals(newLine)) {
        mergedContent.append(oldLine).append("\n");
        oldIndex++;
        newIndex++;
    } else {
        appendConflict(mergedContent, oldLine, newLine);
        oldIndex++;
        newIndex++;
    }
}
```

Note

it's important to mention that Once conflicts have been resolved, users need to **push** the final version of the code to the database.

3.7 Code Executor Design

In my project, the Code Executor Design relies on Docker to run code in an isolated environment, ensuring security and scalability. Here's how I structured the system:



1. **Execution Handling**
   I used a **Docker-in-Docker** approach to execute code within containers based on the language being used (e.g., Java, Python, C++). This design pulls the appropriate Docker image and executes the code in an isolated environment. This ensures that the code runs safely without affecting the main server.

Problems Faced in this approach:

- The main downside is that handling execution on the same server as the rest of the application can cause performance issues. For example:

- **Image preparation time:** Pulling Docker images and preparing containers takes time, which could lead to delays in execution.

- **Server load:** Running multiple containers on the main server may cause resource bottlenecks, especially with many users.

Note

Despite these trade-offs, **I chose this approach because it fits the project requirements and provides a controlled, isolated environment for code execution.** By running the code inside Docker, it ensures that no malicious code can affect the system, as every execution happens in a sandboxed container.

3.7 Code Executor Design

2. JSON-Based Command Template

One of the features of my design is the use of **JSON-based templates** to handle **commands for different programming languages**. This **allows flexibility in adding new languages or modifying commands without changing the codebase.**

Each language's Docker image and corresponding command template is defined in a JSON file. This structure allows me to easily extend the system with new languages or modify the execution logic for existing ones. For example:

- The template for Python pulls the python:3.9 image and runs the code using python3.
- The template for C++ pulls the gcc image and compiles and runs the code within a single command.

This design gives me the flexibility to dynamically support additional languages by simply adding new entries to the JSON configuration file.

data.json

```
{
  "python": {
    "dockerImage": "python:3.9",
    "commandTemplate": "echo \"{input}\" | python3 -c \"{code}\""
  },
  "javascript": {
    "dockerImage": "node:14",
    "commandTemplate": "echo \"{input}\" | node -e \"{code}\""
  },
  "java": {
    "dockerImage": "openjdk:17",
    "commandTemplate": "echo \"{code}\" > Main.java && javac Main.java && echo \"{input}\" | java Main"
  },
  "cpp": {
    "dockerImage": "gcc:latest",
    "commandTemplate": "echo \"{code}\" > main.cpp && g++ main.cpp -o main && echo \"{input}\" | ./main"
  },
  "go": {
    "dockerImage": "golang:latest",
    "commandTemplate": "echo \"{input}\" > main.go && echo \"{input}\" | go run main.go"
  },
  "ruby": {
    "dockerImag
    "commandTe
  }
```

data.java

```
@PostConstruct
public void loadCommandTemplates() throws Exception {
    ObjectMapper objectMapper = new ObjectMapper();
    InputStream templateStream = new ClassPathResource("data/commandTemplates.json").getInputStream();
    commandTemplates = objectMapper.readValue(templateStream, new TypeReference<>() {});
}
```

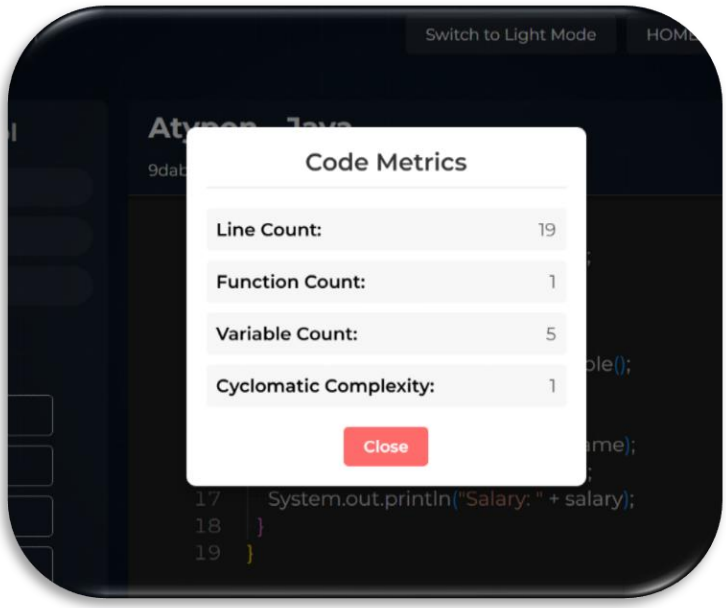
3.8 Code Metrics Feature

I implemented a Metrics and Cyclomatic Complexity feature, which is available specifically for the **Viewer role**. This feature provides valuable insights into the code being worked on, helping Viewers better understand the complexity, number of lines, and variables in the code. Currently, this is implemented for **Java and Python**, but in the future, I plan to extend it to other languages.

Code Metrics Details

The **calculateMetrics** method computes key details such as:

- Number of lines: This simply counts the lines in the code.
- Number of functions: This counts the functions based on language-specific syntax (e.g., public, private for Java and def for Python).
- Number of variables: Variables are identified using typical keywords (e.g., int, String, =).
- Cyclomatic Complexity: A measure of the code's complexity, based on the control flow structures such as if, for, while, etc.



Cyclomatic Complexity Calculation

For each supported language, specific control flow keywords are analyzed to calculate the cyclomatic complexity. For example:

- Java: Keywords like if, else, for, while, switch, catch are counted.
- Python: Keywords like if, elif, else, for, while, try, except are used.

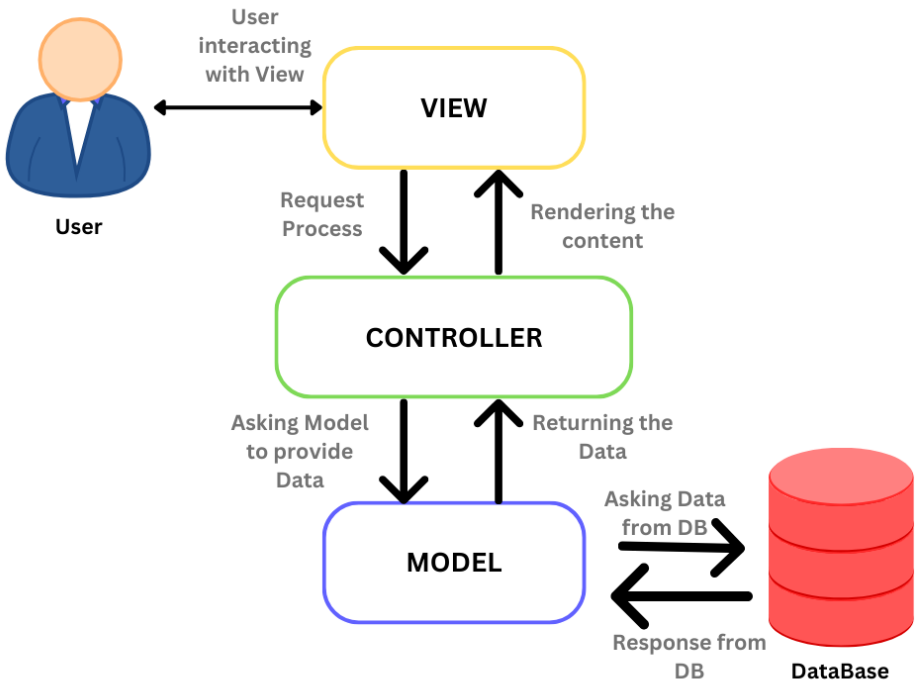
The complexity starts at 1 and increases with every conditional or branching structure found in the code.

Design Patterns

I used various design patterns in my code to structure and organize it effectively. The primary design pattern is Spring MVC, which provides a clean separation between the controllers (responsible for handling HTTP requests), services (business logic), and repositories (data persistence). Let me break down the design patterns I have implemented:

4.1 Spring MVC Pattern

I follow the Model-View-Controller (MVC) pattern using Spring Boot as the framework.



- **Controller Layer**:
  I have structured my controllers in a way that each one handles a specific aspect of the application. Here's how they are organized:

  1. **SignInController:**

     - Handles user sign-in requests.
     - It uses @PostMapping for login and processes the LoginRequest payload.
     - It interacts with the AuthenticationService to validate user credentials and generate tokens.
     - Exception handling is done inside the method itself to provide meaningful HTTP responses (UNAUTHORIZED, NOT_FOUND, etc.).

4.1 Spring MVC Pattern

SignInController .java

```java
@RestController
@CrossOrigin
@RequestMapping("/api")
public class SignInController {
    // Handles sign-in logic and returns JWT tokens or error messages
}
```

2. **SignUpController:**

- Handles user sign-up requests.
- When a user signs up, it uses UserService to create a new user in the database.
- It also includes exception handling to return proper responses based on the error.

SignUpController .java

```java
@RestController
@CrossOrigin
@RequestMapping("/api")
public class SignUpController {
    // Handles sign-up and user registration logic
}
```

3. **ExecutionController:**
   - This controller is responsible for handling code execution requests.
   - It calls DockerExecutorService to run code inside Docker containers and returns the output back to the frontend.

ExecutionController.java

```java
@RestController
@CrossOrigin
@RequestMapping("/api/execute")
public class ExecutionController {
    // Handles code execution requests
}
```

4.1 Spring MVC Pattern

4. **LogsController:**
   - Manages the retrieval of code metrics and logs.
   - The EditorService is responsible for calculating code metrics like lines of code, complexity, etc.

LogsController.java

```java
@RestController
@RequestMapping("/api/viewer")
@CrossOrigin
public class LogsController {
    // Retrieves code metrics and logs
}
```

5. **RoomController:**
   - Handles room management in collaborative coding.
   - It interacts with RoomService, ProjectService, and UserService to manage room membership, project access, and room security.

RoomController.java

```java
@RestController
@CrossOrigin
@RequestMapping("/api/rooms")
public class RoomController {
    // Manages collaborative coding rooms
}
```

6. **UserController:**

- Retrieves authenticated user information and builds a response with their profile information, such as email, name, and profile picture.
- It uses Spring Security to authenticate the user and fetch their details from the SecurityContext.

UserController.java

```java
@RestController
@RequestMapping("/api/user")
public class UserController {
    // Retrieves authenticated user information
}
```

4.1 Spring MVC Pattern

7. VersionController

A) ProjectController:

- Handles project-related requests like creating, retrieving, and updating project information.

ProjectController .java

```java
@RestController
@RequestMapping("/api/projects")
@CrossOrigin
public class ProjectController {
    // Manages project creation and updates
}
```

B) FileController:

- Manages file operations, such as pulling and pushing files, and handles version control for files.
- It ensures that only users with the appropriate roles (e.g., collaborators) can modify files.

ProjectController .java

```java
@RestController
@RequestMapping("/api/files")
@CrossOrigin
public class FileController {
    // Manages file operations and versioning
}
```

C) WebsocketController:

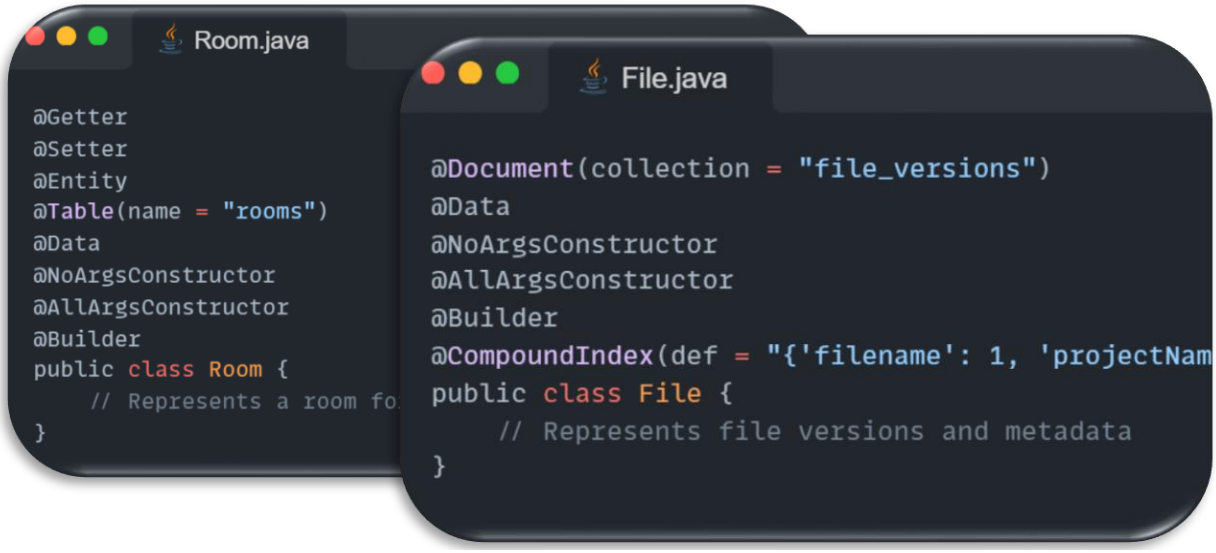
- Manages WebSocket events for real-time collaboration.
- This includes sending and receiving code updates, handling locks on code lines, and communicating changes in real-time to all connected clients.

WebsocketController .java ×

```java
@Controller
public class WebsocketController {
    // Handles real-time WebSocket communication
}
```

4.1 Spring MVC Pattern

- **Models**:
  1. **CodeUpdate:**
     - This is a MongoDB document that tracks changes in the code for a specific file in a project and room.
     - It includes details like the user ID, filename, room ID, project name, line number, and content of the code being updated.
  2. **Room:**
     - This entity represents a coding room where multiple users collaborate on different files. It handles membership and project access.
  3. **User:**
     - This entity represents a user in the application and includes fields for the user's profile and credentials. It is managed by UserService for user-related operations.
  4. **RoomMembership:**
     - This entity tracks user membership in rooms and their roles (e.g., viewer, collaborator).
  5. **File:**
     - This model stores file information, including its versions, in a MongoDB collection. It helps in managing file content during collaboration.
  6. **Project:**
     - This entity represents a project in the MySQL database and is linked to rooms and users. It uses JPA annotations for ORM and database operations.



- **View:**
  - The view part of the Spring MVC pattern in my application is handled by React on the frontend. I use CSS for styling and JavaScript to manage user interactions. The backend controllers are responsible for sending and receiving data via REST APIs, which the frontend consumes.

4.2 Builder Pattern

Overview of Builder Pattern Usage

The Builder design pattern is applied across your entities using **Lombok's @Builder** annotation, which simplifies object creation by eliminating the need for complex constructors and making code more readable and maintainable.

Key Entities and Their Builder Applications:

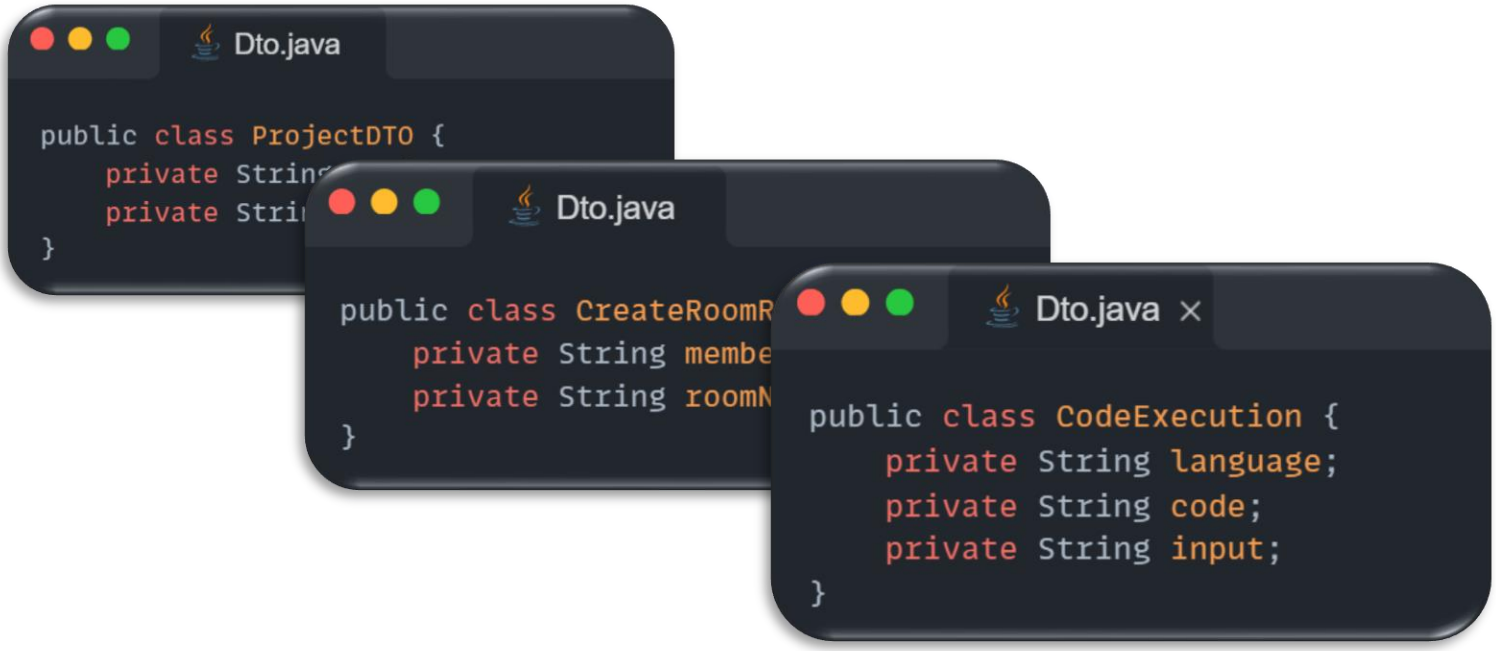
The Builder design pattern is used across various entities in my project, leveraging **Lombok's @Builder** annotation to simplify object creation. This pattern improves readability and flexibility by allowing method chaining and reducing the need for complex constructors, especially for **entities like CodeUpdate, File, Project, Room, and User.** It also enhances immutability and scalability by making it easy to manage complex fields and optional parameters across **different request/response classes like LoginRequest, FileDTO, ProjectDTO, and others.**

4.3 DTO design pattern

DTO (Data Transfer Object) Overview

The DTO (Data Transfer Object) design pattern is used to **encapsulate data** and transfer it between different layers of an application, particularly between the client and server. **This pattern simplifies data management** by providing specific classes for different data types, allowing for efficient communication without exposing internal entities. **It helps reduce the amount of data sent over the network** and establishes a clear contract for the data structures exchanged, enhancing maintainability and flexibility in the application.

Class Name	Purpose
CodeUpdate	Stores information about a code update.
MessageLog	Logs messages for each action in a room.
LoginRequest & LoginResponse	Represents login request and response data structures.
CodeDTO	Represents data transfer object for code.
CodeExecution	Represents data for code execution requests.
CodeMetrics	Represents performance data of the code.
CodeMetricsRequest	Represents request structure for code metrics.
FileDTO	Represents file-related data transfer objects.
ProjectDTO	Represents project-related data transfer objects.
RoomDTO	Represents room-related data transfer objects.
CreateRoomRequest & AddMemberRequest	Represents requests for room creation and adding members.



4.4 Template Method design pattern

The DockerExecutorService implements the Template Method design pattern for executing code in different programming languages using Docker containers.

Template.java

```
public String executeCode(CodeExecution codeRequest) throws Exception {
        Map<String, String> commandTemplate = getCommandTemplateForLanguage(codeRequest.getLanguage());

        String command = prepareCommand(
        commandTemplate.get("commandTemplate"),
        codeRequest.getCode(),
        codeRequest.getInput());

