
DESIGN AND IMPLEMENTATION FOR

Kaiju Academy

Version 1.1

**Prepared by
Group A2**

YU Ching Hei	1155193237	chyu@link.cuhk.edu.hk
Lei Hei Tung	1155194969	1155194969@link.cuhk.edu.hk
Ankhubayar Enkhitaivan	1155185142	1155185142@link.cuhk.edu.hk
Yum Ho Kan	1155195234	1155195234@link.cuhk.edu.hk
Leung Chung Wang	1155194650	1155194650@link.cuhk.edu.hk

**The Chinese University of Hong Kong
Department of Computer Science and Engineering
CSCI3100: Software Engineering**

May 9, 2025

Contents

Contents	ii
Document Revision History	iv
1 Introduction	1
1.1 Summary of Requirements	1
1.2 Quality Goals	1
1.3 Stakeholders	1
1.3.1 Acknowledgments	1
2 System Architecture	2
2.1 Major Components	2
2.2 Component Relationships	2
2.3 Database	2
2.4 Security	2
2.5 User Authentication and Authorization	3
2.6 Testability	3
3 Data Models	4
3.1 Database Schema	4
3.2 Request and Response Structure	4
3.3 Data Flow Sequence	4
4 Interface Design	6
4.1 User Registration and Authentication	6
4.1.1 Course Management	7
4.1.2 Course Access	8
4.1.3 Code Assessment and Grading	8
4.2 Service Communication	8
4.3 Security Implementation	8
4.4 Exception Handling	9
4.4.1 Expected Exceptions	9
4.4.2 Error Handling Example	9
4.4.3 Credit Purchase and Payment Flow	10
4.4.4 Credit Purchase and Course Enrollment Flow	10
4.4.5 Credit Purchase and Enrollment Logic (Mermaid Diagram)	10
4.5 Licence Key Verification	10
5 Component Design	12
5.1 Frontend Components	12
5.1.1 Navbar Component	12
5.1.2 Code Editor Component	12
5.2 Backend Components	12
5.2.1 Authentication Service	12
5.2.2 Course Management Service	12
5.2.3 Assessment Service	12
6 User Interface Design	13
6.1 Design Principles	13
6.2 User-wise Navigation Flow	13
6.2.1 Student	13
6.2.2 Educator	14

6.2.3	Educator Dashboard and Course Management	14
6.2.4	Learning and Assessment	14
6.2.5	Educator Dashboard and Course Management	15
6.2.6	Assessment Creation and Grading	15
6.3	Overall UI Flow	15
6.4	Accessibility Considerations	15
6.5	Responsive Design	15
7	Assumptions	17
7.1	Technical Constraints	17
7.1.1	Hardware Constraints	17
7.1.2	Software Constraints	17
7.2	Operational Assumptions	17
7.3	Dependencies	17
7.3.1	Third-Party Services	17

Document Revision History

Version	Revised By	Revision Date	Comments
0.1	Group A2	2025-02-27	Added: –Initial document structure –Basic content outline
1.0	Group A2	2025-03-11	Updated: –Final review and integration
1.1	C. W. Leung	2025-04-23	Updated: –Pruned and updated per requirements in meeting1.docx
1.2	C. W. Leung	2025-05-08	Updated: –Updated UI Images

1. Introduction

Kaiju Academy is a **web-based e-learning platform** designed to make learning programming accessible and engaging. It combines modern Learning Management System (LMS) capabilities with interactive coding features, enabling users to learn at their own pace.

1.1 Summary of Requirements

Kaiju Academy includes:

- **User Management & Authentication:** Role-based access control for users (student), teachers (educator), and admins, with secure authentication and optional MFA.
- **Course Creation & Management:** Tools for creating, updating, and organizing courses with videos, PDFs, quizzes, and coding assessments.
- **Interactive Learning:** Real-time code execution and automated grading via an online code editor.
- **Profile and Progress:** User and educator profiles, progress tracking, recommended and registered courses.
- **Monetization:** Course credit system for payment and buying credits to unlock courses.

1.2 Quality Goals

Goal	Description
Performance	- Response time <2 seconds for 95% of users. - Code execution results in <5 seconds for 99% of submissions.
Scalability	- Support 10,000 concurrent users. - Horizontal scaling via AWS Lambda and SurrealDB sharding.
Reliability	- 99.9% uptime with automatic failover. - Recovery from failures within 5 minutes.
Security	- AES-256 encryption for data at rest. - TLS 1.2+ for data in transit. - Role-based permissions and MFA.

Table 1.1: Quality Goals for Kaiju Academy

1.3 Stakeholders

Stakeholder	Role & Responsibilities
Admin	- Manage system health, user roles, and platform configurations. - Enforce security policies.
User (Student)	- Enroll in courses, complete assessments, and track progress.
Teacher (Educator)	- Create and update course content. - Grade submissions and provide feedback.

Table 1.2: Stakeholders and Their Roles

1.3.1 Acknowledgments

This document was prepared with the assistance of AI tools (e.g., ChatGPT 4.1) for drafting and review.

2. System Architecture

2.1 Major Components

Frontend Application: A React application providing the user interface across all devices.

Backend Services: Nodejs-based AWS Lambda functions for service logic.

SurrealDB: Primary database for persistent data.

AWS Services: API Gateway, Lambda, Cognito (auth/MFA), S3 (media), CloudFront (CDN), Fargate (code execution).