        String[] dockerCommand = buildDockerCommand(commandTemplate.get("dockerImage"), command);

        return runDockerCommand(dockerCommand);
    }
```

Key methods:

- executeCode
- getCommandTemplateForLanguage
- prepareCommand
- buildDockerCommand
- runDockerCommand

Note

By following this template, you will be allowed to add new languages commands in the future.

4.5 Strategy design pattern

In this case, the strategy for executing code differs based on the language (e.g., Python, Java, C++). Each language has a unique command template that defines how the code should be executed inside a Docker container. The DockerExecutorService dynamically chooses the correct execution strategy (command template) at **runtime based on the programming language in the CodeExecution request.**

Key Methods Involved in the Strategy Pattern

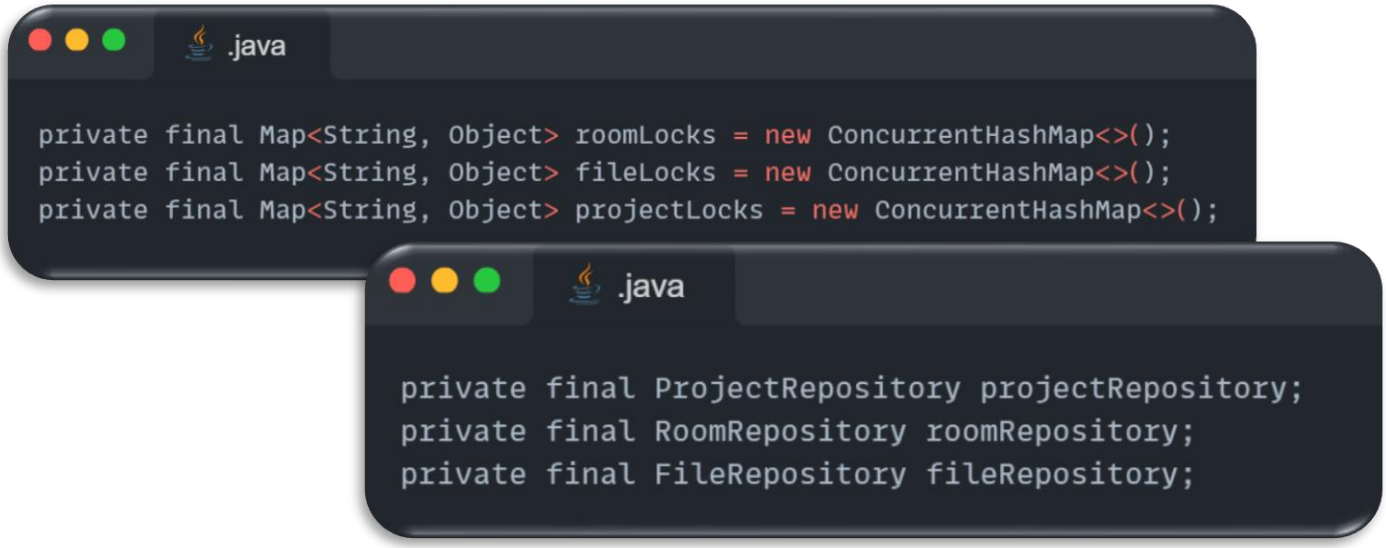
- getCommandTemplateForLanguage(String language)
- prepareCommand(String commandTemplate, String code, String input)
- buildDockerCommand(String dockerImage, String command)

4.6 Singleton Pattern

The Singleton Pattern is applied in two areas:

- **Lock management:** Using globally shared maps (roomLocks, fileLocks, projectLocks) to manage locks.

- **Service dependency injection:** Spring ensures that services are instantiated as singletons, allowing shared access to service logic across the application.



- **This pattern helps ensure thread safety and consistency when managing resources such as files, rooms, and projects in a collaborative, multi-threaded**

4.7 Observer Pattern

In the **WebSocket context**, the server acts as the **subject** that broadcasts updates to clients (the **observers**). The clients are notified whenever a certain event (such as a code update or chat message) occurs on the server.

- **Subjects (Producers):** The @MessageMapping annotated methods in WebsocketController represent the subjects (or event handlers) that produce updates, this method receives code updates for a file and processes the changes. It then sends the update to a specific WebSocket topic **(/topic/file/updates/...)**, notifying all subscribed clients (the observers) about the code change.

- **Observers (Subscribers):** Clients connected to the WebSocket topic (/topic/file/updates/{roomId}/{projectName}/{filename}) act as observers. They automatically receive real-time updates from the server when changes are made to the code. Similarly, chat messages are broadcast to /topic/chat/{roomId}, where all connected clients (observers) receive the new message in real-time.

4.7 Observer Pattern

```java
@MessageMapping("/code/updates/{roomId}/{projectName}/{filename}/COLLABORATOR")
@SendTo("/topic/file/updates/{roomId}/{projectName}/{filename}")
public CodeUpdate handleCollaboratorCode(
        @DestinationVariable String roomId,
        @DestinationVariable String projectName,
        @DestinationVariable String filename,
        @Payload CodeUpdate codeUpdate) {
        ...
}
```

- **Purpose:** This method handles code updates from collaborators. After processing the update (saving it to the database using editorService.saveCodeUpdate(codeUpdate)), it broadcasts the update to all clients subscribed to the topic /topic/file/updates/....
- **Observer Role:** It notifies all relevant observers (clients connected to that file's WebSocket topic) about the update.

4.8 Global Exception Handling Design Pattern

In this design, the Global Exception Handling pattern is essentially a combination of the Chain of Responsibility and Strategy patterns:

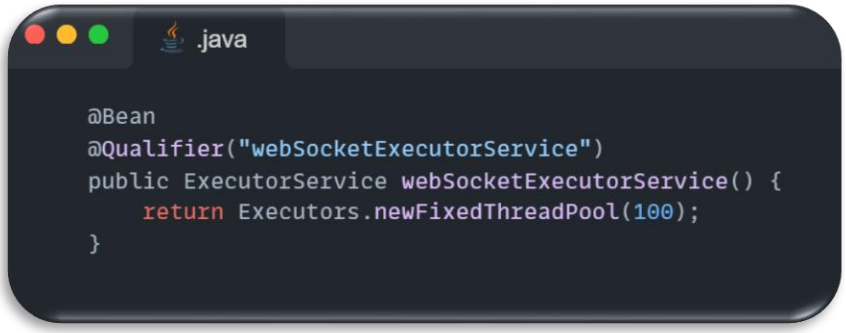
- **Chain of Responsibility:** Different exception handlers are responsible for handling different types of exceptions, creating a chain where an exception will be passed to the next handler until it is handled.
- **Strategy:** Each @ExceptionHandler provides a different strategy for dealing with specific exceptions.

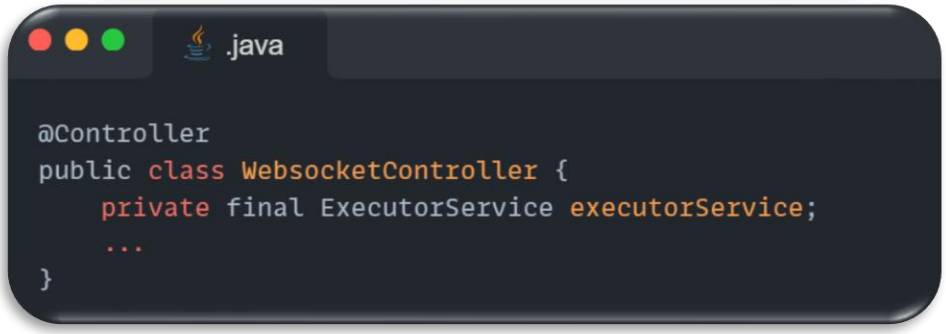
Multithreading

- **Multithreading in WebSocket Code Updates**
  Multithreading is essential for handling simultaneous operations on the same file or line of code by multiple users. The **ExecutorService** is used to execute tasks in parallel, which allows multiple clients to collaborate in real time without blocking other operations.

  Example:

  ExecutorService is initialized with a fixed thread pool to limit the number of concurrent threads handling WebSocket events. By using **Executors.newFixedThreadPool(100)**, we ensure that a maximum of 100 threads can run concurrently for handling incoming requests and updates.

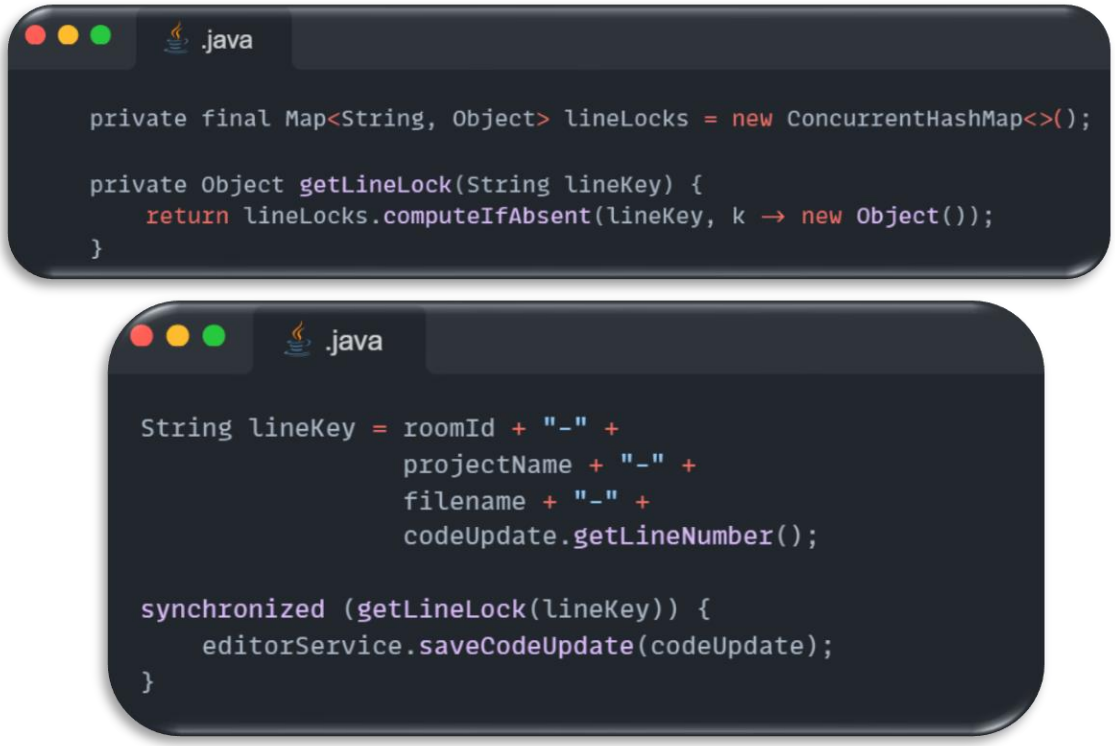




5.2 Thread Safety with Synchronization and Locks

Since multiple users can edit the same file simultaneously, the risk of race conditions is mitigated by using locks. In cases where multiple users try to update the same line of code or the same file, PUSH the same code or managing the room, synchronized blocks and locks ensure that only one thread can modify a particular section of code at a time.

1. **Line-level Locking:** When users update a specific line in the editor, a line-based lock is applied using a **unique key** that identifies the line **(roomId + projectName + filename + lineNumber)**. The **ConcurrentHashMap** is used to store these locks, and the synchronized keyword ensures that only one thread can hold the lock for a specific line while performing operations on it.



```java
private final Map<String, Object> lineLocks = new ConcurrentHashMap<>();

private Object getLineLock(String lineKey) {
    return lineLocks.computeIfAbsent(lineKey, k -> new Object());
}
```

```java
String lineKey = roomId + "-" +
                 projectName + "-" +
                 filename + "-" +
                 codeUpdate.getLineNumber();

synchronized (getLineLock(lineKey)) {
    editorService.saveCodeUpdate(codeUpdate);
}
```

2. **File-level Locking:** For file operations such as pushing or retrieving file content, a similar locking mechanism is used to ensure that two clients cannot modify the file content concurrently. Each file operation uses a unique lock based on the roomId, projectName, and filename.

```java
String fileKey = file.getRoomId() + "-" +
                 file.getProjectName() + "-" +
                 file.getFilename();

synchronized (getFileLock(fileKey)) {
    fileVersionRepository.upsertFileContent( ... );
}
```

5.2 Thread Safety with Synchronization and Locks

3. **Room-level Locking:** For room operations such as adding or removing member in the room, a similar locking mechanism is used to ensure that two clients cannot modify the file content concurrently. Each file operation uses a unique lock based on the roomId only.

```java
private final Map<String, Object> roomLocks = new ConcurrentHashMap<>();
private Object getRoomLock(String roomId) {
    return roomLocks.computeIfAbsent(roomId, k → new Object());
}
```

```java
@Override
public void addUserToRoom(Room room, User user, RoomRole role) {
    Object roomLock = getRoomLock(room.getRoomId());
    synchronized (roomLock) {
        RoomMembership newMembership = RoomMembership
                .builder()
                .room(room)
                .user(user)
                .role(role)
                .build();

        room.getRoomMemberships().add(newMembership);
        user.getRoomMemberships().add(newMembership);
        roomMembershipRepository.save(newMembership);
    }
}
```

4. **Pessimistic Locking:** For database operations, particularly when updating file content, pessimistic locking is used to prevent conflicts. The **@Lock(LockModeType.PESSIMISTIC_WRITE)** annotation ensures that once a thread has locked a record, other threads must wait until the current operation is

```java
@Lock(LockModeType.PESSIMISTIC_WRITE)
@Modifying
@Update(...)
void upsertFileContent(...);
```

5.3 Optimistic Locking for Operations

By combining optimistic and pessimistic locking strategies, the system ensures that both database-level and in-memory data remain consistent, even in a concurrent environment, this overall strategy ensures that file content updates, code updates, and room modifications are safely handled in a multithreaded environment, preventing race conditions and ensuring data consistency.

In the context of room management, versioning is implemented using the **@Version** annotation in the Room entity. This approach ensures **optimistic locking**, where the application checks if the **version number** of an entity matches before committing a transaction. If another thread has modified the room in the meantime, an **OptimisticLockException** is thrown, preventing concurrent modifications.

SOLID Principles

I've applied SOLID principles to ensure that everything is structured in a way that's easy to maintain and extend. When I think about these principles, it's all about keeping each piece of code focused on one responsibility, making sure new features can be added without breaking the existing ones, and keeping things flexible for future changes. I've broken down logic across different classes, so responsibilities are separated, and interfaces ensure that

6.1 Authentication Defense (SOLID Principles)

Here's a breakdown of how SOLID Principles are applied in Authentication classes:

1. **Single Responsibility Principle (SRP)**

   SRP Defense: Each class related to authentication has a single, well-defined responsibility.

   - **SignInController:** Responsible for handling the user sign-in process.
   - **SignUpController:** Responsible for handling the user sign-up process.
   - **AuthenticationService:** Responsible for handling authentication-related logic (validating credentials, generating tokens).
   - **JwtUtil:** Handles token generation and parsing.
   - **PasswordValidator and EmailValidator:** Validates password and email formats independently, focusing only on validation logic.
   - **UserService:** Manages user creation, retrieval, and related user logic.

6.1 Authentication Defense (SOLID Principles)

2. Open/Closed Principle (OCP)

OCP Defense: Classes are open for extension but closed for modification.

- **SignUpController:** can add new authentication providers in the providerSignIn method by adding a new provider option without altering the logic.
- **AuthenticationService:** could be extended by creating new implementations (e.g., OAuth2, SAML and LDAP) without modifying existing logic.
- **UserServiceImpl:** Similarly, additional user creation or validation strategies can be implemented and injected without changing the core class.
- **JwtUtil:** can easily support different token generation strategies by extending or modifying methods without changing the core authentication service.

6.1 Authentication Defense (SOLID Principles)

3. Liskov Substitution Principle (LSP)

LSP Defense: Subtypes (implementations of **AuthenticationService**, **UserService**, etc.) can replace their base types without altering the correctness of the program.

For instance, AuthenticationServiceImpl can be substituted by another implementation, such as OAuth2AuthenticationServiceImpl, and the system would still work without breaking the contract. The base interface ensures that new implementations of authentication services adhere to the required behavior.

```java
public interface AuthenticationService {
    String verify(LoginRequest loginRequest);
}

// Implementation 1: Default JWT-based authentication
@Service("AuthenticationServiceImpl")
public class AuthenticationServiceImpl implements AuthenticationService {
    @Override
    public String verify(LoginRequest loginRequest) {
        // Default JWT authentication logic
    }
}

// Implementation 2: OAuth2-based authentication (can replace the default implementation)
@Service("OAuth2AuthenticationServiceImpl")
public class OAuth2AuthenticationServiceImpl implements AuthenticationService {
    @Override
    public String verify(LoginRequest loginRequest) {
        // OAuth2 authentication logic
    }
```

4. Interface Segregation Principle (ISP)

ISP Defense: Interfaces are kept small, specific, and focused.

- **AuthenticationService** focuses only on authentication logic.
- **UserService** focuses on user-related operations like creation, retrieval, etc.

```java
public interface UserService {
    void createUser(User user);
    Optional<User> findUserByEma
    User findUserByUsername(Stri
    User getUser(Authentication
}
```