2.2 Component Relationships

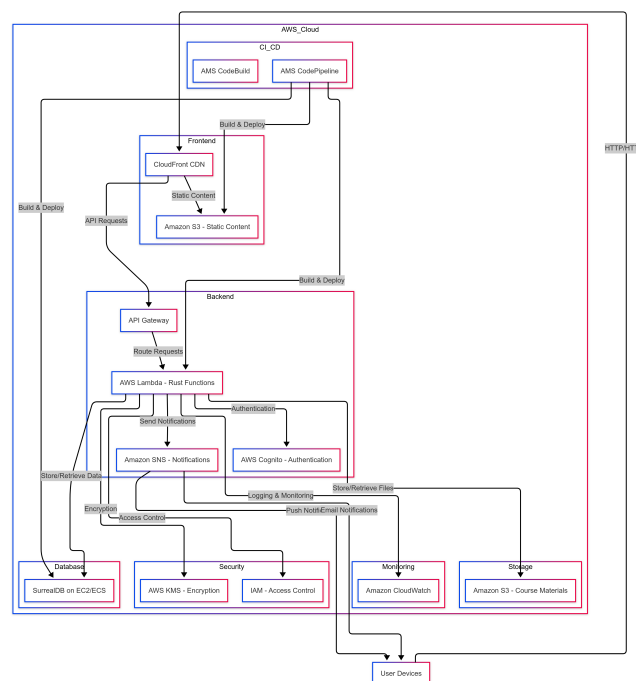


Figure 2.1: AWS Serverless Deployment Architecture

- Users access via browsers, routed through CloudFront CDN and API Gateway.
- Lambda functions handle business logic, SurrealDB stores data.
- Cognito manages authentication and optional MFA.
- S3 stores learning materials.

2.3 Database

SurrealDB's multi-model database supports course, user, credit/payment, progress, and assessment data.

2.4 Security

- AWS-managed VPC and IAM boundaries.
- AES-256 encryption at rest, TLS 1.2+ in transit.
- JWT for stateless API authentication, MFA support via Cognito.

2.5 User Authentication and Authorization

- Email/password registration and login, MFA if supported.
- JWT tokens for session management.
- Roles: user (student), teacher (educator), admin.

2.6 Testability

- Automated unit and integration tests in Nodejs.
- CI/CD pipeline with test coverage enforcement.

3. Data Models

3.1 Database Schema

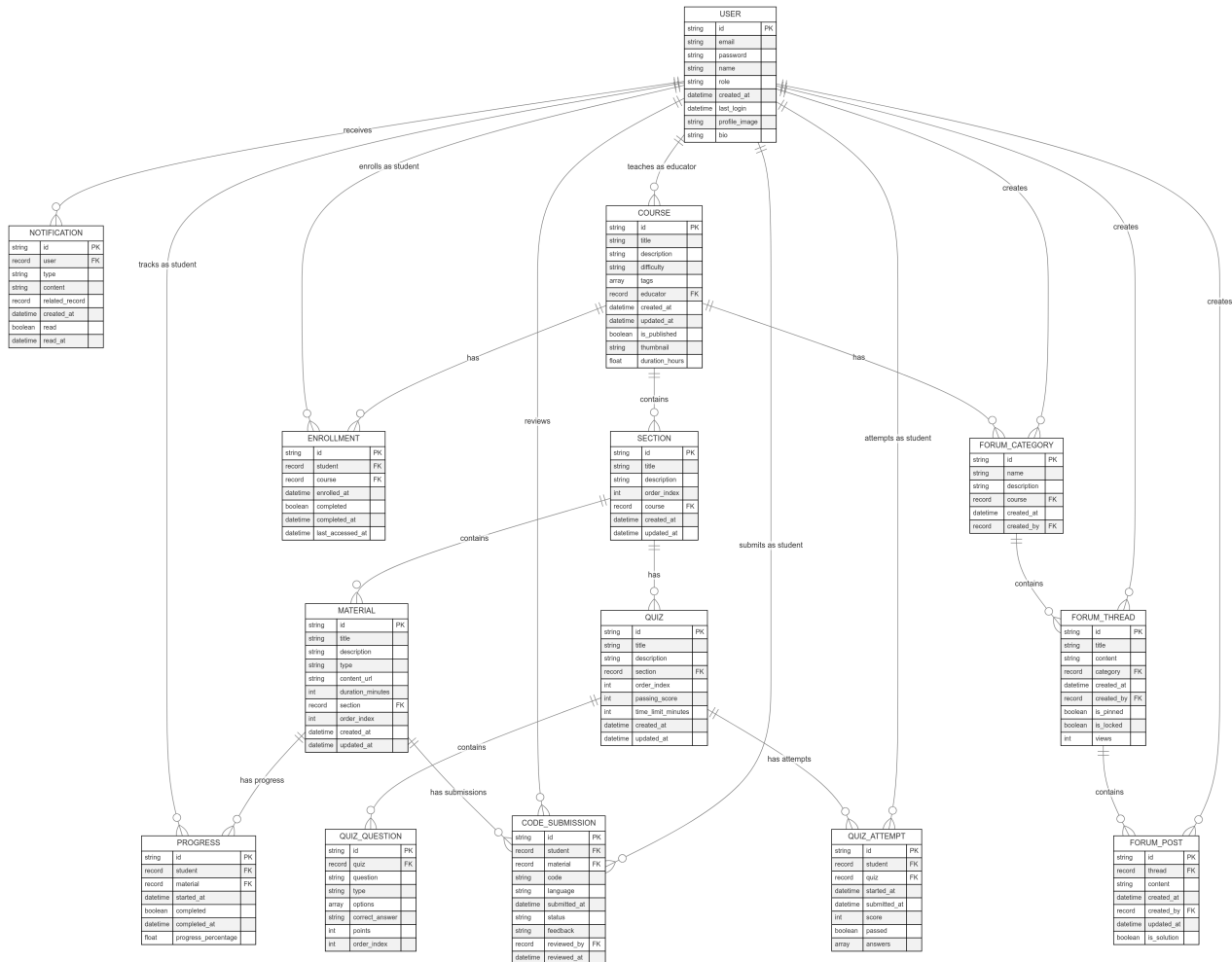
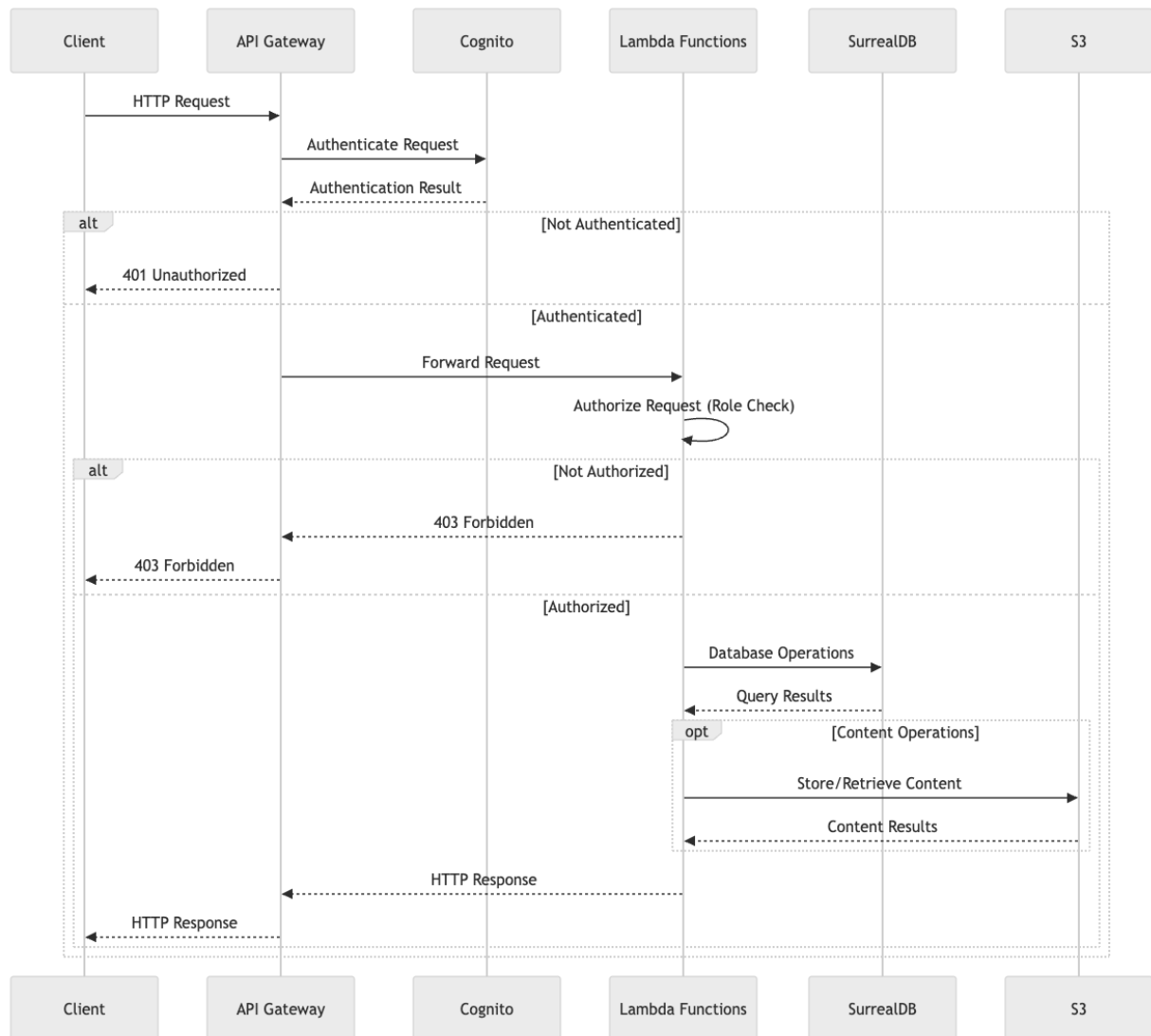