```java
public interface AuthenticationService {
    String verify(LoginRequest loginRequest);
}
```

6.1 Authentication Defense (SOLID Principles)

5. Dependency Inversion Principle (DIP)

DIP Defense: High-level modules (like AuthenticationServiceImpl) depend on abstractions (AuthenticationManager, JwtUtil) rather than concrete implementations. This makes the system more flexible and easier to refactor, as lower-level components can be swapped out without changing the high-level logic.

- **SignUpController**: the UserService is injected using the @Qualifier annotation, meaning the controller depends on an abstraction (UserService interface) rather than a concrete implementation (UserServiceImpl).
- **SignInController:** The SignInController depends on the AuthenticationService abstraction, not the concrete implementation. This allows for different authentication services to be injected.
- **UserServiceImpl:** Similarly, the UserServiceImpl depends on the UserRepository abstraction, allowing different repository implementations to be used without changing the core service logic.

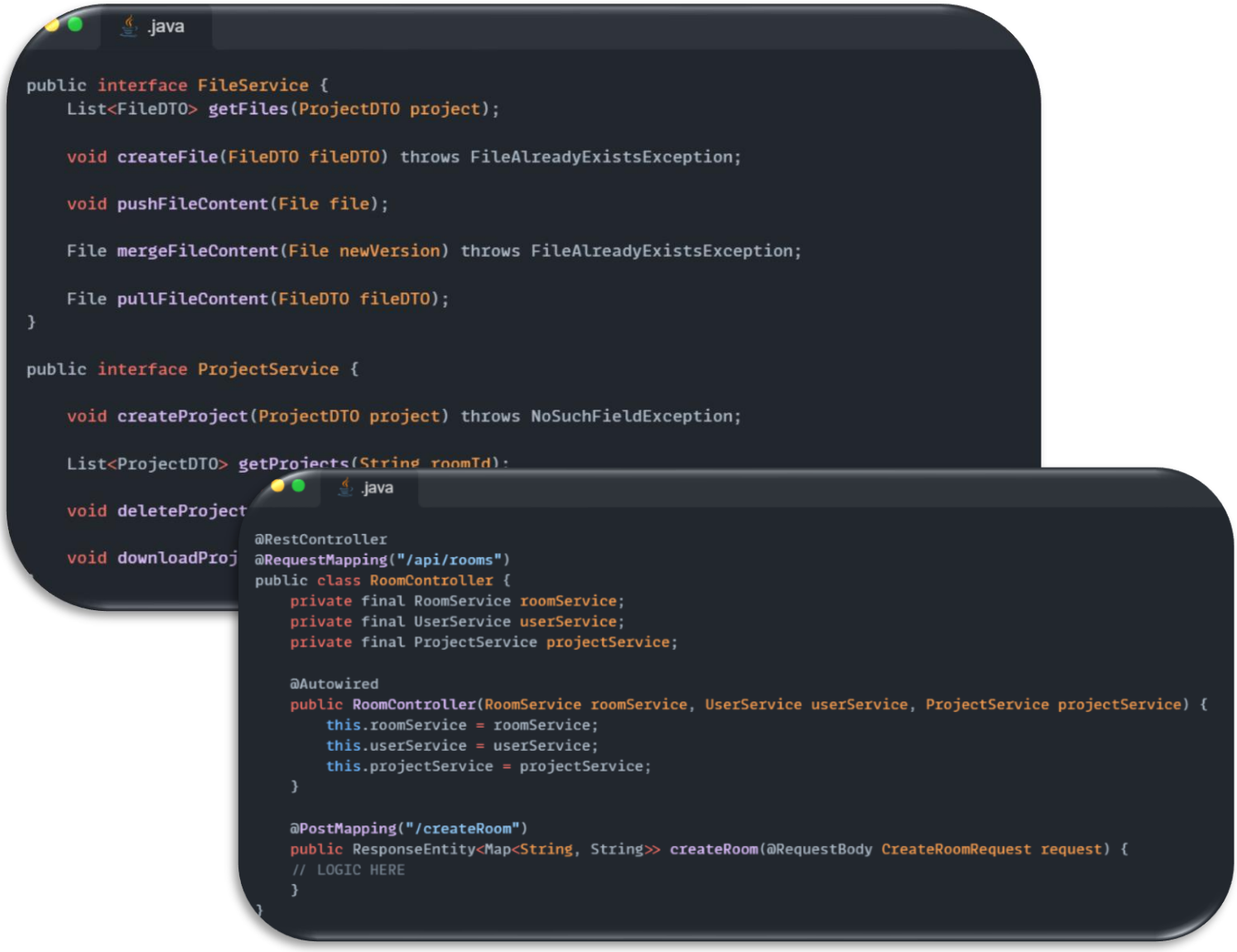
6.2 Room Management Defense (SOLID Principles)

Here's a breakdown of how SOLID Principles are applied in Room Management classes:

1. **Single Responsibility Principle (SRP)**

SRP Defense: In the Room, File, and Project management classes, each class has a single responsibility.

- **RoomController:** handles HTTP requests related to rooms and delegates tasks to RoomService, UserService, and ProjectService.
- **RoomServiceImpl:** manages core business logic related to rooms, such as creation, deletion, and membership management.
- **FileServiceImpl:** focuses on managing files associated with projects, providing methods to fetch, push, and merge file content.
- **ProjectServiceImpl:** handles creating, deleting, and managing projects linked to a room.



6.2 Room Management Defense (SOLID Principles)

2. Open/Closed Principle (OCP)

OCP Defense: In cases where new features need to be added, the existing structure can accommodate changes without altering existing code.

- **RoomService interface** can be extended by adding new methods, and any new services (such as notifications, or logging) can be implemented in separate classes.

- **The FileServiceImpl** allows for file versioning, and new functionalities like file encryption can be added by introducing a new **FileEncryptionHandler** without modifying the original service.

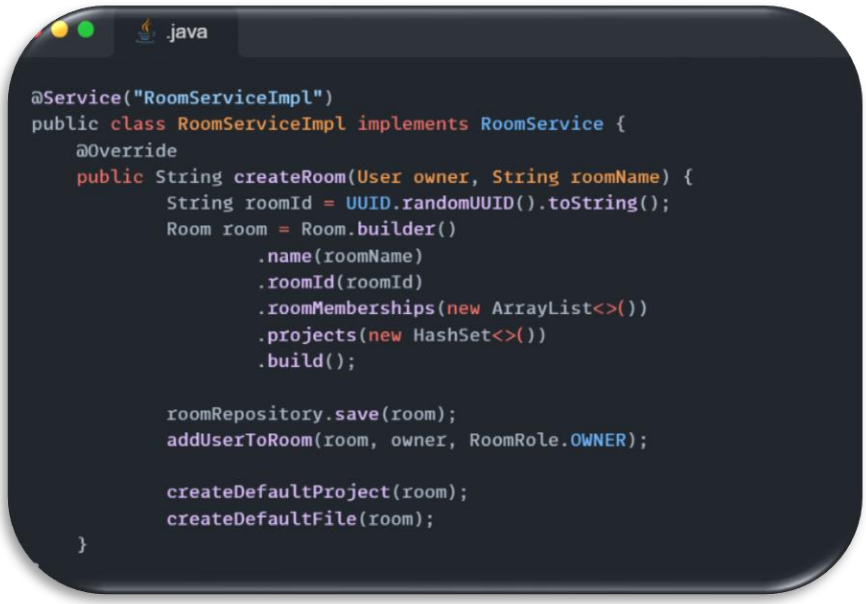
- Similarly, for FileService and ProjectService.

6.2 Room Management Defense (SOLID Principles)

3. Liskov Substitution Principle (LSP)

LSP Defense is followed by ensuring that subclasses or implementations of interfaces can be substituted for their parent classes without affecting the functionality.

For instance, The **RoomServiceImpl** and **FileServiceImpl, ProjectServiceImpl** classes both adhere to their respective service interfaces, ensuring that any class implementing RoomService or FileService can be substituted without breaking the system.



4. Interface Segregation Principle (ISP)

ISP Defense: is applied by ensuring that clients are not forced to depend on interfaces they do not use. This is seen in how each service interface (RoomService, FileService, ProjectService) is designed to include only methods related to its specific functionality.

- **FileService** includes methods related to file management (pushFileContent, pullFileContent).
- **RoomService** focuses on room operations like creation, deletion, and membership management.

6.2 Room Management Defense (SOLID Principles)

5. Dependency Inversion Principle (DIP)

DIP Defense: in the RoomController, FileController and ProjectController, services are injected via their interfaces, not concrete classes (I used different Dependency Inversion methods field injection and Constructor injections)

- **By injecting interfaces rather than implementations, the controllers can easily work with different service implementations without being tightly coupled to them.**

6.3 Editor Defense (SOLID Principles)

Here's a breakdown of how SOLID Principles are applied in Editor classes:

1. **Single Responsibility Principle (SRP)**

SRP Defense: In the Editor environment each class has a single responsibility.

- **WebsocketController:** Handles WebSocket communication for code updates and chat messages.
- **LogsController:** Manages log retrieval for rooms, users, projects, and files.
- **ExecutionController:** Executes code in Docker containers.
- **EditorService:** Responsible for business logic related to code editing, saving updates, and calculating metrics.
- **DockerExecutorService:** Executes Docker commands and runs code within isolated containers.

```java
@RestController
@RequestMapping("/api/execute")
public class ExecutionController {

    private final DockerExecutorService dockerService;

    public ExecutionController(DockerExecutorService dockerService) {
        this.dockerService = dockerService;
    }

    @PostMapping("/run")
    public ResponseEntity<Map<String, String>> runCode(@RequestBody CodeExecution codeRequest) {
        try {
            String output = dockerService.executeCode(codeRequest);
            return ResponseEntity.ok(Map.of("output", output));
        } catch (Exception e) {
            return Respon
        }
    }
}
```

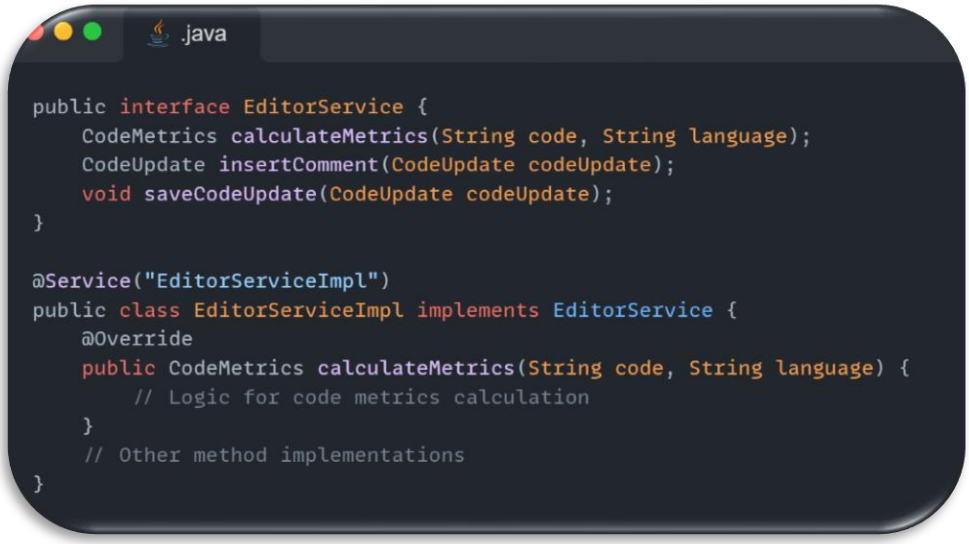
```java
@RestController
@RequestMapping("/api/viewer")
@CrossOrigin
public class EditorController {

    private final EditorService editorService;

    public EditorController(@Qualifier("EditorServiceImpl") EditorService editorService) {
        this.editorService = editorService;
    }

    @PostMapping("/CodeMetrics")
    public ResponseEntity<Map<String, CodeMetrics>> getCodeMetrics(@RequestBody CodeMetricsRequest request) {
        try {
            CodeMetrics metrics = editorService.calculateMetrics(request.getCode(), request.getLanguage());
            return ResponseEntity.ok(Map.of("metrics", metrics));
        } catch (Exception e) {
            return ResponseEntity.unprocessableEntity().build();
        }
    }
```

6.3 Editor Defense (SOLID Principles)

2. Open/Closed Principle (OCP)

OCP Defense: By using interfaces and abstractions, we ensure that we can extend the system without modifying existing code.

- **EditorService:** This interface allows for different implementations (EditorServiceImpl). New behaviors can be added without changing the existing service logic.
- **DockerExecutorService:** The JSON-based command template allows the addition of new languages or commands without altering the core class.



3. Liskov Substitution Principle (LSP)

LSP Defense is followed by ensuring that subclasses or implementations of interfaces can be substituted for their parent classes without affecting the functionality.

- **EditorServiceImpl:** Fulfills the EditorService contract. Any other class implementing this interface can be substituted without breaking functionality.
- **DockerExecutorService:** Can be replaced by another execution service as long as it adheres to the method signatures and behavior defined by its usage.

6.3 Editor Defense (SOLID Principles)

4. Interface Segregation Principle (ISP)

ISP Defense: The classes depend only on the methods they need. Large interfaces are broken into smaller, specific ones.

- **EditorService:** Contains only methods related to code updates and metrics, without forcing the implementation of unnecessary methods.
- **Other controllers** (LogsController, ExecutionController, WebsocketController) focus only on their responsibilities, avoiding coupling with irrelevant methods.

5. Dependency Inversion Principle (DIP)

DIP Defense: High-level modules should not depend on low-level modules but on abstractions. This is achieved through dependency injection and the use of interfaces. (I used different Dependency Inversion methods field injection and Constructor injections)

- **Controllers (WebsocketController, LogsController, ExecutionController) depend on services via their interfaces, not concrete implementations, allowing for flexibility and testability.**

Clean Code

My approach to software development is based on the idea that code should be easy to read, understand, and maintain. I believe that this can be achieved by following a set of principles and practices, such as:

7.1 Meaningful Names

❖ **[Principle] Use Intention-Revealing Names:**

- **Defend:** Method names like ***createProject, listProjects, deleteProject,*** and ***downloadProject in ProjectController*** clearly describe their purposes.

  Example:

```java
@PostMapping("/create-project")
public ResponseEntity<String> createProject(@RequestBody ProjectDTO request) {
    try {
        projectService.createProject(request);
        return ResponseEntity.ok("Project created successfully!");
    } catch (Exception e) {
        return ResponseEntity.badRequest().body("Failed to create project.");
    }
}
```

- **Defend:** Method names like ***getUserRolesForRoom, isOwner, isCollaborator,*** and ***isViewer in RoomMembershipService*** clearly describe their purposes.

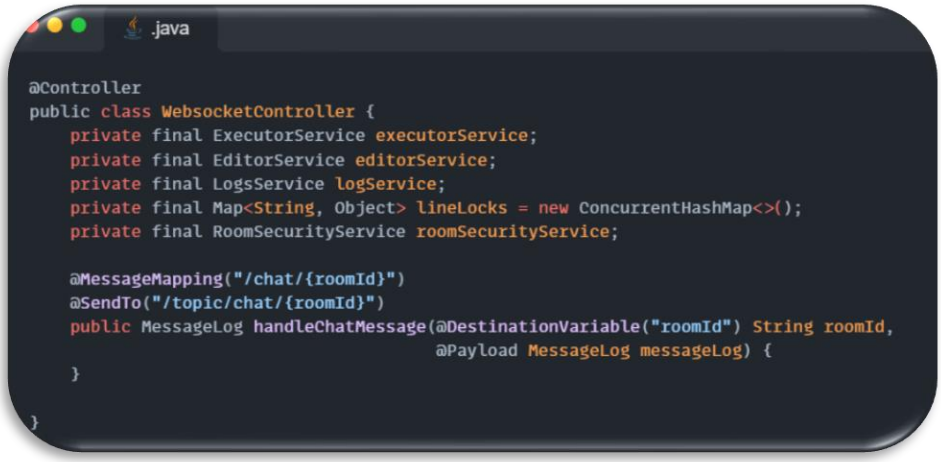
  Example:

```java
public boolean isCollaborator(String userEmail, String roomId) {
    return getUserRolesForRoom(userEmail, roomId).contains(RoomRole.COLLABORATOR);
}

public boolean isViewer(String userEmail, String roomId) {
    return getUserRolesForRoom(userEmail, roomId).contains(RoomRole.VIEWER);
}
```

7.1 Meaningful Names

- **Defend:** Method names like ***handleCollaboratorCode, handleChatMessage,*** and ***handleViewerComment in WebsocketController*** clearly describe their purposes.

Example:



```java
@Controller
public class WebsocketController {
    private final ExecutorService executorService;
    private final EditorService editorService;
    private final LogsService logService;
    private final Map<String, Object> lineLocks = new ConcurrentHashMap<>();
    private final RoomSecurityService roomSecurityService;

    @MessageMapping("/chat/{roomId}")
    @SendTo("/topic/chat/{roomId}")
    public MessageLog handleChatMessage(@DestinationVariable("roomId") String roomId,
                                        @Payload MessageLog messageLog) {
    }
}
```

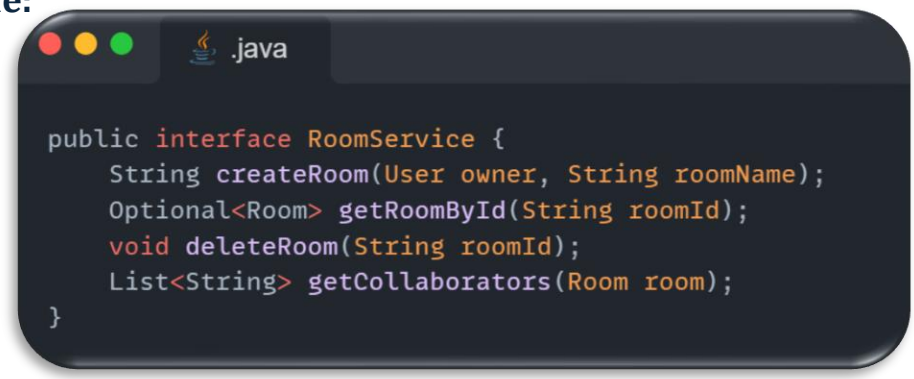
- **Defend:** ***AuthenticationServiceImpl*** contains a method ***verify***, which reflects its role in verifying login requests.

Example:

```java
@Override
public String verify(LoginRequest loginRequest) {
    Authentication authentication = authenticateUser(loginRequest);
    SecurityContextHolder.getContext().setAuthentication(authentication);
    return jwtUtil.generateToken(authentication);
}
```

- **Defend:** *The RoomService interface uses meaningful names for its methods, such as createRoom, getRoomById, deleteRoom, addUserToRoom, and getCollaborators.*

Example:



```java
public interface RoomService {
    String createRoom(User owner, String roomName);
    Optional<Room> getRoomById(String roomId);
    void deleteRoom(String roomId);
    List<String> getCollaborators(Room room);
}
```

7.1 Meaningful Names

❖ **[Principle] Pronounceable and Searchable Names:**

- **Defend:** Variable names like token, email, and authenticationService are pronounceable and easy to search for, improving readability and maintainability.

  Example:

```java
private final AuthenticationService authenticationService;
```

- **Defend:** *Names like generateToken, validateToken, getEmail, and getUsernameFromToken in the JwtUtil class clearly express what the method does.*

  Example:

```java
public String generateToken(Authentication authentication)
```

- **Defend:** In DockerExecutorService, the variables like commandTemplate, dockerCommand, and commandTemplates are descriptive and searchable.

  Example:

```java
public String executeCode(CodeExecution codeRequest) throws Exception {
    Map<String, String> commandTemplate = getCommandTemplateForLanguage(codeRequest
    String command = prepareCommand(commandTemplate.get("commandTemplate"), codeReq
    String[] dockerCommand = buildDockerCommand(commandTemplate.get("dockerImage"),
    return runDockerCommand(dockerCommand);
}
```

7.2 Functions (Methods)

❖ **[Principle] Small Functions & Doing One Thing:**

- **Defend: getEmail(Authentication authentication):** This method is focused only on extracting an email from the authentication object, maintaining a singular responsibility. Its clear objective is to return the email, with no additional logic.

Example:

```java
public String getEmail(Authentication authentication) {

    if (authentication.getPrincipal() instanceof UserDetails userDetails) {
        return userDetails.getUsername();
    }
    if (authentication instanceof OAuth2AuthenticationToken oauthToken) {
        return oauthToken.getPrincipal().getAttribute("email");
    }
    throw new IllegalArgumentException("Unsupported authentication principal type");
}
```

- **Defend: saveCodeUpdate(CodeUpdate codeUpdate)**This method is focused only on saving the temporary updating the code in live editing.

Example:

```java
@Override
public void saveCodeUpdate(CodeUpdate codeUpdate) {

    String codeKey = codeUpdate.getRoomId() + "-" + codeUpdate.getProjectName()

    synchronized (getCodeLock(codeKey)) {
        updateCode(codeUpdate);
    }

}
```

- **Defend: createDefaultFile(Room room)** This method is focused only on create Default **File**.

Example:

```java
private void createDefaultFile(Room room) {
    try {
        fileService.createFile(
                FileDTO
                        .builder()
                        .filename("README")
                        .projectName("Main-Branch")
                        .roomId(room.getRoomId())
                        .extension(".md")
                        .build()
        );
    } catch (Exception e) {
        throw new RuntimeException("Failed to create default file: ");
    }
}
```

7.2 Functions (Methods)

❖ **[Principle] Methods should take the minimum number of arguments necessary.:**

- **Defend:** signIn(LoginRequest loginRequest): The signIn method only takes a LoginRequest object, which encapsulates all the necessary data (email, password) in a single object. This reduces complexity and improves readability by avoiding multiple arguments.

  Example:

```java
public ResponseEntity<LoginResponse> signIn(@RequestBody LoginRequest loginRequest)
```

- **Defend:** executeCode(CodeExecution codeRequest): The executeCode method accepts just one object, CodeExecution, which contains the necessary properties like language, code, and input. This keeps the method signature clean and limits unnecessary arguments.

  Example:

```java
public String executeCode(CodeExecution codeRequest)
```

- **Defend:** calculateMetrics(String code, String language): The calculateMetrics method accepts just two objects.
  Example:

```java
@Override
public CodeMetrics calculateMetrics(String code, String language) {
    int lines = code.split("\n").length;
    int functions = countFunctions(code, language);
    int variables = countVariables(code, language);
    int cyclomaticComplexity = calculateCyclomaticComplexity(code, language);

    return new CodeMetrics(lines, functions, variables, cyclomaticComplexity);
}
```

7.3 Comments

❖ **[Principle] Avoid unnecessary comments, use comments to explain complex decisions.**

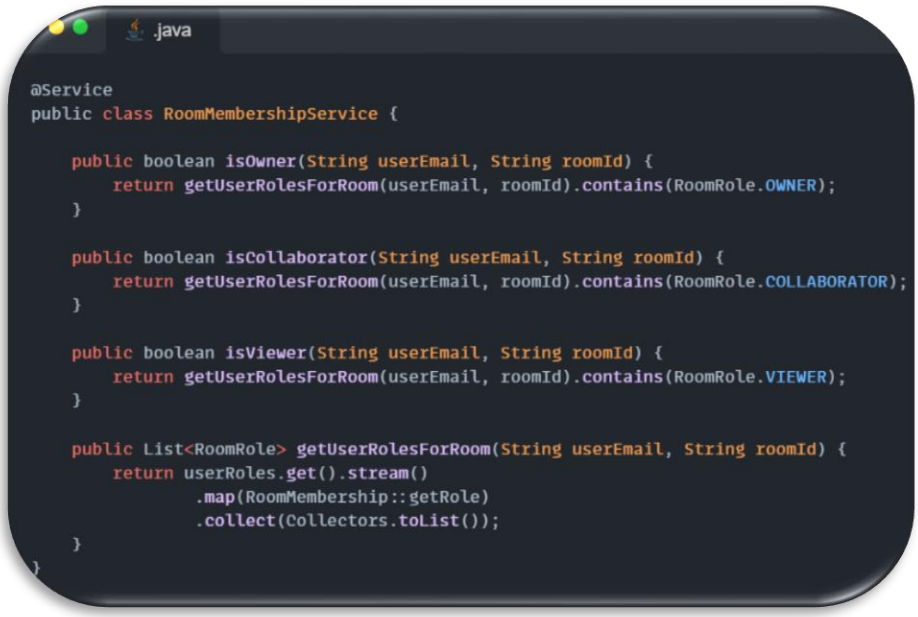
- **Defend:** If you have the chance to visit my code you could observe that you will not be able to find comments, because I believe it the code with applied (SOLID PRINCIPLES, CLEAN CODE And JAVA EFFECTIVE) It is not necessary to add any comments.

7.4 Formatting

❖ **[Principle] Group related code vertically and use consistent horizontal/vertical formatting.**

- **Defend:** Methods are grouped logically, and spacing is used effectively to separate logical blocks of code.
  The logical flow of token generation is easy to read, with clear spacing between method components.

Example:



7.5 Don't Repeat Yourself

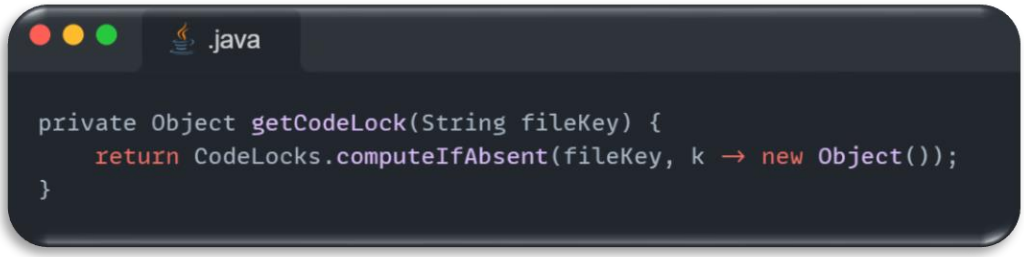
❖ **[Principle] Avoiding Duplication – DRY Principle.**

- **Defend:** Instead of having each controller or service build its response separately, this common logic is centralized into a single function that can be reused across different controllers or services. This ensures consistency and reduces code duplication.

  Example:

- **Defend:** The logic for locking files during concurrent edits is abstracted into the getCodeLock(fileKey) method to avoid repeating the locking logic in multiple places. The method is reused in both insertComment and saveCodeUpdate methods.

  Example:



- **Defend:** The checkExistingFile(File file) method to avoid repeating the check Existing File logic in multiple places. The method is reused in different places inside the class **FileServiceImpl.**

  Example:

7.6 Don't Repeat Yourself

- **Defend:** Logic for handling file content (e.g., pushing, pulling, and merging file content) is placed in the FileService, by centralizing the file operations in FileService, the code ensures that file management logic is not duplicated across different parts of the codebase, such as various controllers.

Example:

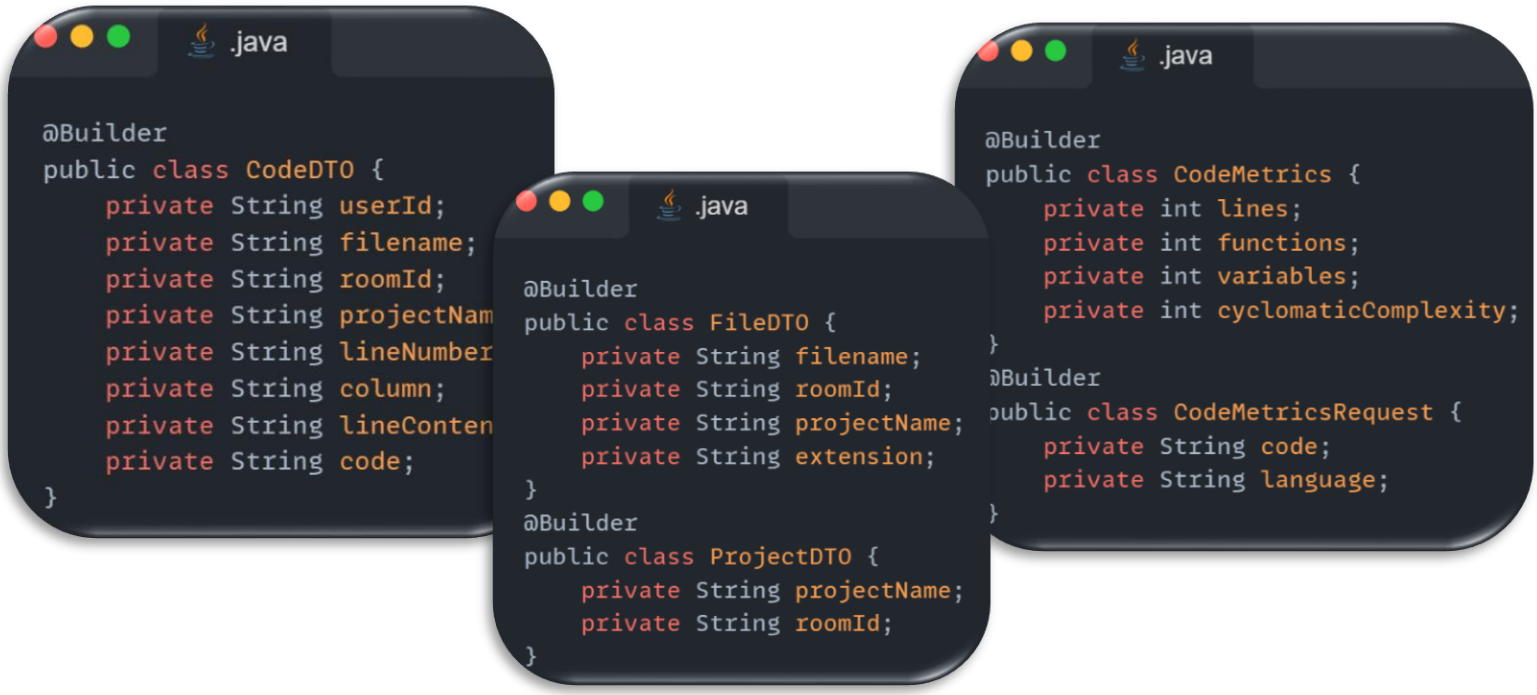
```java
@PostMapping("/pull-file-content")
public ResponseEntity<Map<String, File>> pullFileContent(@RequestBody FileDTO fileDTO) {
    try {
        File pulledFile = fileService.pullFileContent(fileDTO);
        return ResponseEntity.ok(Map.of("file", pulledFile));
    } catch (FileNotFoundException e) {
        return ResponseEntity.notFound().build();
    }
}
```

7.7 Use of DTOs

❖ **[Principle] Avoiding Duplication – DRY Principle.**

- **Defend:** DTOs (Data Transfer Objects) are used extensively in the code to abstract data representations and facilitate communication between layers (controllers, services, etc.) so I used it most of the time when coding.

Examples:



```java
@Builder
public class CodeDTO {
    private String userId;
    private String filename;
    private String roomId;
    private String projectNam
    private String lineNumber
    private String column;
    private String lineConten
    private String code;
}
```

```java
@Builder
public class FileDTO {
    private String filename;
    private String roomId;
    private String projectName;
    private String extension;
}
@Builder
public class ProjectDTO {
    private String projectName;
    private String roomId;
}
```

```java
@Builder
public class CodeMetrics {
    private int lines;
    private int functions;
    private int variables;
    private int cyclomaticComplexity;
}
@Builder
public class CodeMetricsRequest {
    private String code;
    private String language;
}
```

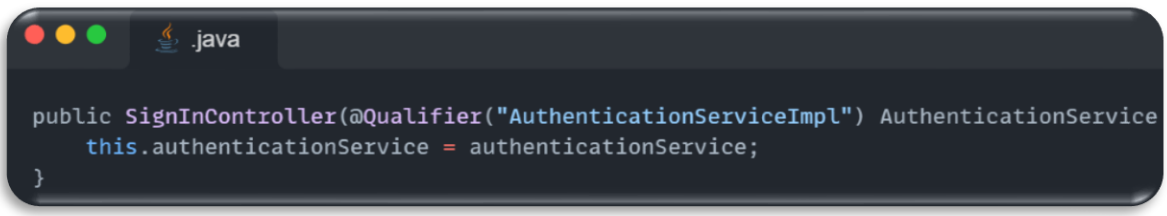
Effective Java

❖ [Item - 1] Consider static factory methods instead of constructors

- **Defense:** JwtUtil, SecurityConfig, and RoomController rely on Spring's framework for instantiation and management of dependencies. This approach avoids the direct use of constructors and aligns with the principle by using a factory method (Spring's @Bean and @Component annotations) for object creation.

- **Defense:** The code does use constructors, but in appropriate places. For example, constructors in the **Project, MessageLog, Room, RoomMembership, User, and CodeUpdate** classes are simple and necessary for initializing entities. For more complex object creation, the code follows a builder pattern (e.g., ProjectDTO.builder()), which is aligned with the principle.

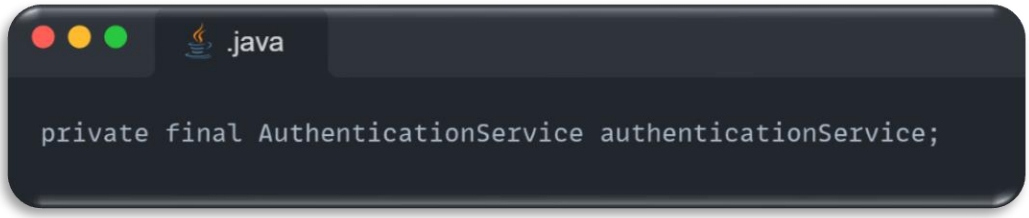
- **Defense:** The classes (e.g., SignInController, SignUpController, UserController, FileController etc . . .) use constructor injection for their dependencies (such as AuthenticationService, UserServiceImpl and UserService). This follows the principles of dependency injection.



8.1 Effective Java

❖ **[Item - 3] Minimize the accessibility of classes and members**

- **Defense:** the controllers are appropriately marked as private, such as the authenticationService in the SignInController. This is in line with the principle of encapsulation and keeping the class's internal representation hidden.



❖ **[Item - 5] Prefer Dependency Injection to Hardwiring Resources**

- **Defense:** The controller classes, like UserController, FileController, and services like DockerExecutorService, all depend on Spring's @Autowired or constructor-based dependency injection.

❖ **[Item - 9] Try-with-Resources to try-finally**

- **Defense:** The DockerExecutorService loads a command template via an input stream. However, this could be enhanced using a try-with-resources statement instead of relying on implicit closure.

❖ **[Item - 10] In public classes, use accessor methods, not public fields**

- **Defense:** the **entire classes I used private fields with @Getter @Setter annotations.**

8.1 Effective Java

❖ [Item - 17] Favor Composition Over Inheritance

- **Defense:** entity relationships (e.g., RoomMembership to Room and User) are represented with composition, not inheritance. The relationships are modeled with @ManyToOne and @OneToMany, which reflects a correct design choice.

❖ [Item - 20] Prefer Interfaces over abstract classes

- **Defense:** Interfaces are preferable than the abstract classes, that's because Java only allows single inheritance, so I used the interfaces in most of the services.

❖ [Item - 30] Use enums instead of int constants

- **Defense:** the **RoomRole** enum in methods like addMember and removeMember is excellent. It enhances code clarity and type safety.

8.1 Effective Java

❖ [Item - 39] Use annotations

- **Defense:** Annotations such as @Test, @BeforeEach, @Mock, and @InjectMocks are used correctly in your test cases. They make tests cleaner and easier to maintain.

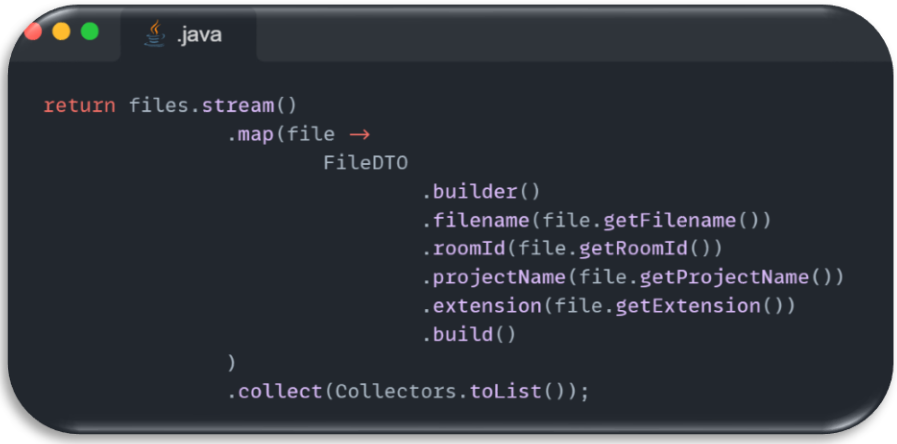
```java
class LogsServiceImplTest {

    @InjectMocks
    private LogsServiceImpl logsService;

    @Mock
    private LogsRepository logsRepository;

    @BeforeEach
    void setUp() {
        MockitoAnnotations.openMocks(this);
    }

    @Test
    void testSaveLog() {

    }
```

❖ [Item - 16] Know and Use Libraries

- **Defense:** In this project I researched libraries to help me in this project and made an effective use of them, I used
  • Spring boot: for building the API and for networking aspects
  • Lombok: for implementing builder classes and implementing getters and setters
  • Jason: for parsing and handling JSON processing
  • Junit: for writing automated tests
  • JBcrypt: for handling hashing passwords and comparing hashes with plain passwords

❖ [Item - 18] Prefer lambdas to anonymous classes:

- **Defense:** I used them quite often especially when working with streams.



```java
return files.stream()
                .map(file →
                        FileDTO
                                .builder()
                                .filename(file.getFilename())
                                .roomId(file.getRoomId())
                                .projectName(file.getProjectName())
                                .extension(file.getExtension())
                                .build()
                )
                .collect(Collectors.toList());
```

8.1 Effective Java

❖ **[Item - 19] Document all exceptions thrown by each method:**

- **Defense:** I used them quite often especially when working with the Centralized Exceptions.

```java
@ExceptionHandler(UserNotFoundException.class)
@ResponseStatus(HttpStatus.NOT_FOUND)
public Map<String, String> handleUserNotFoundException(UserNotFoundException ex) {
    logger.warn("User not found: {}", ex.getMessage(), ex);
    return createErrorResponse("User Not Found", ex.getMessage(), "USER_NOT_FOUND");
}
```

❖ **[Item - 49] Check parameters for validity**

- **Defense:** For example, validating that LoginRequest and User objects are not null and that essential fields are populated could be done before proceeding with further logic.

```java
if (loginRequest == null || loginRequest.getUsername() == null) {
    throw new IllegalArgumentException("Invalid login request");
}
```

❖ **[Item - 67] Optimize method signatures**

- **Defense:** with minimal parameters. This is especially true for the methods handling simple requests like signIn, createAccount, and runCode.

```java
@PostMapping("/sign-in")
public ResponseEntity<LoginResponse> signIn(@RequestBody LoginRequest loginRequest) {
    ...
}
```

❖ **[Item – 77+85] Synchronize Access to Shared Mutable Data && Prefer Executors and Tasks to Threads**

- **Defense:** using the fileLocks map and the synchronized keyword in methods like pushFileContent and mergeFileContent

```java
private final Map<String, Object> fileLocks = new ConcurrentHashMap<>();
private Object getFileLock(String roomId) {
    return fileLocks.computeIfAbsent(roomId, k → new Objec
}