Figure 3.1: Database Schema

3.2 Request and Response Structure

```
let response = ApiGatewayProxyResponse {
  status_code: 200,
  headers: std::collections::HashMap::new(),
  multi_value_headers: std::collections::HashMap::new(),
  body: Some(json!({ "message": "Hello from Kaiju Academy API!" })),
  to_string(),
  is_base64_encoded: Some(false),
};
Ok(response)
```

3.3 Data Flow Sequence

**Figure 3.2:** Data Flow Sequence Diagram

4. Interface Design

4.1 User Registration and Authentication

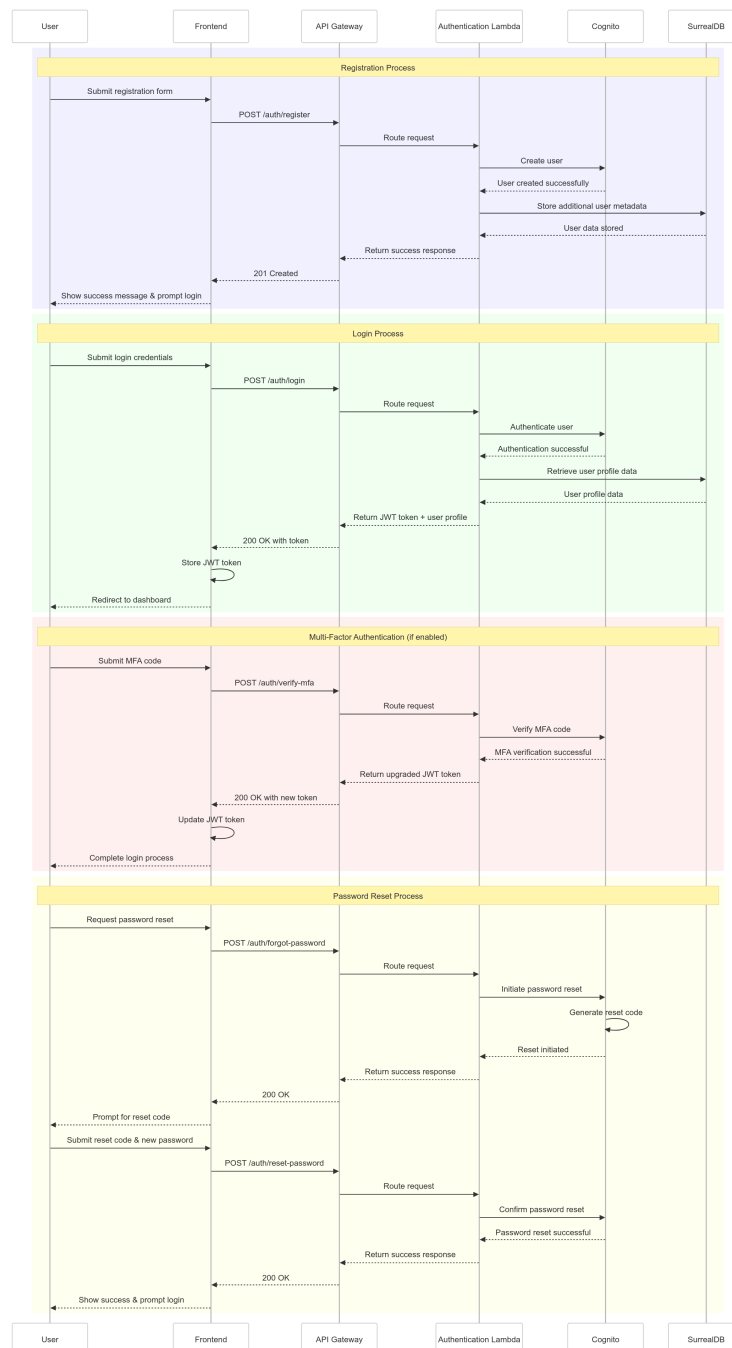


Figure 4.1: User Authentication Workflow

1. User submits registration/login with optional MFA.
2. API Gateway routes to Authentication Lambda.
3. Lambda creates/validates user in Cognito and SurrealDB.
4. JWT token returned for session.