        String fileKey = newVersion.getRoomId() + "-" + new

    synchronized (getFileLock(fileKey)) {
    ...
    }
```

```java
private final ExecutorService executorService;
@Bean
@Qualifier("webSocketExecutorService")
public ExecutorService webSocketExecutorService() {
    return Executors.newFixedThreadPool(100);
}
```

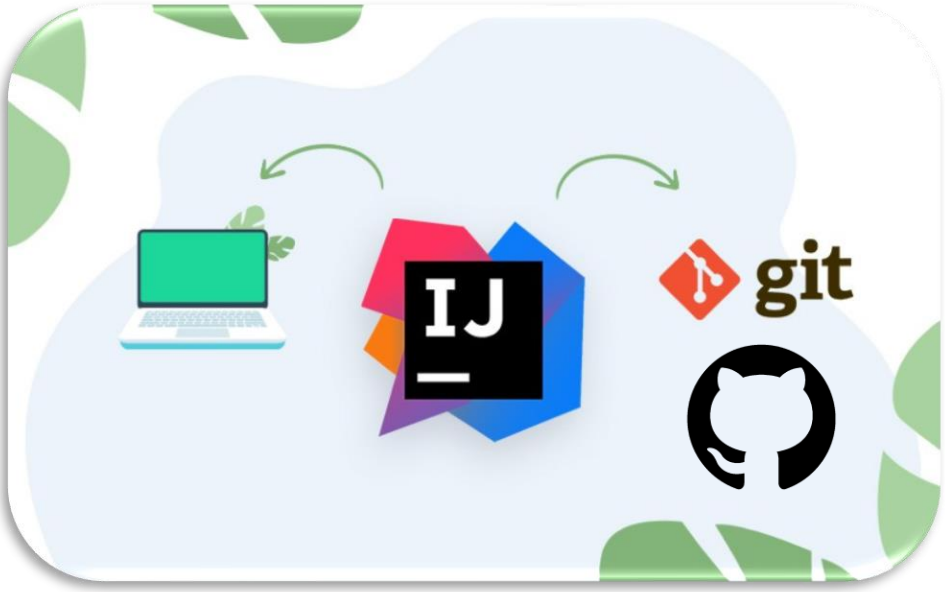
DevOps Practices

In the project, I implemented several key DevOps practices that significantly enhanced the workflow, scalability, and maintainability. These include **GitHub** for version control, **Docker** for containerization, **AWS** for deployment and scalability, and a **CI/CD** pipeline setup using **GitHub Actions** and **DockerHub**. I will explain why these choices were critical for the project and how they contributed to its success.

9.1 Git & GitHub

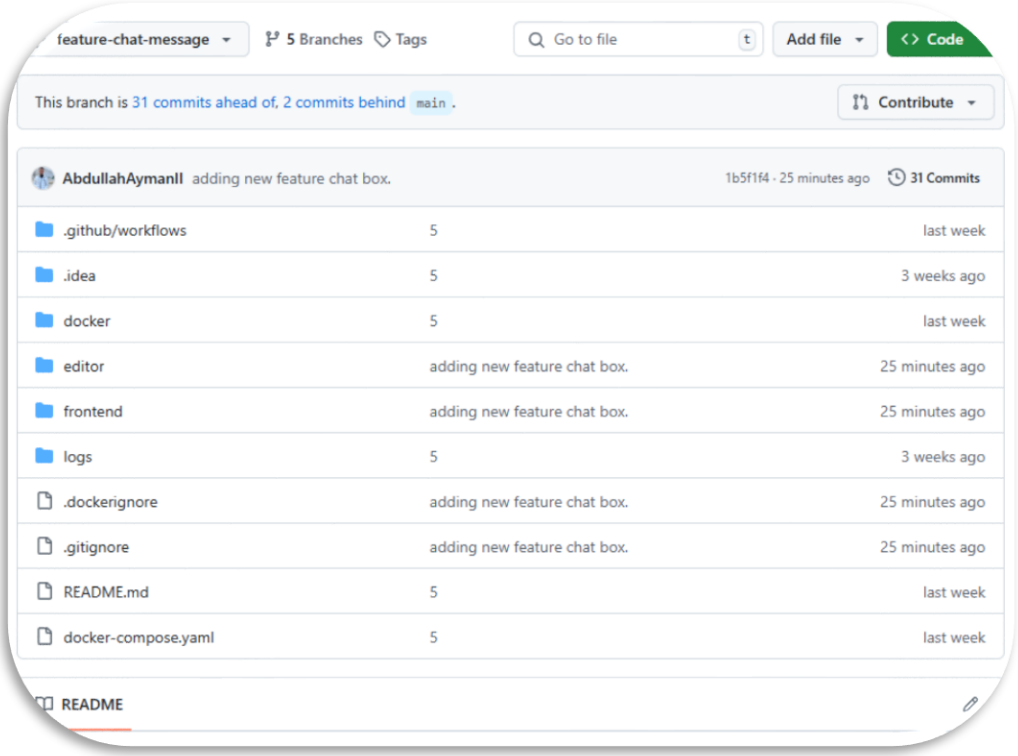
I chose ***GitHub*** as the version control system for this project due to its robust collaboration features.

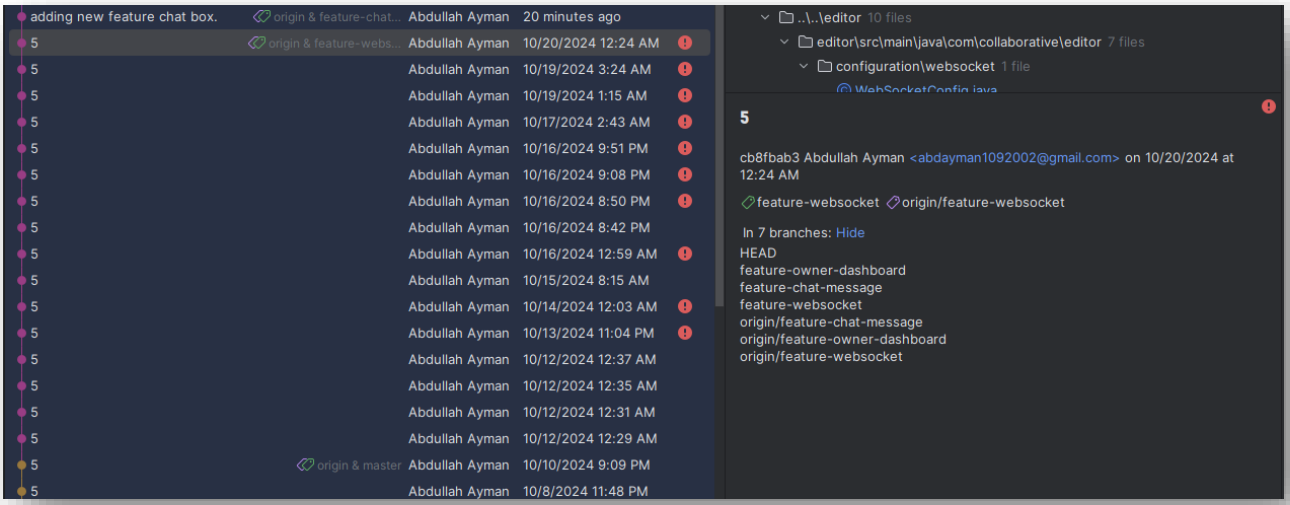
Additionally, GitHub's integration with other DevOps tools, such as **CI/CD** pipelines (like **GitHub Actions**), **DockerHub**, and **AWS**, streamlined the entire development and deployment process. Its issue tracking system and project boards also helped manage tasks, track progress, and maintain documentation all in one place. By using GitHub, the project benefited from aversion control system that facilitated collaboration and continuous integration with other tools.



In this project, I used the **Git GUI** integrated with **IntelliJ IDEA**, which streamlined the process of managing version control directly within the development environment. After completing each feature, I pushed the changes to a dedicated branch, ensuring that each feature was isolated from the main codebase to prevent conflicts. **Once the feature was ready**, I created a **pull request** to review how well the feature integrated with the entire application before merging it into the main branch.

9.1 Git & GitHub



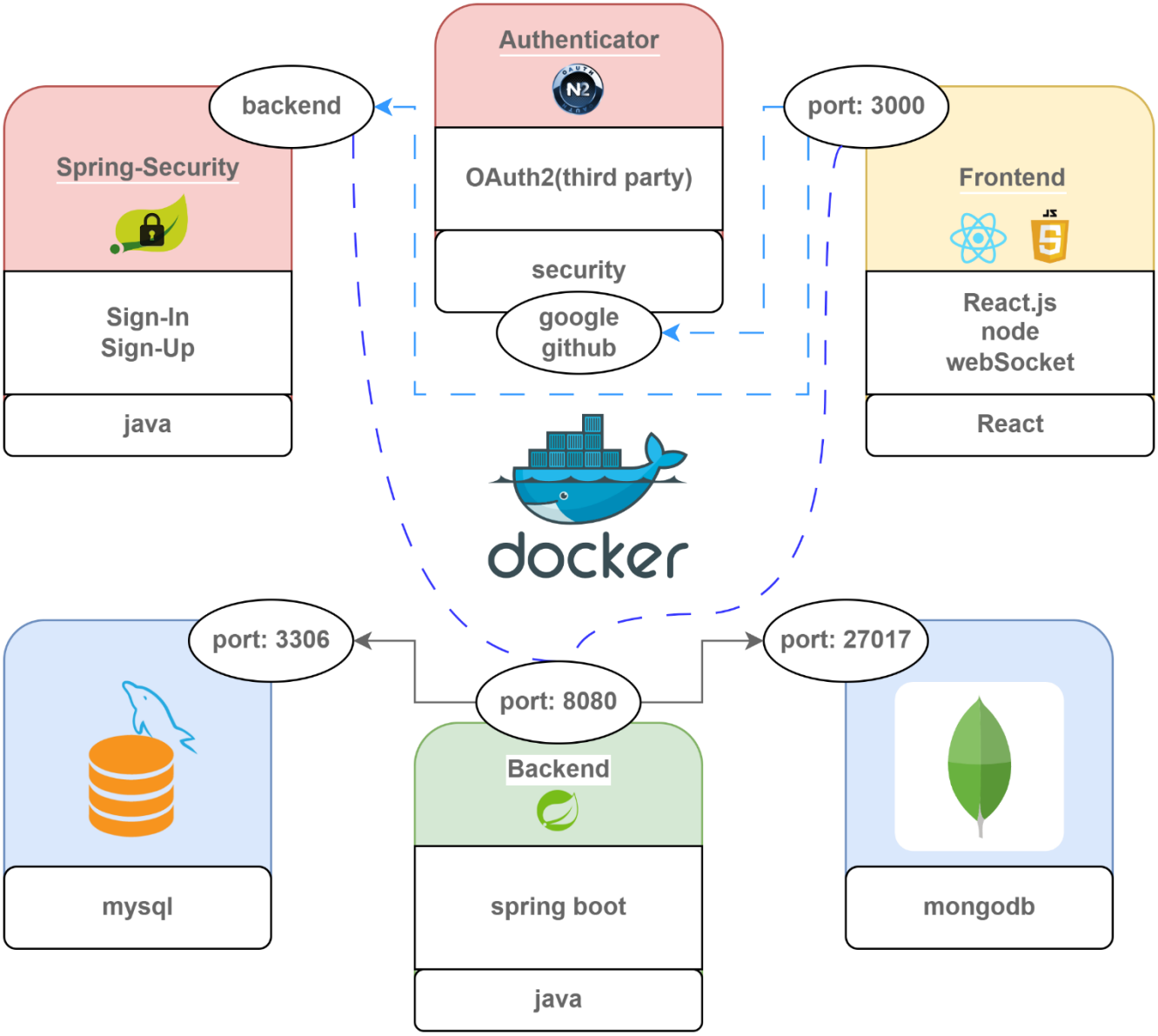


In the project's .**gitignore** file, I ensured that certain directories and files were excluded from version control to maintain a clean repository and prevent unnecessary files from being tracked.

Node.js/React (Frontend):

- This directory contains the dependencies installed by npm. there's no need to version them, which would otherwise lead to large commits.

Docker



In this project, I used Docker to streamline both **development and deployment** environments. For development, I created Dockerfiles and a Docker Compose setup that supports a multi-container architecture. This architecture includes services for the backend, frontend, MySQL, and MongoDB, all of which work together.

10.1 Docker for Development

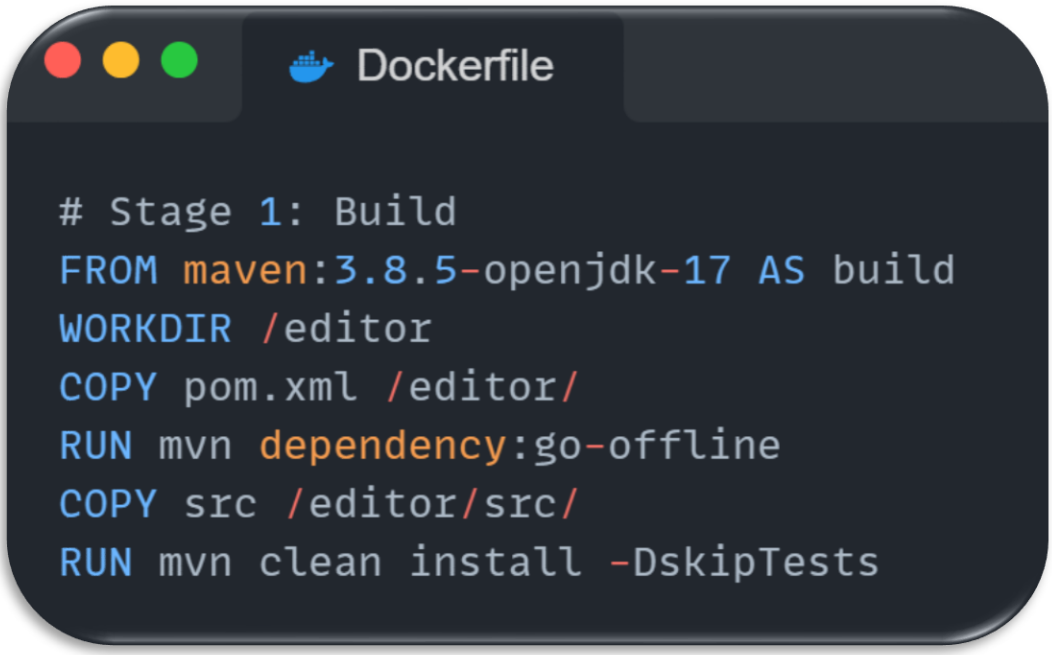
The backend is built using Maven with a multi-stage Dockerfile, while the frontend uses Node.js with live reloading via Nodemon. MySQL and MongoDB containers are included, along with their management UIs, phpMyAdmin and Mongo Express, to simplify database management during development. The Docker Compose file ensures all services run together in isolated containers, making the development process more efficient and consistent.

1. **Backend (Dockerfile and Docker Compose)**

    - **Dockerfile for Backend (Spring Boot):** The backend is built using a two-stage multi-stage build process to optimize the container size and isolate the build from the run environment.

- **Stage 1: Build**

  I used a Maven Docker image to compile the project. It installs dependencies in offline mode to reduce build times and ensures that all necessary libraries are available. The **pom.xml** and source code are copied, then the application is built using mvn clean install -DskipTests, skipping the tests **to save time during development.**



10.1 Docker for Development

- **Stage 2: Run**

  The application is run in a slim OpenJDK 17 image. I installed Docker CLI within the container to support Docker-in-Docker functionality, allowing commands to be executed inside the container (**for RUN the code of the editor**). The JAR file from the build stage is copied and executed with **Spring Boot's DevTools enabled for live reload (only for development)**.

Dockerfile

```
# Stage 2: Run
FROM openjdk:17-jdk-slim
RUN apt-get update && apt-get install -y docker.io
WORKDIR /editor
COPY --from=build /editor/target/editor-0.0.1-SNAPSHOT.jar
EXPOSE 8080
ENTRYPOINT ["java", "-jar",
            "/editor/editor.jar",
            "-Dspring.devtools.restart.enabled=true"]
```

- **Docker Compose for Backend:** In the docker-compose.yml file, the backend service is defined with a build context and specific ports exposed. To ensure the backend works seamlessly in the development environment, I used volumes to mount the source code and Maven dependencies to enable live reload. Additionally, I mounted the **Docker socket to allow the backend to interact with Docker (Docker-in-Docker)**.

Dockerfile

```
services:
  app:
    build:
      context: './editor'
      dockerfile: Dockerfile
    container_name: collaborative-editor
    ports:
      - "8080:8080"
    depends_on:
      - mysql
      - mongo
    networks:
      - backend
    volumes:
      - ./editor/src:/editor/src        # Mount source code for live reload
      - ./editor/target:/editor/target  # Mount target directory for output
      - ~/.m2:/root/.m2                 # Cache Maven dependencies
      - /var/run/docker.sock:/var/run/docker.sock  # Mount Docker socket for Docker-in-Docke
```

10.1 Docker for Development

2. Frontend (Dockerfile and Docker Compose)

- **Dockerfile for Frontend (React):** The frontend uses a Node.js base image, with Yarn as the package manager. I installed the dependencies and **Nodemon for live reloading during development.** The source code is copied into the container, and the container exposes port 3000 for the React application.

Dockerfile

```
FROM node:18
WORKDIR /app
COPY package.json package-lock.json ./
RUN yarn install
RUN yarn add --dev nodemon //only i use in development
COPY . .
EXPOSE 3000
CMD ["yarn", "start"]
```

- **Docker Compose for Frontend:** The frontend service in the Docker Compose file builds from its Dockerfile, exposing port 3000. Like the backend, volumes are used to mount the source code to allow live reloading of changes during development.

Dockerfile

```
frontend:
  build:
    context: './frontend'
    dockerfile: Dockerfile
  container_name: collaborative-frontend
  ports:
    - "3000:3000"
  depends_on:
    - app
  networks:
    - backend
  volumes:
    - ./frontend/src:/app/src # Mount frontend code for live reload
```

10.1 Docker for Development

3. MySQL (Docker Compose)

- **For the MySQL database**, I used the official MySQL 8.0 image. Environment variables were set for the root user, password, and the initial database. Port 3306 is exposed to connect to the database from the backend, PHP MyAdmin service is included for a simple web interface to view and manage mysql data**.**

Dockerfile

```
mysql:
  image: mysql:8.0
  container_name: collaborative-mysql
  restart: always
  environment:
    MYSQL_DATABASE: mysql_db
    MYSQL_ROOT_PASSWORD: root
    MYSQL_ROOT_USER: root
  ports:
    - "3306:3306"
  volumes:
    - mysql_data:/var/lib/mysql
  networks:
    - backend
```

Dockerfile

```
# phpMyAdmin Service
phpmyadmin:
  image: phpmyadmin/phpmyadmin
  container_name: collaborative-phpmyadmin
  environment:
    PMA_HOST: collaborative-mysql
    PMA_PORT: 3306
    PMA_USER: root
    PMA_PASSWORD: root
  ports:
    - "8082:80"
  networks:
    - backend
  depends_on:
    - mysql
```

4. MongoDB (Docker Compose)

- **For MongoDB,** I used the official MongoDB image with environment variables for the root username, password, and database. Mongo Express is included for a simple web interface to view and manage MongoDB data**.**

Dockerfile

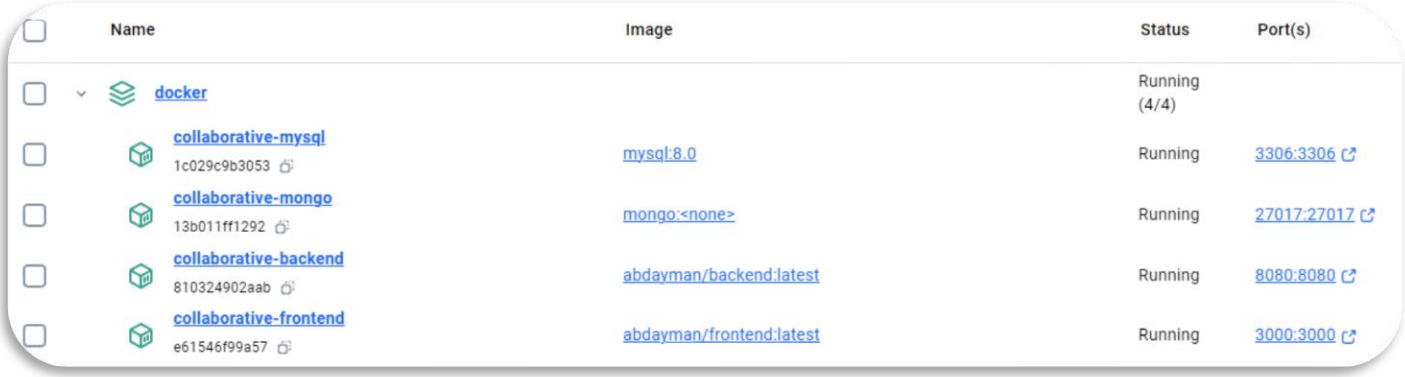
```
mongo:
  image: mongo
  container_name: collaborative-mongo
  environment:
    MONGO_INITDB_ROOT_USERNAME: devroot
    MONGO_INITDB_ROOT_PASSWORD: devroot
    MONGO_INITDB_DATABASE: mongo_db
  ports:
    - "27017:27017"
  volumes:
    - ./mongo_data:/data/mongo_db
    - ./mongo_init:/docker-entrypoint-initdb.d
  networks:
    - backend
```

Dockerfile

```
mongo-express:
    image: mongo-express
    environment:
      ME_CONFIG_MONGODB_SERVER: collaborative-mongo
      ME_CONFIG_MONGODB_PORT: 27017
      ME_CONFIG_MONGODB_ENABLE_ADMIN: true
      ME_CONFIG_MONGODB_AUTH_USERNAME: devroot
      ME_CONFIG_MONGODB_AUTH_PASSWORD: devroot
      ME_CONFIG_BASICAUTH_USERNAME: dev
      ME_CONFIG_BASICAUTH_PASSWORD: dev
    ports:
      - "8888:8081"
    networks:
      - backend
```

10.2 Docker for Deployment

By using the images which created in dockerHub, I used them in deployment at docker instead of AWS because the free tier and cost constraint in AWS.
Here no need to use the docker file, only using the docker compose will be enough.



1. Backend in Docker Compose for Deployment

Dockerfile

```yaml
backend:
  image: abdayman/backend:latest
  container_name: collaborative-backend
  ports:
    - "8080:8080"
  depends_on:
    - mysql
    - mongo
  networks:
    - backend
  volumes:
    - /var/run/docker.sock:/var/run/docker.sock
```

Explanation:

- **Image**: Specifies a custom image **(abdayman/backend:latest),** which should already be built and available.
- Ports: Maps port 8080 of the host to port 8080 of the container, allowing access to the backend application.
- Depends On: Indicates that this service should start after the mysql and mongo services are up and running, ensuring the backend has access to its database dependencies.
- Networks: Connects this service to the backend network.
- Volumes:
- **Mounts the Docker socket (/var/run/docker.sock)** into the container to enable Docker-in-Docker functionality, allowing the backend service to run the codes.

10.2 Docker for Deployment

2. Frontend in Docker Compose for Deployment

Dockerfile

```
frontend:
  image: abdayman/frontend:latest
  container_name: collaborative-frontend
  ports:
    - "3000:3000"
  depends_on:
    - backend
  networks:
    - backend
```

Explanation:

- Image: Specifies a custom image (abdayman/frontend:latest) for the frontend application.
- Ports: Maps port 3000 of the host to port 3000 of the container, allowing access to the frontend application.
- Depends On: Indicates that this service should start after the backend service is up and running, ensuring the frontend can communicate with the backend.
- Networks: Connects this service to the backend network.

3. Mysql and MongoDb Docker Compose for Deployment

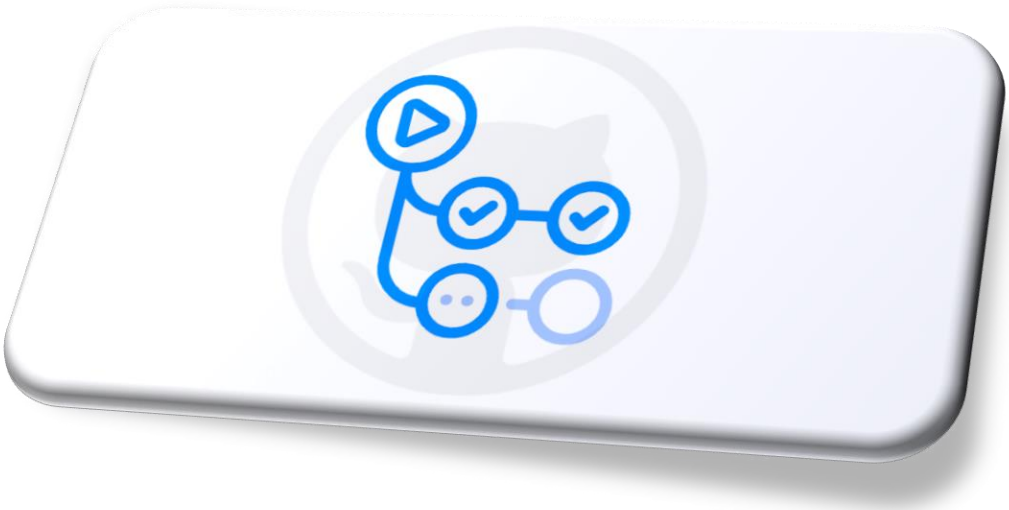
Dockerfile

```
# MongoDB Service
mongo:
  image: mongo
  container_name: collaborative-mongo
  environment:
    MONGO_INITDB_ROOT_USERNAME: devroot
    MONGO_INITDB_ROOT_PASSWORD: devroot
    MONGO_INITDB_DATABASE: mongo_db
  ports:
    - "27017:27017"
  volumes:
    - ./mongo_data:/data/mongo_db
    - ./mongo_init:/docker-entrypoint-initdb.d
  networks:
    - backend
```

Dockerfile

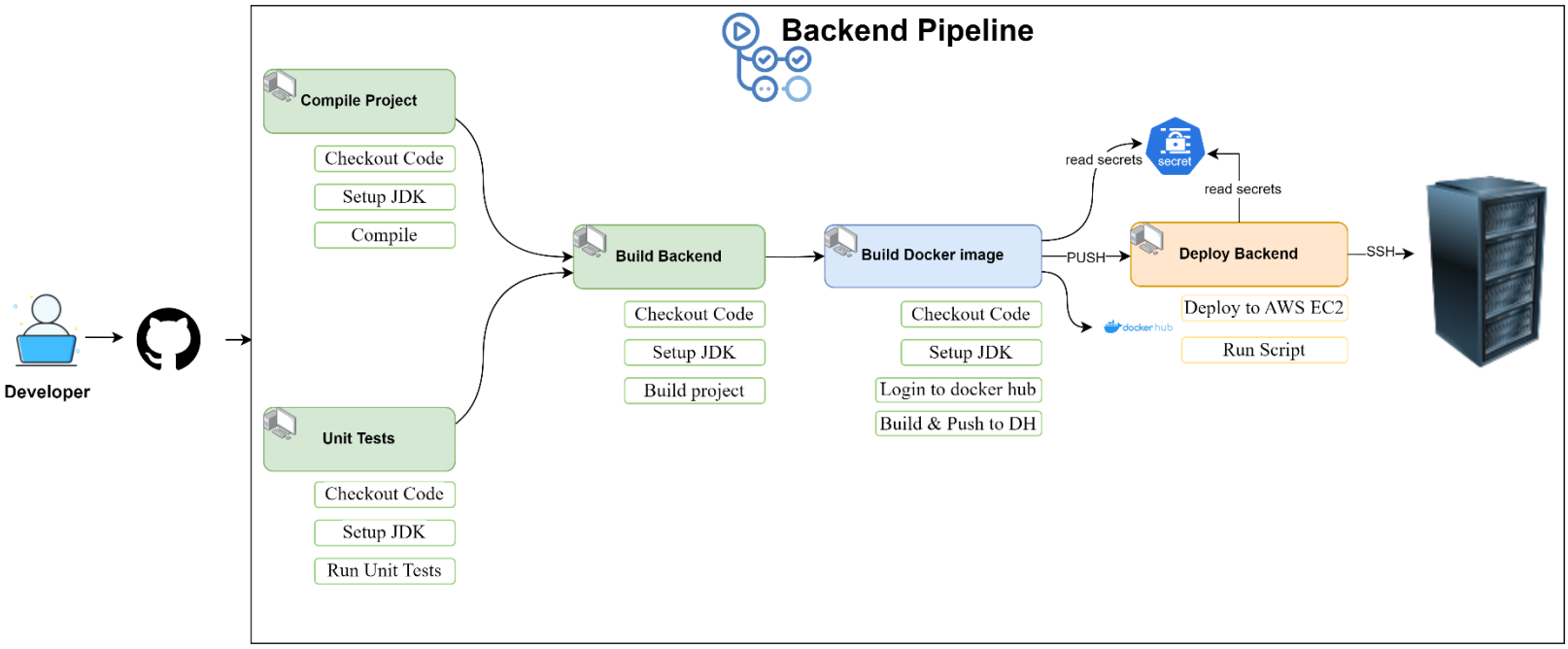
```
# MySQL Service
mysql:
  image: mysql:8.0
  container_name: collaborative-mysql
  restart: always
  environment:
    MYSQL_DATABASE: mysql_db
    MYSQL_ROOT_PASSWORD: root
    MYSQL_ROOT_USER: root
  ports:
    - "3306:3306"
  volumes:
    - mysql_data:/var/lib/mysql
  networks:
    - backend
```

CI/CD Pipeline



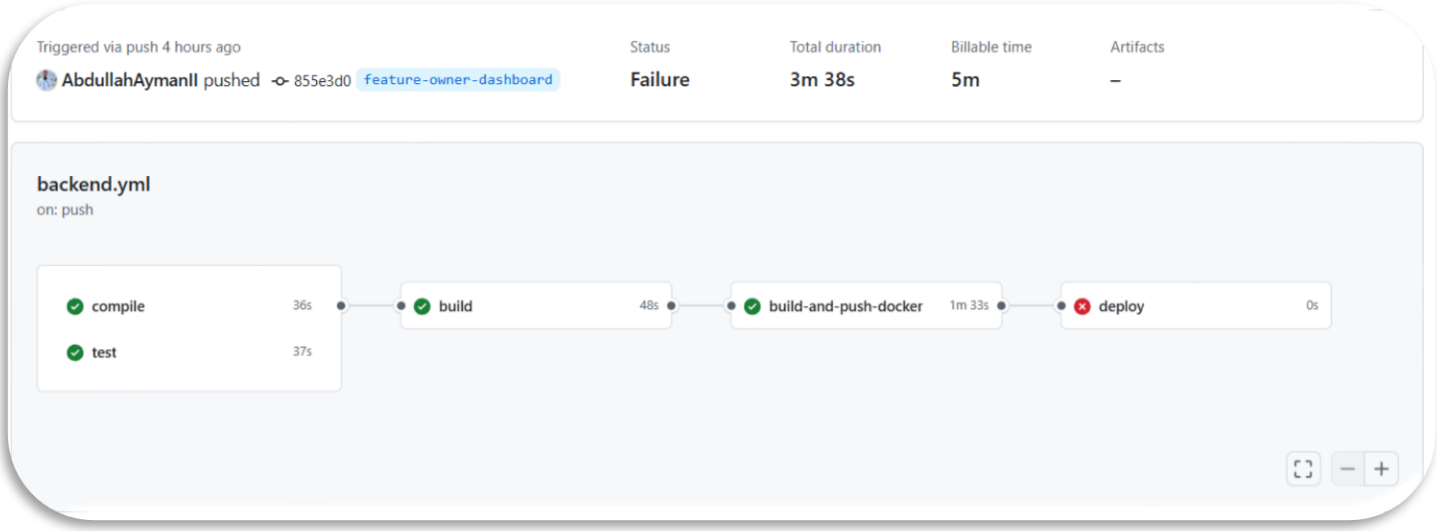
In my project, I used ***GitHub Actions*** for CI/CD. I created **two separate pipelines**: one for the backend and one for the frontend. Each pipeline has different stages for testing, building, and deploying the code. However, due to cost constraints and limitations with the AWS free tier, the deployment to AWS is not functioning (I did the deployment in the previous part). Below is an explanation of the CI/CD pipeline for both the backend and frontend.

11.1 Backend Pipeline



This pipeline is responsible for compiling, testing, building, pushing Docker images, and deploying the backend code.

11.1 Backend Pipeline

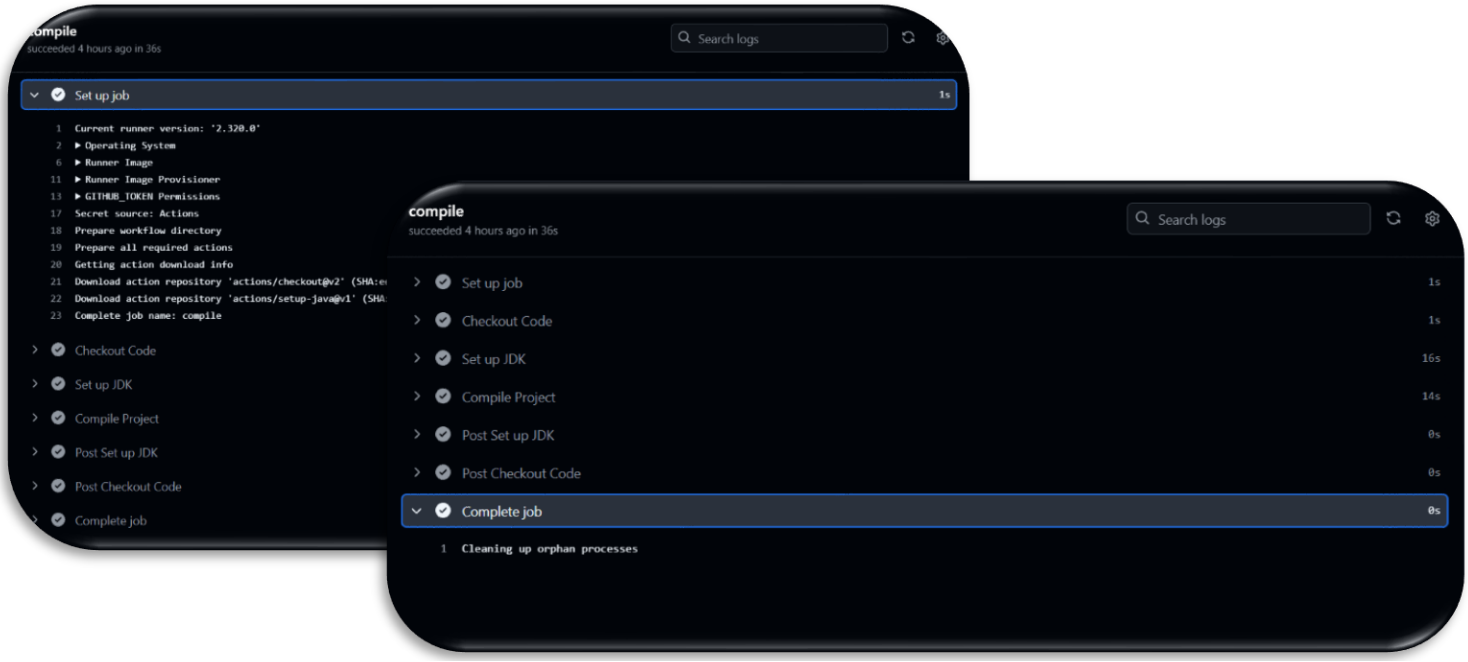


1. **Compile Job:**
   This stage compiles the backend project to ensure the codebase is in good condition.

```yaml
compile:
  runs-on: ubuntu-latest
  steps:
    - name: Checkout Code
      uses: actions/checkout@v2
    - name: Set up JDK
      uses: actions/setup-java@v1
      with:
        java-version: '17'
    - name: Compile Project
      run: mvn clean compile
      working-directory: ./editor
```

- Checkout Code: Retrieves the latest code from the repository.
- Set up JDK: Configures the environment with JDK 17 to match the backend's Java requirements.
- Compile Project: Runs mvn clean compile to compile the project in the editor directory.

11.1 Backend Pipeline

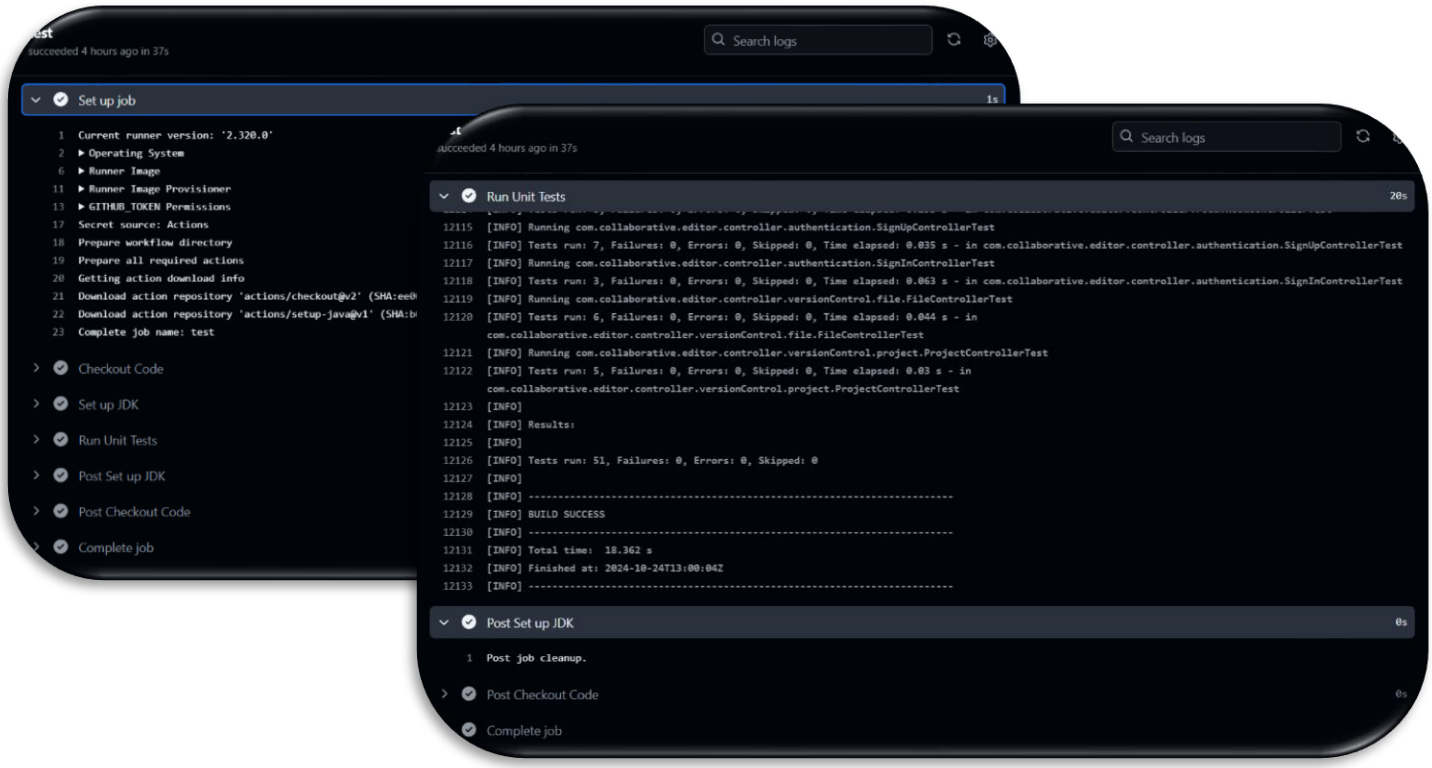


2. **Test Job:**
   In this stage, unit tests are executed to validate the code.

```yaml
test:
  runs-on: ubuntu-latest
  steps:
    - name: Checkout Code
      uses: actions/checkout@v2
    - name: Set up JDK
      uses: actions/setup-java@v1
      with:
        java-version: '17'
    - name: Run Unit Tests
      run: mvn test -DskipTests=false
      working-directory: ./editor
```

- Run Unit Tests: Executes unit tests using Maven (mvn test). The -DskipTests=false ensures that tests are not skipped.

11.1 Backend Pipeline



❖ **Junit & Mockito (Testing)**

In my project, I've implemented unit tests for various controller and service classes using JUnit and Mockito.

11.1 Backend Pipeline

- **SignInControllerTest and SignUpControllerTest**

  Tests:

  - **signInSuccess:** Verifies successful login.
  - **signInInvalidCredentials:** Tests login failure due to invalid credentials.
  - **signInUserNotFound:** Tests failure when the user is not found.
  - **createAccountSuccess:** Tests successful account creation.
  - **createAccountFailureDueToExistingEmail:** Tests failure due to an already existing email.
  - **createAccountFailureDueToInvalidEmail:** Tests failure due to invalid email format.
  - **createAccountFailureDueToWeakPassword:** Tests failure due to weak password.
  - **providerSignIn:** Tests OAuth provider sign-in for Google and GitHub.

11.1 Backend Pipeline

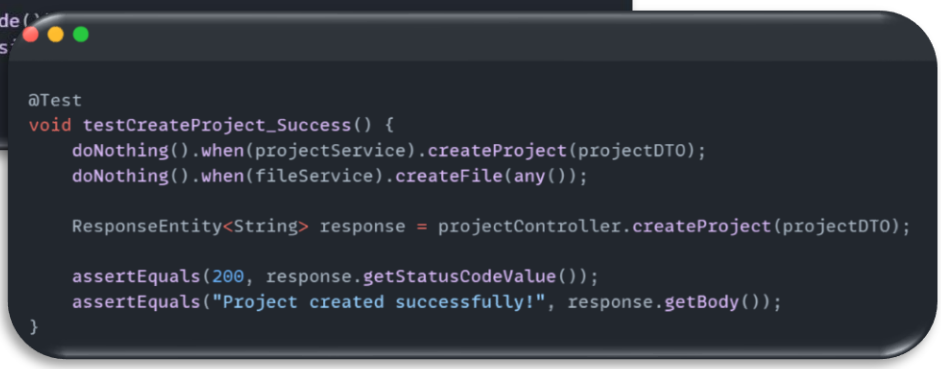
- **RoomControllerTest**

  Tests:
  - **createRoom_success: Verifies room creation success.**
  - **deleteRoom_success: Verifies successful room deletion.**
  - **addMember_success: Tests successful addition of a member.**
  - **getRoomDetails_success: Verifies successful retrieval of room details.**
  - **renameRoom_success: Verifies room renaming.**

```
@Test
void createRoom_success() {
    when(userService.findUserByEmail(anyString())).thenReturn(Optional.of(owner));
    when(roomService.createRoom(any(User.class), anyString())).thenReturn("roomId123");

    ResponseEntity<Map<String, String>> response = roomController.createRoom(createRoomRequest);

    assertEquals(200, response.getStatusCodeValue());
    assertNotNull(response.getBody());
    assertEquals("roomId123", response.getBody().get("roomId"));
}
```

- **FileControllerTest and ProjectControllerTest**
  Tests:
  - **listFiles:** Tests listing of files in a project.
  - **createFile:** Tests file creation.
  - **pullFileContent:** Tests pulling file content.
  - **mergeFileContent:** Tests merging file content.
  - **testCreateProject_Success:** Tests successful project creation.
  - **testCreateProject_Failure:** Tests project creation failure.
  - **testListProjects_Success:** Verifies successful listing of projects.
  - **testDeleteProject_Success:** Verifies successful project deletion.