4.1.1 Course Management

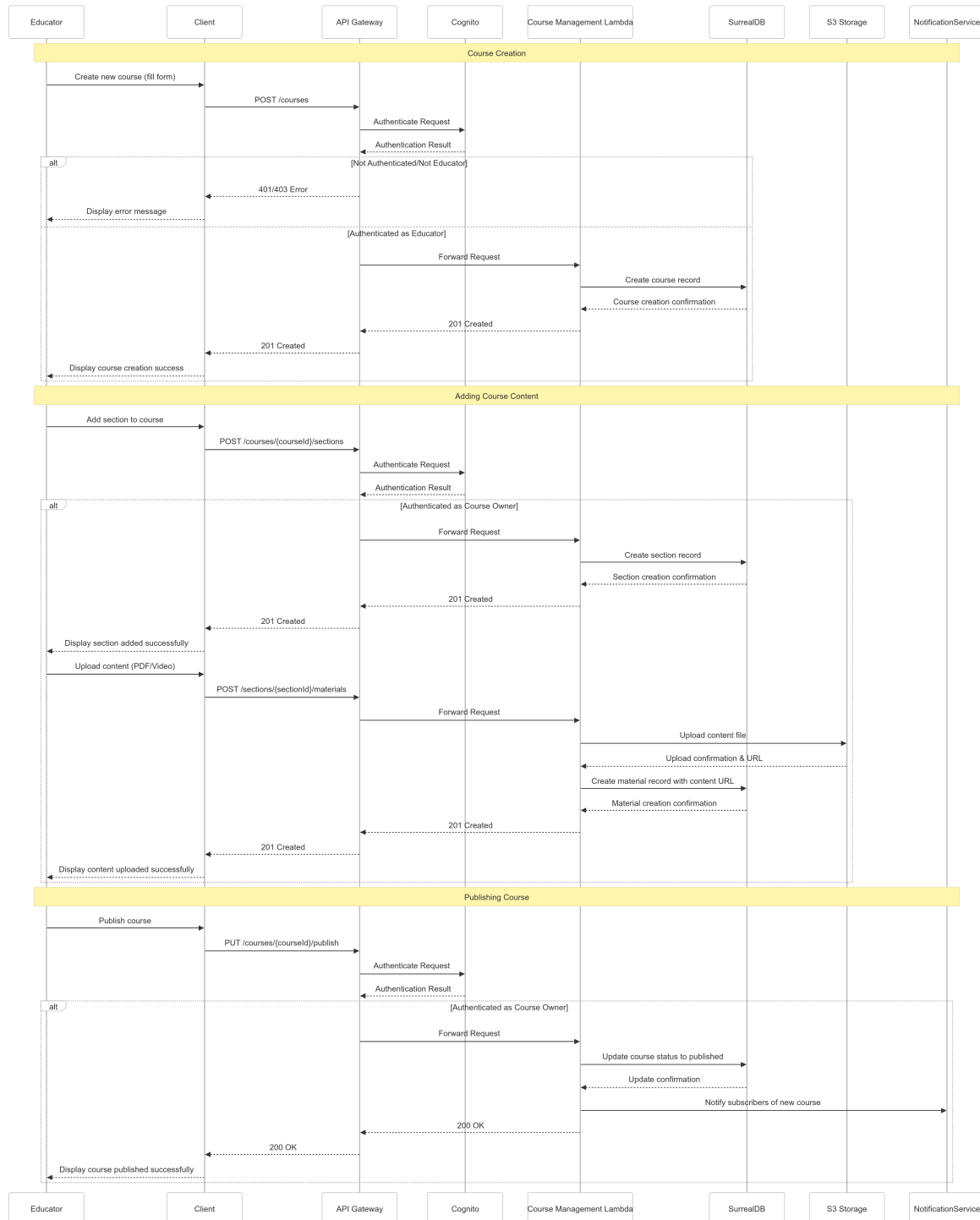


Figure 4.2: Course Management Workflow

1. Educator manages course structure and modules.
2. Materials uploaded to S3.
3. Changes stored in SurrealDB.

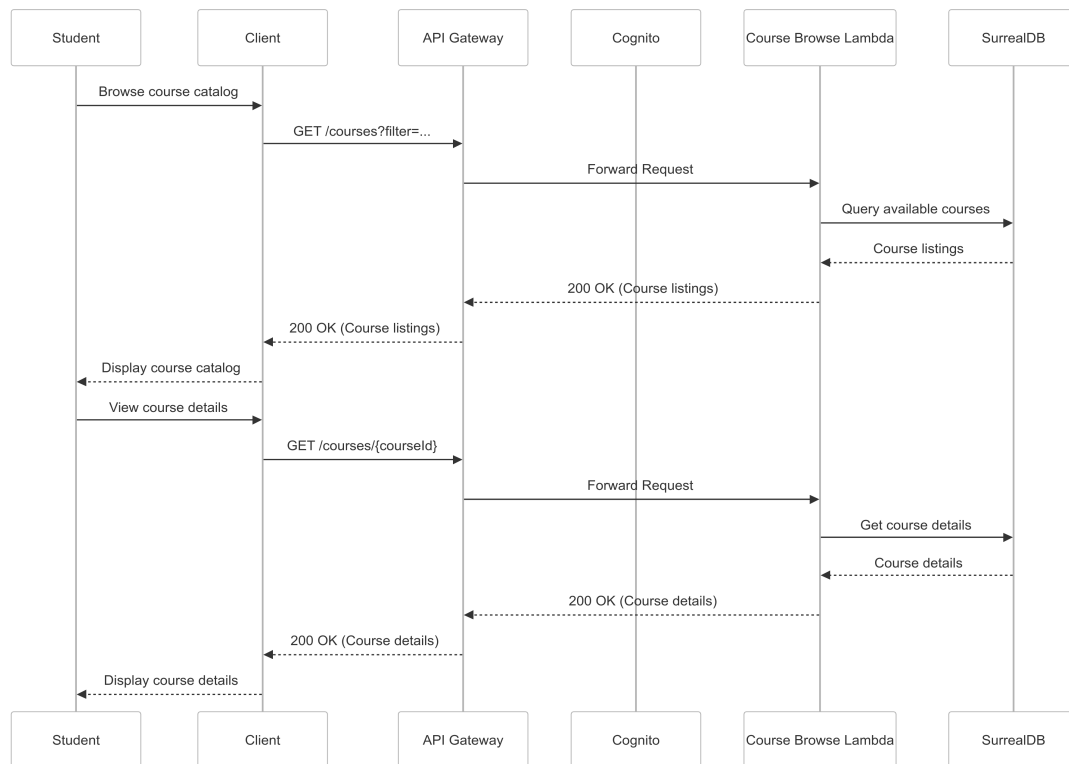


Figure 4.3: Course Access Workflow

4.1.2 Course Access

4.1.3 Code Assessment and Grading

Sample code assessment editor (simplified):

```

// Code Assessment Editor (conceptual)
fn CodeEditor() {
  let code = "// Write your code here";
  fn run_code() {
    // send code to backend, display result
  }
  // Renders a textarea and Run button
}

```

4.2 Service Communication

- RESTful APIs with JSON payloads.
- Rate limiting per user/IP.
- Batch operations and pagination.

4.3 Security Implementation

- Multi-factor Authentication (MFA) optional for all users.
- OAuth2 integration for social login.
- JWT for API authentication.
- AES-256 encryption for sensitive data.

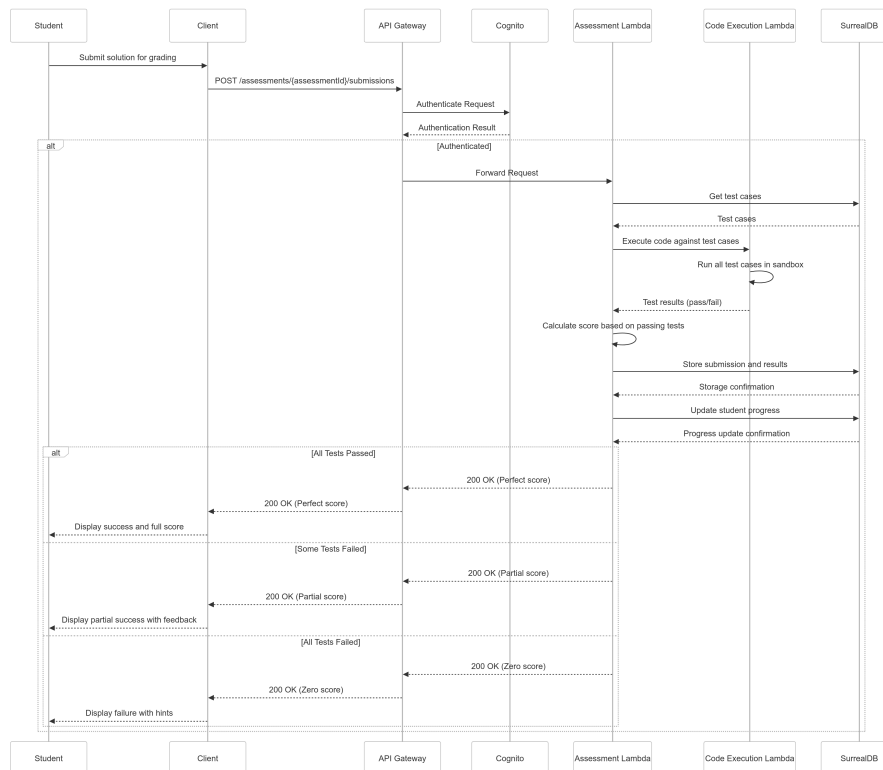


Figure 4.4: Code Auto-grading Workflow

4.4 Exception Handling

4.4.1 Expected Exceptions

- Authentication errors (401)
- Authorization errors (403)
- Validation errors (400)
- Not found errors (404)
- Database errors (500)
- Internal server errors (500)
- External service errors (502)
- Rate limit errors (429)