```
@Test
void listFiles() {
    when(fileService.getFiles(any())).thenReturn(Collections.singletonList(fileDTO));

    ResponseEntity<Map<String, List<FileDTO>>> response = fileController.listFiles("project1", "room1");

    assertEquals(HttpStatus.OK, response.getStatusCode()
    assertEquals(1, response.getBody().get("files").s
}
```

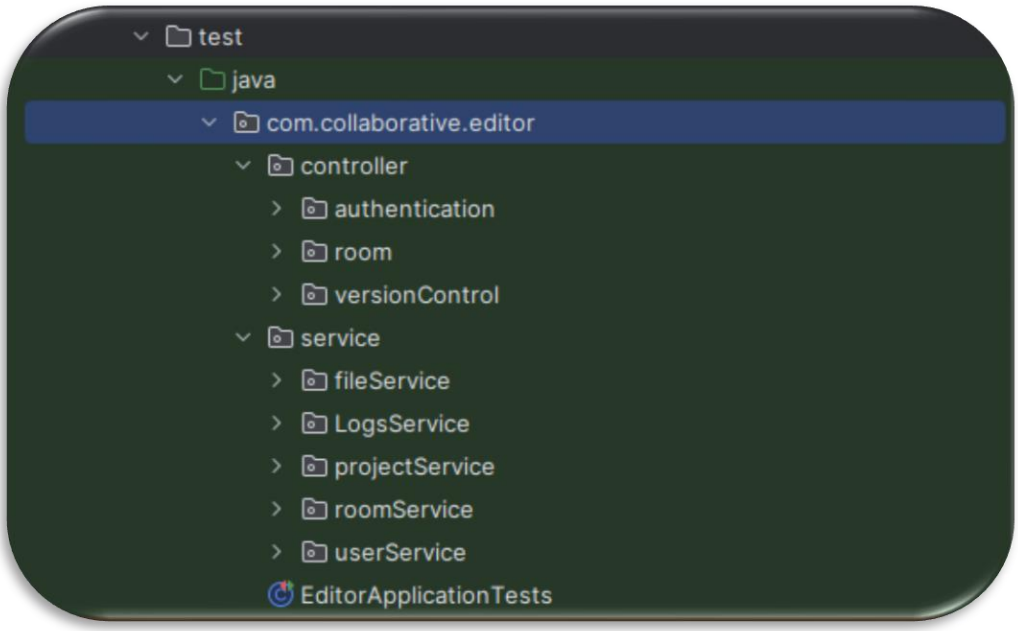


```
@Test
void testCreateProject_Success() {
    doNothing().when(projectService).createProject(projectDTO);
    doNothing().when(fileService).createFile(any());

    ResponseEntity<String> response = projectController.createProject(projectDTO);

    assertEquals(200, response.getStatusCodeValue());
    assertEquals("Project created successfully!", response.getBody());
}
```

11.1 Backend Pipeline

Note

The other Unit tests you can find them inside the codes.



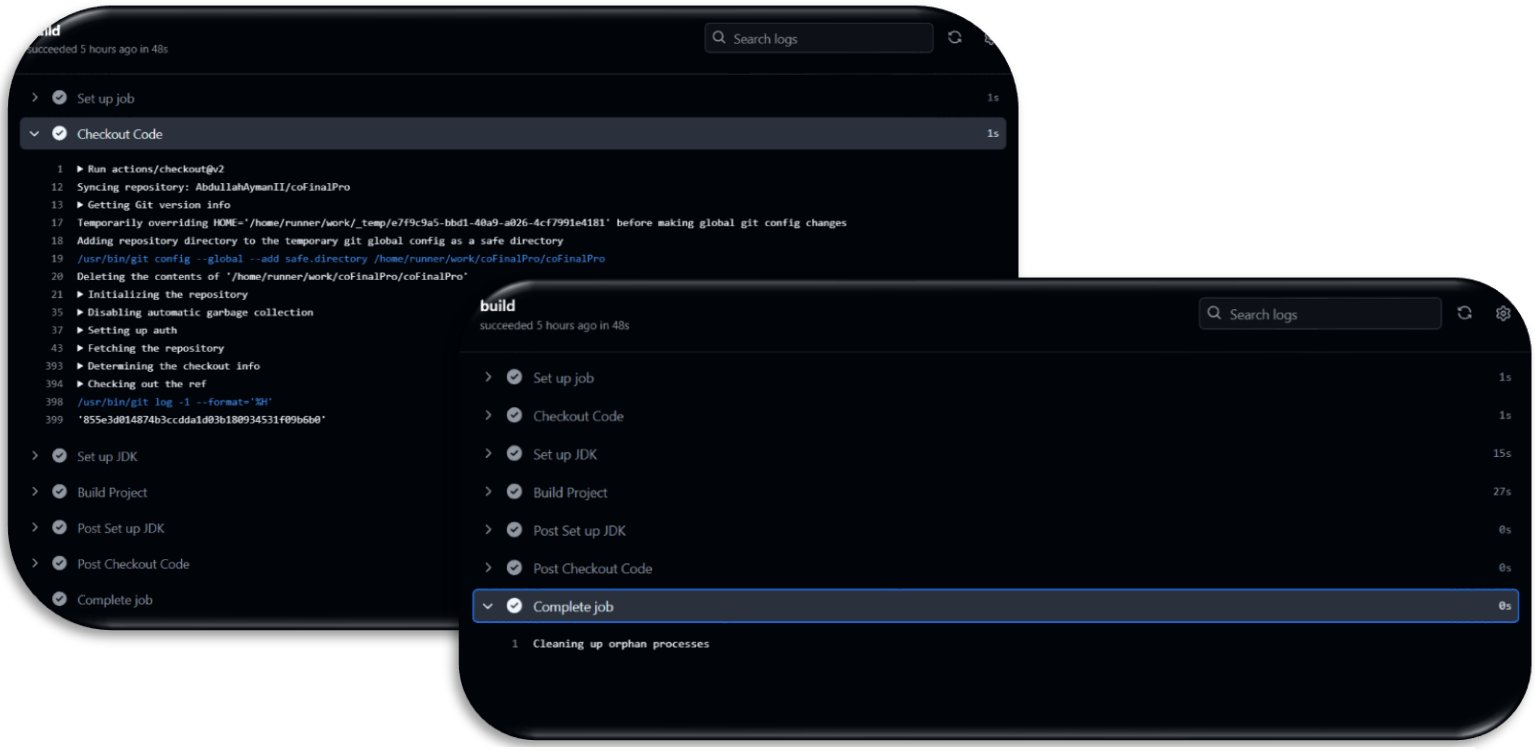
3. **Build Job:**
   This stage builds the final JAR file for deployment after both **compilation and testing are completed.**

```yaml
build:
  runs-on: ubuntu-latest
  needs: [test, compile]
  steps:
    - name: Checkout Code
      uses: actions/checkout@v2
    - name: Set up JDK
      uses: actions/setup-java@v1
      with:
        java-version: '17'
    - name: Build Project
      run: mvn clean package -DskipTests
      working-directory: ./editor
```

- **Needs:** This job depends on both compile and test jobs being successful.

- **Build Project:** Uses mvn clean package to package the backend project, creating the JAR file for later use.

11.1 Backend Pipeline



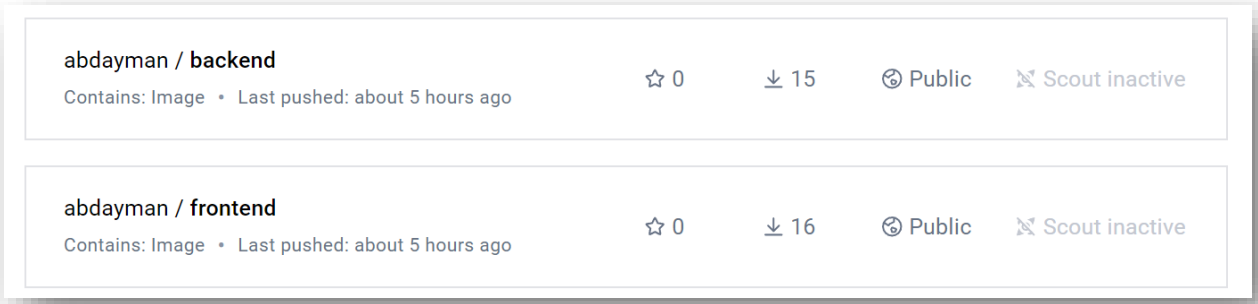
4. **Build and Push Docker Image:**
   This job builds the Docker image for the backend and pushes it to Docker Hub.

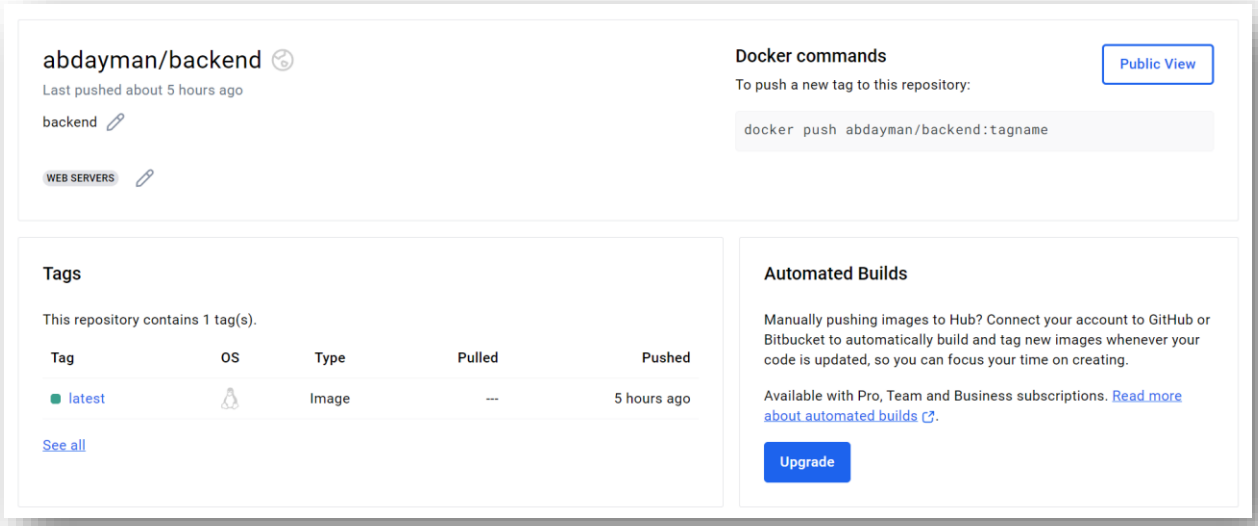
```yaml
build-and-push-docker:
  runs-on: ubuntu-latest
  needs: build
  steps:
    - name: Checkout Code
      uses: actions/checkout@v2
    - name: Set up Docker Buildx
      uses: docker/setup-buildx-action@v2
    - name: Log in to Docker Hub
      run: echo "${{ secrets.DOCKER_PASSWORD }}" | docker login -u "${{ secrets.DOCKER_USERNAME }}" --password-stdin
    - name: Build Docker Image
      run: docker build -t ${{ secrets.DOCKER_USERNAME }}/backend:latest ./editor
    - name: Push Docker Image
      run: docker push ${{ secrets.DOCKER_USERNAME }}/backend:latest
```

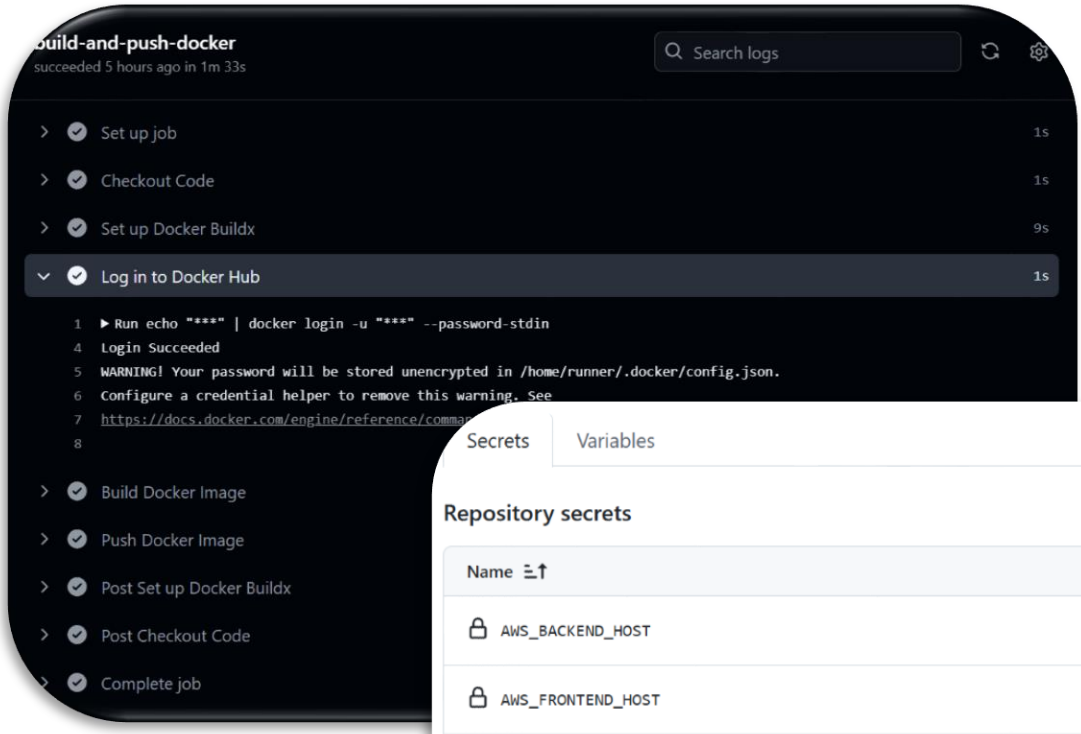
- **Build Docker Image:** Uses the Dockerfile in the ./editor directory to create a Docker image.

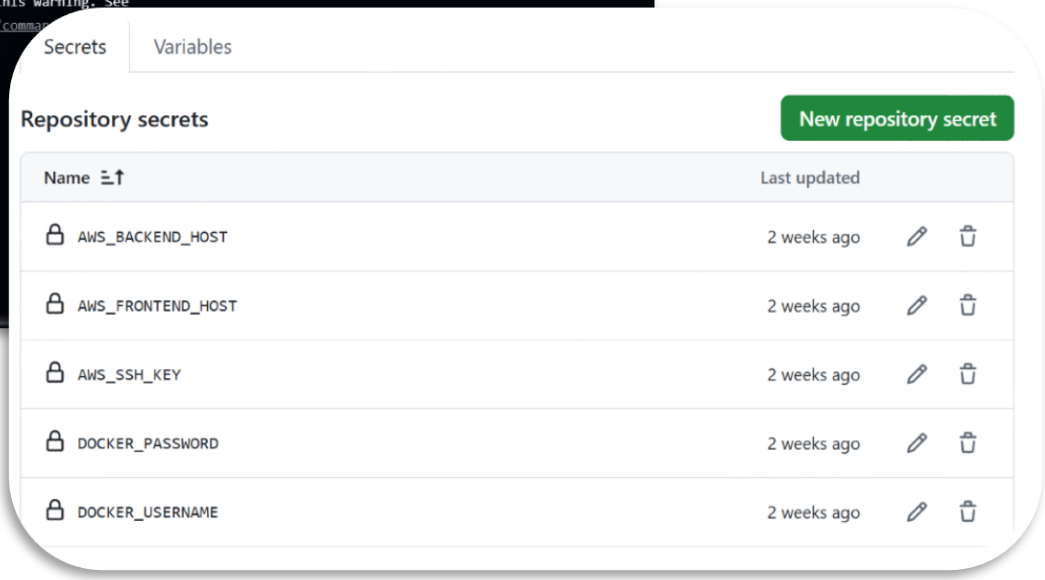
- **Push Docker Image:** Pushes the newly built image to Docker Hub.

11.1 Backend Pipeline







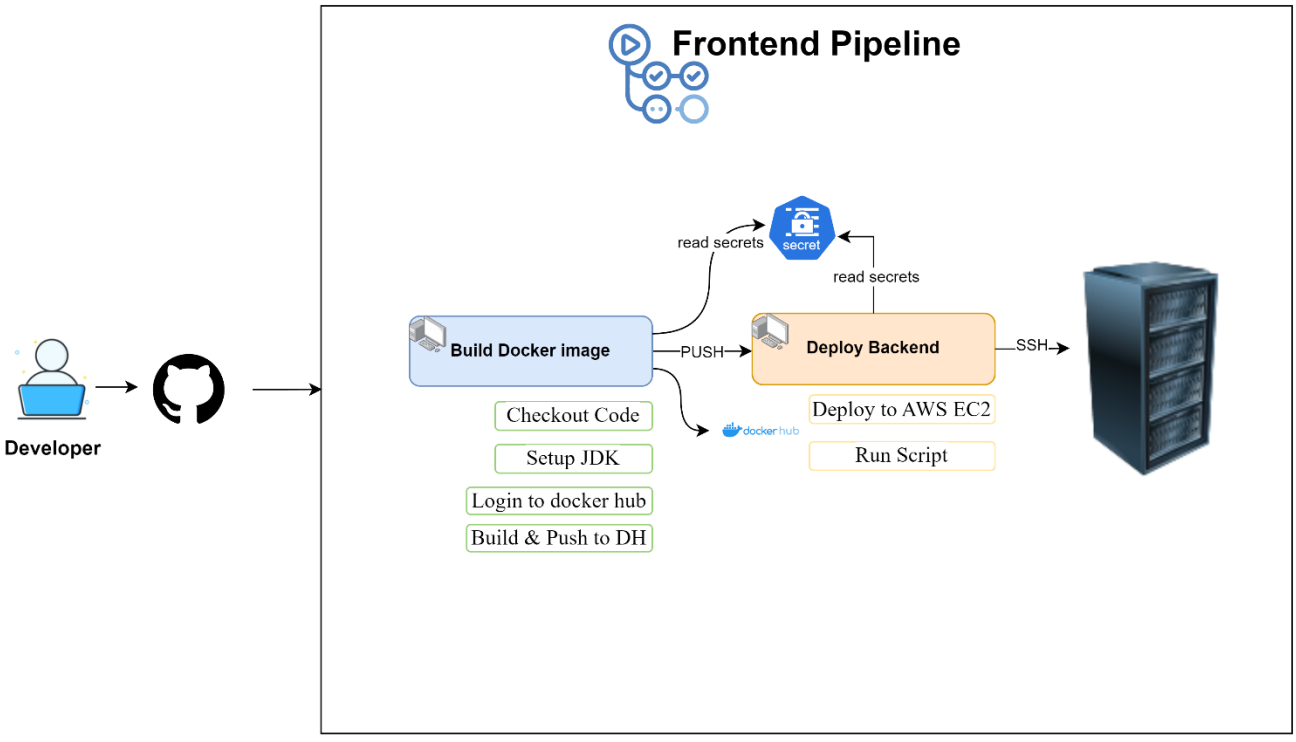


11.1 Backend Pipeline

5. Deploy Job (Not Working Due to AWS Constraints) Attempts to deploy the Docker image to an AWS EC2 instance.

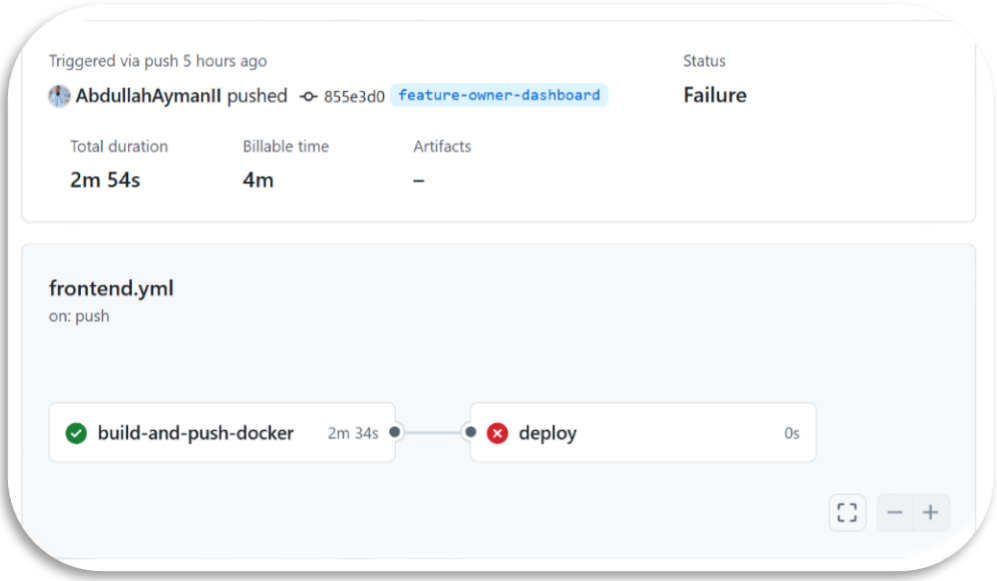
```yaml
deploy:
  runs-on: ubuntu-latest
  needs: build-and-push-docker  # Run after Docker image is pushed
  steps:
    - name: Deploy to AWS EC2
      run: |
        ssh -o StrictHostKeyChecking=no -i ${{ secrets.AWS_EC2_KEY }}
        ubuntu@${{ secrets.AWS_EC2_IP }}
         'docker pull ${{ secrets.DOCKER_USERNAME }}/backend:latest && docker-compose up -d'
    - name: SSH into Backend EC2
      uses: appleboy/ssh-action@master
      with:
          host: ${{ secrets.AWS_BACKEND_HOST }}
          username: i-0adabf6ef59b093e9
          key: ${{ secrets.AWS_SSH_KEY }}
          script: |
            # Pull the latest backend image
            docker pull ${{ secrets.DOCKER_USERNAME }}/backend:latest

            # Stop and remove existing backend container
            docker stop backend || true
            docker rm backend || true

            # Run MySQL container
            docker run --name mysql -e MYSQL_ROOT_PASSWORD=root -e MYSQL_DATABASE=mysql_db -p 3306:3306 -d mysql:8.0 || docker start mysql

            # Run MongoDB container
            docker run --name mongo -e MONGO_INITDB_ROOT_USERNAME=devroot -e MONGO_INITDB_ROOT_PASSWORD=devroot -p 27017:27017 -d mongo || docker start mongo

            # Run the backend container
            docker run -d -p 8080:8080 --name backend --link mysql:mysql --link mongo:mongo ${{ secrets.DOCKER_USERNAME }}/backend:latest
```

11.2 Frontend Pipeline



11.2 Frontend Pipeline

This pipeline handles the process for building and deploying the frontend.



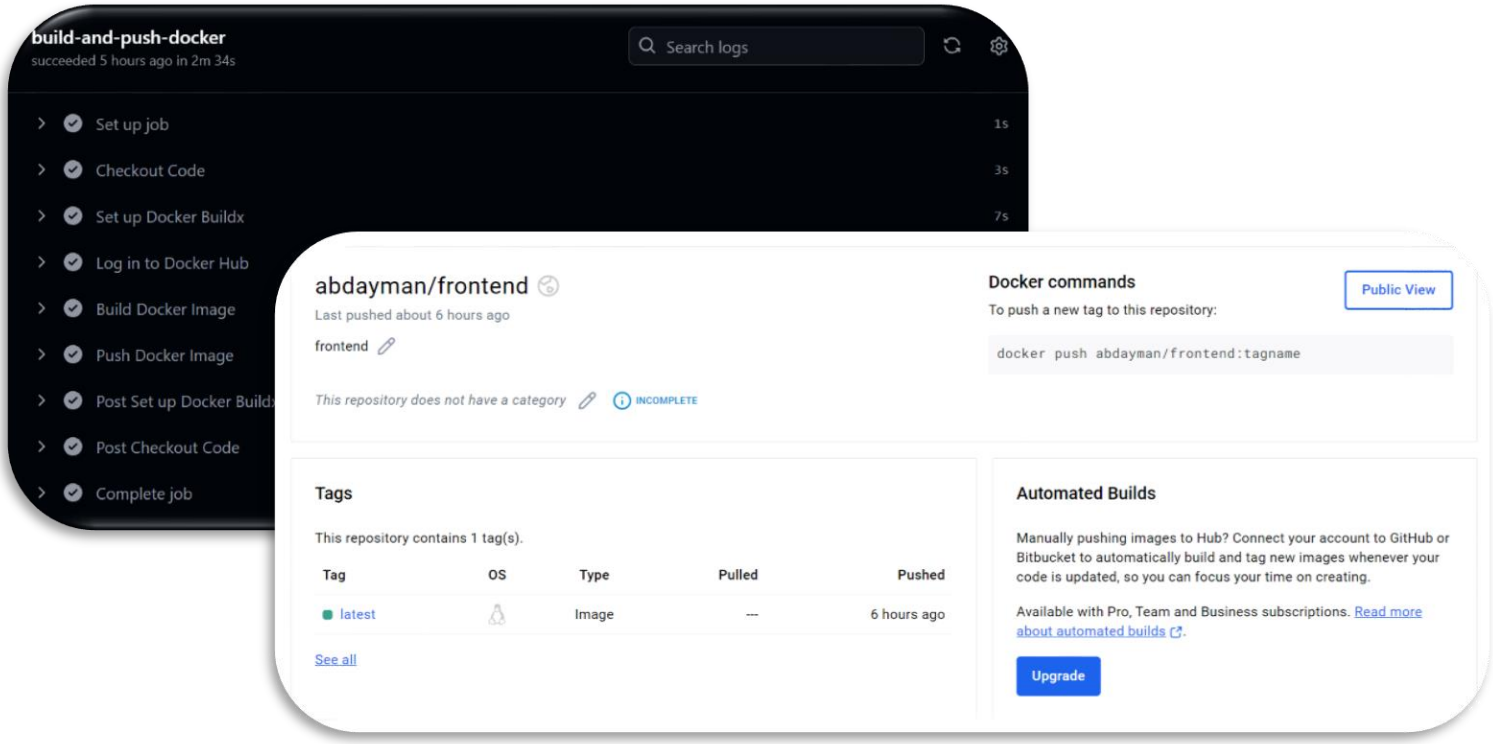
1. Build and Push Docker Image

Like the backend, this stage builds the frontend Docker image and pushes it to Docker Hub.

```yaml
build-and-push-docker:
  runs-on: ubuntu-latest
  steps:
    - name: Checkout Code
      uses: actions/checkout@v2
    - name: Set up Docker Buildx
      uses: docker/setup-buildx-action@v2
    - name: Log in to Docker Hub
      run: echo "${{ secrets.DOCKER_PASSWORD }}" | docker login -u "${{ secrets.DOCKER_USERNAME }}" --password-stdin
    - name: Build Docker Image
      run: docker build -t ${{ secrets.DOCKER_USERNAME }}/frontend:latest ./frontend
    - name: Push Docker Image
      run: docker push ${{ secrets.DOCKER_USERNAME }}/frontend:latest
```

- **Build Docker Image:** Creates the frontend Docker image using the ./frontend directory.
- **Push Docker Image**: Pushes the frontend image to Docker Hub.

11.2 Frontend Pipeline

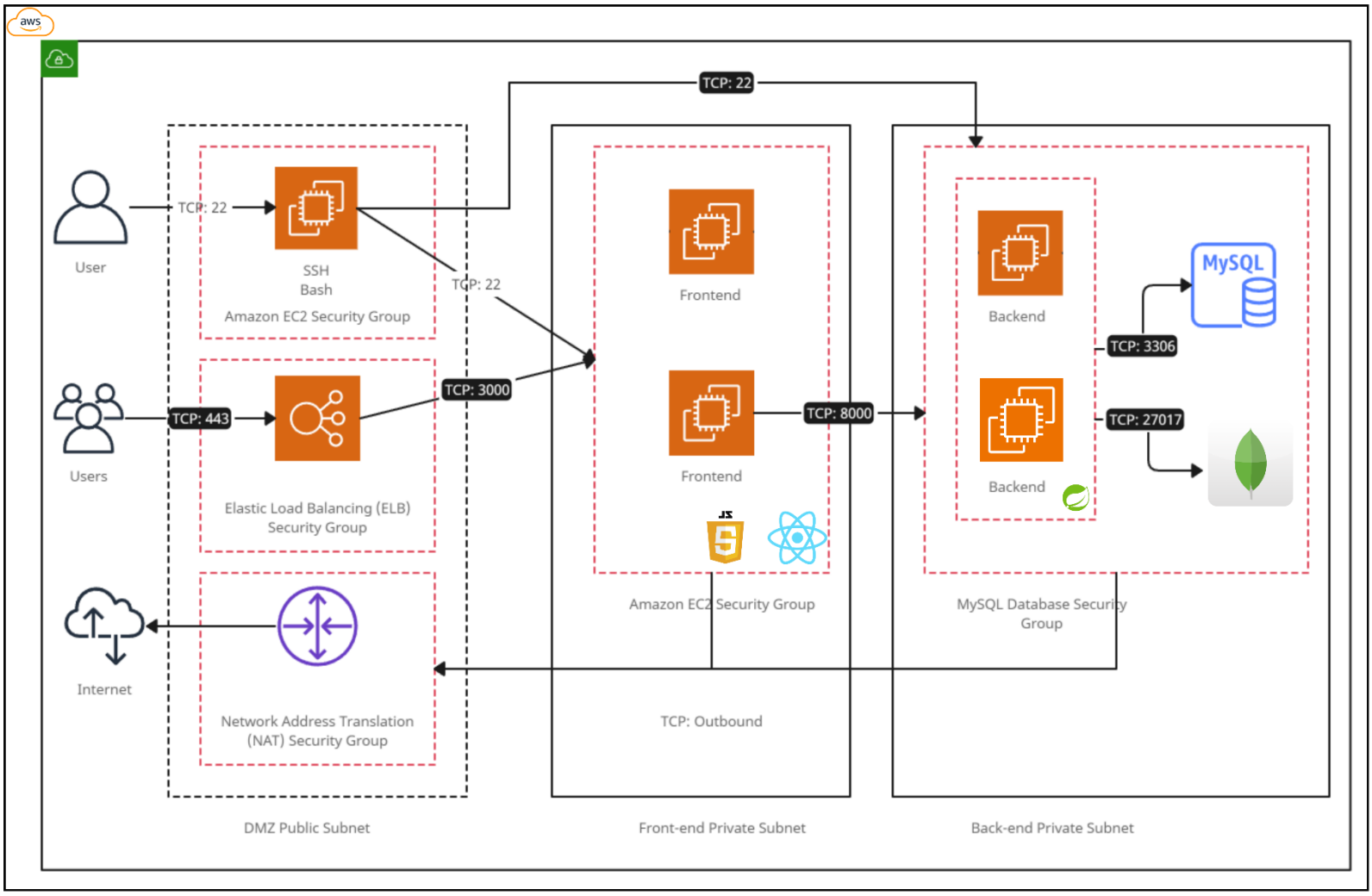


5. Deploy Job (Not Working Due to AWS Constraints) Attempts to deploy the frontend Docker image to an AWS EC2 instance.

```yaml
deploy:
  runs-on: ubuntu-latest
  needs: build-and-push-docker
  steps:
    - name: Deploy to AWS EC2
      run: |
        ssh -o StrictHostKeyChecking=no -i ${{ secrets.AWS_EC2_KEY }} ubuntu@${{ secrets.AWS_EC2_IP }}
         'docker pull ${{ secrets.DOCKER_USERNAME }}/frontend:latest && docker-compose up -d'
    - name: SSH into Frontend EC2
      uses: appleboy/ssh-action@master
      with:
        host: ${{ secrets.AWS_FRONTEND_HOST }}
        username: i-013c7f2dc6a0b6e68
        key: ${{ secrets.AWS_SSH_KEY }}
        script: |
          # Pull the latest frontend image
          docker pull ${{ secrets.DOCKER_USERNAME }}/frontend:latest

          # Stop and remove existing frontend container
          docker stop frontend || true
          docker rm frontend || true

          # Run the frontend container
          docker run -d -p 3000:3000 --name frontend ${{ secrets.DOCKER_USERNAME }}/frontend:latest
```

- **Deploy to AWS:** Pulls the latest frontend image from Docker Hub and runs it on AWS EC2 using docker-compose up. Again, this step doesn't work because of the AWS free tier constraints.

AWS



In the AWS network I used the same scalable network infrastructure as that is one in the AWS assignment, and **I used Terraform to automate the creation process**. The architecture includes a Virtual Private Cloud (VPC) with both public and private subnets, designed to host a multi-tier web application. Key components include an Internet Gateway (IGW), NAT Gateway, Security Groups for access control, EC2 instances for compute resources, and
an Application Load Balancer (ALB) for traffic distribution. The following sections provide a detailed breakdown of each component and its

12.1 Terraform

I used the terraform to automate the network creation, and the explanations of the scripts used.

1. **AWS Provider and VPC**

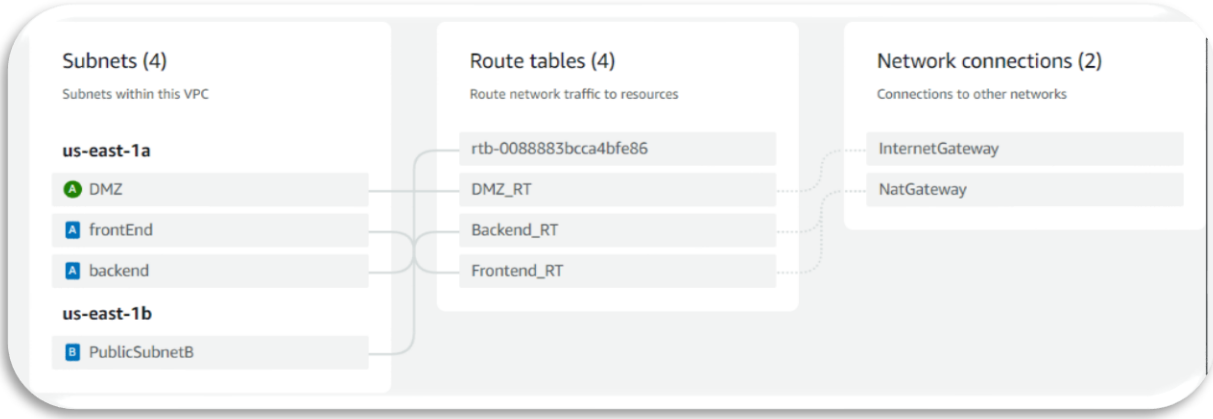
```
provider "aws" {
  region = "us-east-1"
}
resource "aws_vpc" "vpc" {
  cidr_block = "10.0.0.0/16"
  enable_dns_support = true
  enable_dns_hostnames = true
  tags = {
    Name = "collaborativeCodeEditor"
  }
}
```

- **Provider:** Specifies AWS as the cloud provider and sets the region to us-east-1.
- **VPC:** Creates a Virtual Private Cloud (VPC) with the specified CIDR range and DNS support.

2. **Subnets**

```
resource "aws_subnet" "publicB" { ... }
resource "aws_subnet" "frontend" { ... }
resource "aws_subnet" "backend" { ... }
resource "aws_subnet" "DMZ" {
  vpc_id = aws_vpc.vpc.id
  cidr_block = "10.0.1.0/24"
  map_public_ip_on_launch = true
  availability_zone = "us-east-1a"
  tags = {
    Name = "DMZ"
  }
}
```

- **Subnets:** Defines different subnets for DMZ, public, frontend, and backend within the VPC, each with unique CIDR blocks and availability zones.



3. Internet Gateway and Route Tables

```
resource "aws_internet_gateway" "igw" {
  vpc_id = aws_vpc.vpc.id
  tags = {
    Name = "InternetGateway"
  }
}

resource "aws_route_table" "DMZ_RT" {
  vpc_id = aws_vpc.vpc.id
  route {
    cidr_block     = "0.0.0.0/0"
    gateway_id     = aws_internet_gateway.igw.id
  }
  tags = {
    Name = "DMZ_RT"
  }
}
resource "aws_route_table" "Frontend_RT" { ... }
resource "aws_route_table" "Backend_RT" { ... }
```

- **Internet Gateway:** Connects the VPC to the internet.
- **Route Tables:** Defines routes for public (DMZ) and private (Frontend/Backend) traffic, connecting via either the internet gateway or NAT gateway.

4. NAT Gateway and Elastic IP

```
resource "aws_eip" "nat_eip" {
  domain = "vpc"
  tags = {
    Name = "Elastic IP"
  }
}

resource "aws_nat_gateway" "my_nat" {
  allocation_id = aws_eip.nat_eip.id
  subnet_id     = aws_subnet.DMZ.id
  tags = {
    Name = "NatGateway"
  }
}
```

- **Elastic IP:** Allocates a static IP for the NAT gateway.
- **NAT Gateway:** Allows instances in private subnets (Frontend/Backend) to access the internet.

5. Route Table Associations

```
resource "aws_route_table_association" "DMZ_subnet_association" {
  subnet_id      = aws_subnet.DMZ.id
  route_table_id = aws_route_table.DMZ_RT.id
}

resource "aws_route_table_association" "Frontend_association" {
  subnet_id      = aws_subnet.frontend.id
  route_table_id = aws_route_table.Frontend_RT.id
}

resource "aws_route_table_association" "Backend_association" {
  subnet_id      = aws_subnet.backend.id
  route_table_id = aws_route_table.Backend_RT.id
}
```

- **Associations:** Links subnets with their corresponding route tables.

6. Security Groups

```
resource "aws_security_group" "ssh_bastion" {
  name        = "ssh-bastion-sg"
  description = "Security group for SSH Bastion instance"
  vpc_id      = aws_vpc.vpc.id
}

resource "aws_security_group" "app_lb" {
  name        = "appLB-sg"
  description = "Security group for Load Balancer"
  vpc_id      = aws_vpc.vpc.id
}
resource "aws_security_group" "frontend_app" { ... }
resource "aws_security_group" "backend_app" { ... }
resource "aws_security_group" "databases" { ... }
```

- **Security Groups:** Defines access control for SSH bastion, load balancer, frontend, backend, and database layers.

7. Security Group Rules

```
resource "aws_security_group_rule" "ssh_bastion_ingress" {
  type              = "ingress"
  from_port         = 22
  to_port           = 22
  protocol          = "tcp"
  cidr_blocks       = ["0.0.0.0/0"]
  security_group_id = aws_security_group.ssh_bastion.id
}
resource "aws_security_group_rule" "app_lb_ingress_http" { ... }
resource "aws_security_group_rule" "Frontend_app_ingress_http" { ... }
```

- **Ingress and Egress Rules:** Control inbound/outbound traffic to instances (SSH, HTTP, DB connections, etc.).

12.1 Terraform

8. Load Balancer and Target Group

```
resource "aws_lb" "app_lb" {
  name               = "app-lb"
  internal           = false
  security_groups    = [aws_security_group.app_lb.id]
  subnets            = [aws_subnet.DMZ.id, aws_subnet.publicB.id]
  load_balancer_type = "application"
  enable_deletion_protection = false
  tags = {
    Name = "Application Load Balancer"
  }
}
resource "aws_lb_target_group" "app_tg" {
  name     = "app-tg"
  port     = 3000                    # Port the frontend listens on
  protocol = "HTTP"
  vpc_id   = aws_vpc.vpc.id

}
resource "aws_lb_listener" "web_app_listener" { ... }
```

- **Load Balancer:** Distributes incoming traffic across multiple frontend instances.
- **Target Group:** Groups instances for the load balancer to forward traffic to.
- **Listener:** Listens on port 80 for HTTP requests and forwards them to the target group.

9. EC2 Instances

```
resource "aws_instance" "ssh_bastion" {
  ami             = "ami-06b21ccaeff8cd686"
  instance_type   = "t2.micro"
  key_name        = "deployer_key"
  security_groups = [aws_security_group.ssh_bastion.id]
  subnet_id       = aws_subnet.DMZ.id
  tags = {
    Name = "ssh-bastion"
  }
}

resource "aws_instance" "Frontend_app" { ... }
resource "aws_instance" "Backend_app" { ... }
resource "aws_instance" "databases" { ... }
```

- **EC2 Instances:** Defines instances for the SSH bastion, frontend, backend, and database services. Each runs Docker containers for the respective services.

Name	Instance ID	Instance state	Instance type	Status check	Alarm status
frontend-insta…	i-0d2b8845f5cebaa77	Running	t2.micro	2/2 checks passec	View alarms
databases	i-05eb0ee750eae8270	Running	t2.micro	2/2 checks passec	View alarms
ssh-bastion	i-06720b5c30d476a2c	Running	t2.micro	2/2 checks passec	View alarms
backend-insta…	i-01a9e4ccd7a2f2b50	Running	t2.micro	2/2 checks passec	View alarms

- **The t2.micro is not enough to deploy our collaborative code editor that is why I deploy it in docker environment.**

Future Work

- Implement SSL for secure WebSocket and HTTP communication to enhance security.
- Improve AWS deployment by creating an S3 bucket for HTTPS certificates, ensuring encrypted data transmission.
- Integrate Kubernetes for better orchestration of Docker containers, enhancing scalability and management of backend and frontend applications.
- Add Pull Request functionality in the collaborative code editor for version control, allowing team collaboration and code reviews.
- Introduce a notification system to keep users updated on room activities and actions.
- Develop a more powerful dashboard for room owners, offering detailed insights and control over the collaborative environment.