4.4.2 Error Handling Example

```

impl From<AppError> for ApiGatewayProxyResponse {
    fn from(error: AppError) -> Self {
        let (status_code, error_type) = match &error {
            AppError::Authentication(_) => (401, "Authentication Error"),
            AppError::Authorization(_) => (403, "Authorization Error"),
            AppError::NotFound(_) => (404, "Not Found"),
            AppError::Validation(_) => (400, "Validation Error"),
            AppError::Database(_) => (500, "Database Error"),
            AppError::Internal(_) => (500, "Internal Server Error"),
            AppError::ExternalService(_) => (502, "External Service Error"),
            AppError::RateLimit(_) => (429, "Rate Limit Exceeded"),
        };
        // Response body omitted for brevity
        ApiGatewayProxyResponse { ... }
    }
}

```

4.4.3 Credit Purchase and Payment Flow

Overview:

Kaiju Academy uses a credit-based payment system. Users buy credits through an integrated payment gateway and spend credits to unlock/register for courses. This system decouples payment from course registration and supports flexible monetization.

4.4.4 Credit Purchase and Course Enrollment Flow

1. User navigates to the “Buy Credits” page from the profile or course page.
2. User selects a credit package (e.g., 100 credits, 200 credits).
3. User can select to redeem a key or pay with credit card.
 - If redeeming a key, user enters the key to top up the credit balance.
 - If paying with credit card, user is redirected to a third-party payment gateway (e.g., Stripe) to complete the transaction.
4. Upon successful payment, the backend updates the user’s credit balance.
5. User can now browse courses; when enrolling in a paid course, the platform checks credit balance:
 - If sufficient, deducts credits and confirms registration.
 - If insufficient, prompts the user to buy more credits.
6. All transactions are logged for auditing and user transparency.

Security Note: All payment processing is handled via a PCI-compliant gateway. No sensitive payment data is stored on Kaiju Academy servers.

4.4.5 Credit Purchase and Enrollment Logic (Mermaid Diagram)

4.5 Licence Key Verification

Overview:

Since some of the courses on Kaiju Academy are charged, we need to offer ways for users to purchase credits. To purchase credits, except for paying with credit card, we also offer a licence key purchase option. This part will be explaining the licence key verification process.

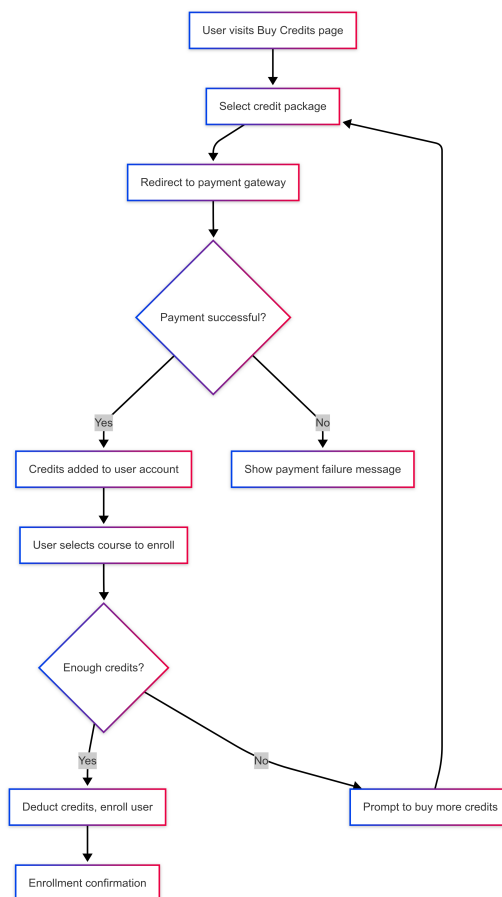
1. When user is trying to purchase credits, the user will be redirected to select the payment method.
2. If user selects to redeem a licence key, user will be prompted to enter the licence key.
3. User can purchase license keys with different price and credit amount and they would be stored in the database.
4. The entered key is sent to the backend for validation.
5. If valid, user’s credit balance will be updated accordingly.
6. If invalid, an error message is displayed and access is denied.

Minimal Implementation Note:

If time is limited, licence management may be implemented as a stub or described as future work, but the design must be documented.

Security Note:

Licence keys must not be predictable and should be stored securely.

**Figure 4.5:** Credit Purchase and Course Enrollment Flow

5. Component Design

5.1 Frontend Components

5.1.1 Navbar Component

- **Intention:** Provides navigation links and user profile access.
- **Input:** User interactions (clicks), authentication state.
- **Output:** Navigation actions, profile dropdown.

5.1.2 Code Editor Component

- **Intention:** Provides syntax highlighting, code execution, and result display.
- **Input:** User code, language, test cases.
- **Output:** Code submission to backend, execution result.

5.2 Backend Components

5.2.1 Authentication Service

- **Intention:** Registration, login, MFA, token management.
- **Input:** Credentials, MFA codes.
- **Output:** JWT tokens, authentication status, error messages.

5.2.2 Course Management Service

- **Intention:** Course/module creation, update, and deletion.
- **Input:** Course objects, materials.
- **Output:** Course IDs, content structures.

5.2.3 Assessment Service

- **Intention:** Executes user code, grades submissions, provides feedback.
- **Input:** User code, language, test cases.
- **Output:** Execution results, scores, feedback.

6. User Interface Design

6.1 Design Principles

- **Consistency:** Unified design language
- **Accessibility:** WCAG 2.1 AA compliance
- **Responsiveness:** Mobile friendly
- **Feedback:** Clear system status for all actions

6.2 User-wise Navigation Flow

6.2.1 Student

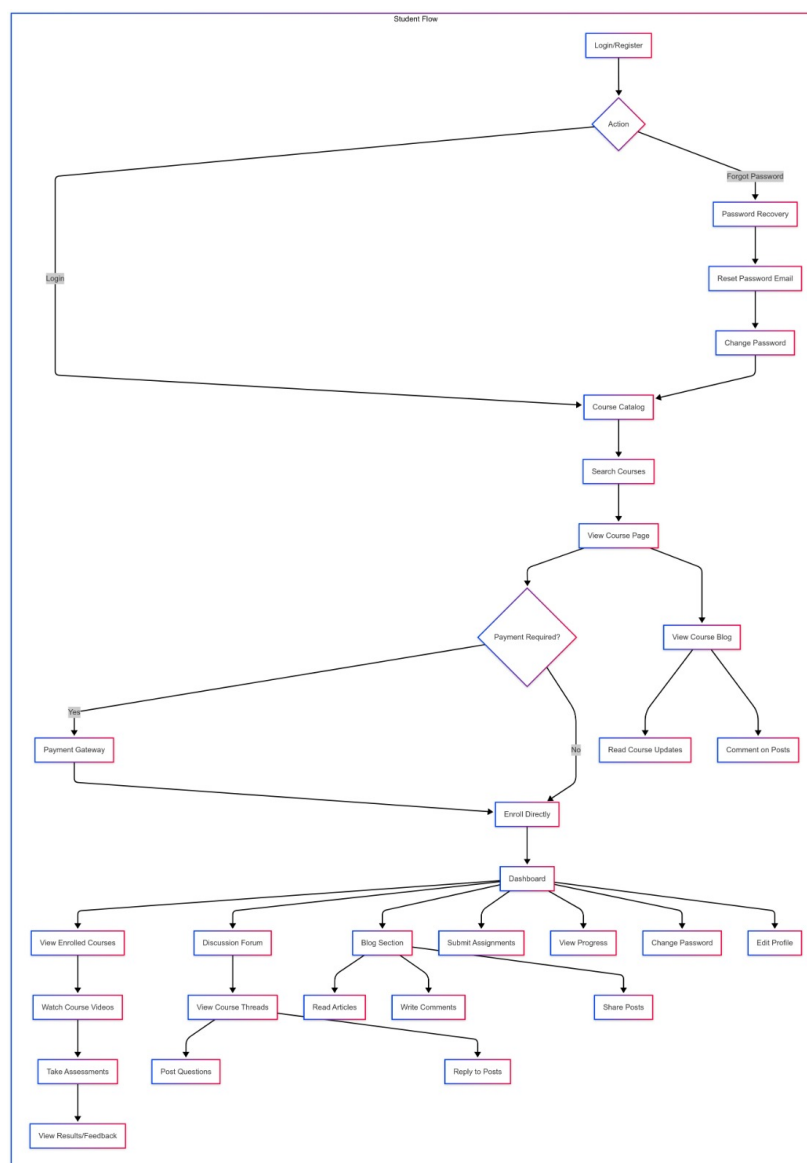


Figure 6.1: Student Navigation Flow

6.2.2 Educator

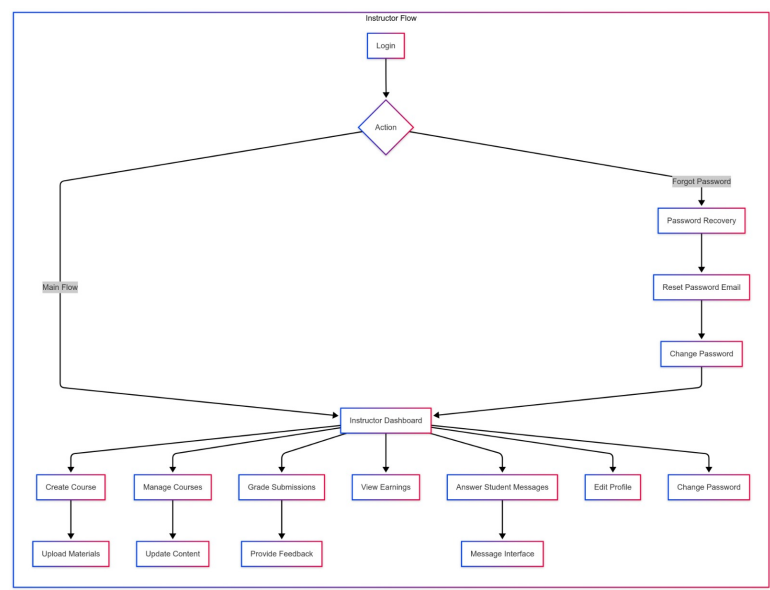


Figure 6.2: Educator Navigation Flow

6.2.3 Educator Dashboard and Course Management



Figure 6.3: Educator Profile and Course Management

6.2.4 Learning and Assessment



Figure 6.4: Student Assessment and Course Detail

6.2.5 Educator Dashboard and Course Management

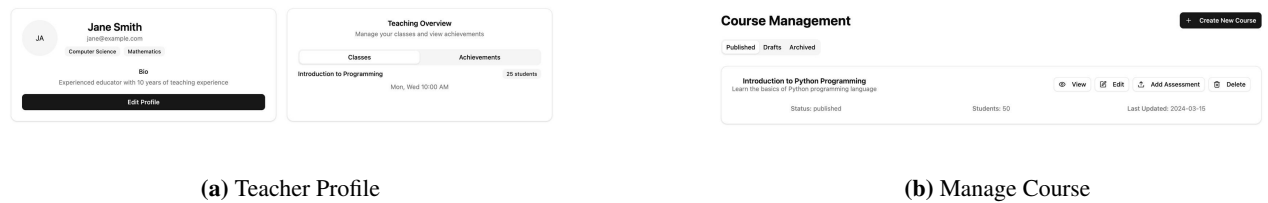


Figure 6.5: Educator Profile and Course Management

6.2.6 Assessment Creation and Grading

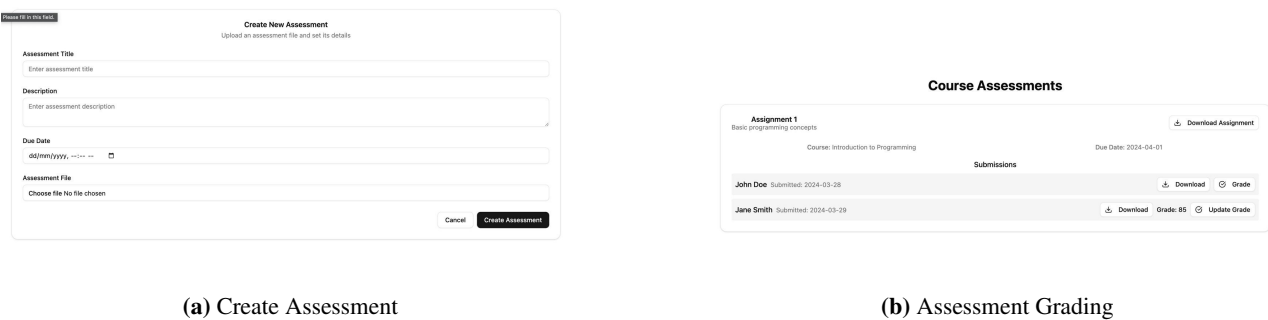


Figure 6.6: Assessment Creation and Grading

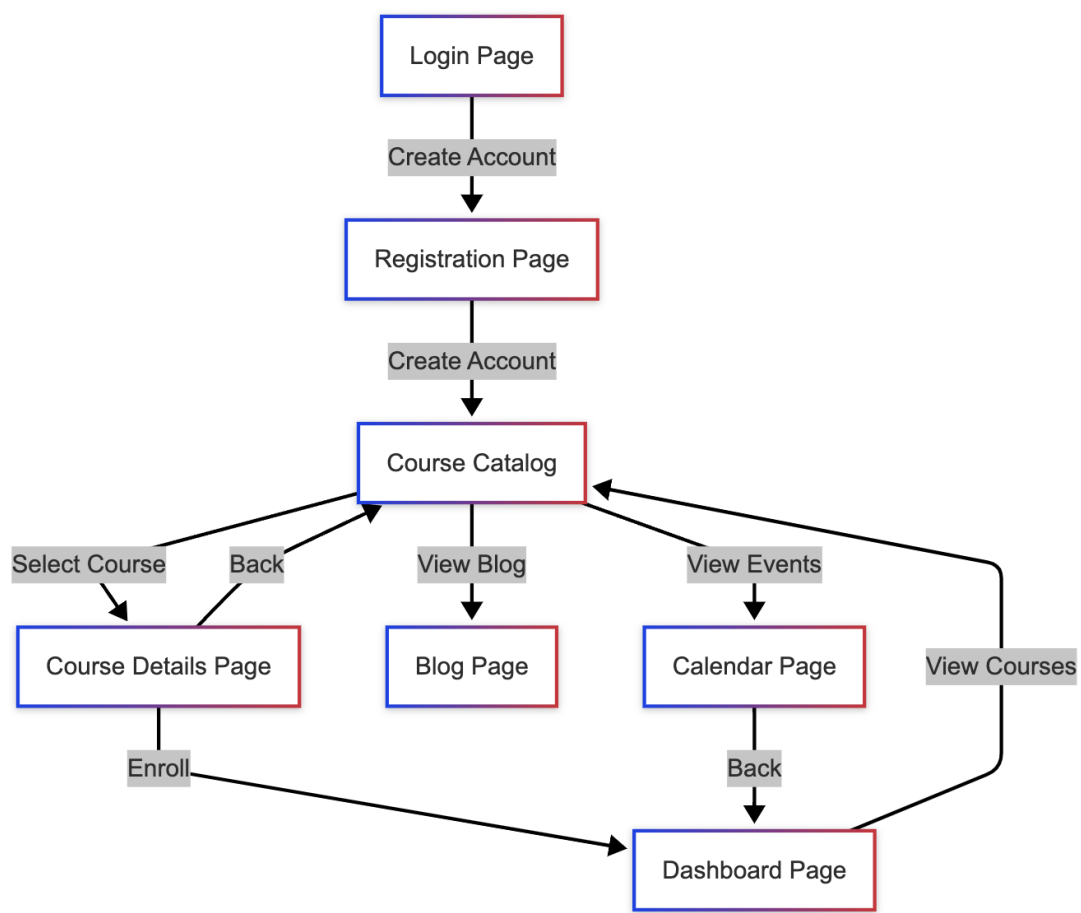
6.3 Overall UI Flow

6.4 Accessibility Considerations

- **Screen Reader Support:** Proper ARIA labels and semantic HTML
- **Text Resize:** Interface remains functional when text is enlarged 200%
- **Motion Control:** Animations can be disabled
- **Alternative Text:** All images include descriptive alt text
- **Light/Dark Mode:** Option to switch between light and dark themes
- **Font Size Adjustment:** Users can easily change font size

6.5 Responsive Design

- **Breakpoints:** 480px, 768px, 1024px, and 1440px
- **Layout:**
 - Single column on mobile
 - Sidebar overlay on small screens
 - Multi-column on larger screens
- **Touch Targets:** Minimum 44×44px for all interactives

**Figure 6.7:** Overall User Interface Flow

7. Assumptions

7.1 Technical Constraints

7.1.1 Hardware Constraints

- At least 4GB RAM, 320px width, 5 Mbps internet
- AWS cloud deployment, serverless Lambda, horizontal scaling

7.1.2 Software Constraints

- Modern browsers (Chrome, Firefox, Safari, Edge, latest 2 versions)
- HTML5 and JavaScript required
- Responsive web (no native app initially)

7.2 Operational Assumptions

- Peak: 10,000 code submissions/minute
- 80/20 read/write database
- Code execution max 5 seconds
- CI/CD pipeline with automated testing
- 99.9% uptime excluding maintenance, daily backups

7.3 Dependencies

7.3.1 Third-Party Services

- Authentication via OAuth providers (Google, GitHub, Microsoft)
- Payment processing for course credits
- Email delivery through Amazon SNS
- CDN via CloudFront
- Media transcoding via AWS MediaConvert