A

MINOR PROJECT REPORT ON

Study in Woods 🪵

Submitted to the

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

In partial fulfillment of the requirement for the award of the Degree of

MASTER OF COMPUTER APPLICATIONS

Submitted to

DEPARTMENT OF COMPUTER APPLICATIONS
Gyan Ganga College of Technology
Jabalpur (M.P.)

Under the guidance of

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MCA III SEM | SESSION 2025-26

ACKNOWLEDGEMENT

Behind every successful effort there lies contribution from numerous sources irrespective of their magnitude, my project has no exception and I take this opportunity to thank those helping hand whole heartedly.

First and foremost, we have great pleasure in expressing my deep sense of gratitude to all the **Management Members,** Gyan Ganga Group of Institutions, for providing me the needed facilities throughout the duration of the project.

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At last but not the least my heartily recognition to all our academic teachers, my family members, friends and those who directly or indirectly helped me in this endeavor.

Thanks & Regards

Name of Students

1. Sahil Chouksey
2. Rohit Kumar Namdeo
3. Vivek Raj Dhurwey
4. Ajay Kori

This is to certify that the project report entitled “**Study in Woods**” which has been completed and submitted by ***Sahil Chouksey, Rohit Kumar Namdeo, Vivek Raj Dhurwey, Ajay Kori*** **III SEM MCA** the Student of Master of Computer Applications (MCA) is a bonafide work by his/her. This Project report has been approved by us. The project report is satisfactory both in respect of its contents and literally representation.

This project report is in accordance with the requirement of degree of Master of Computer Applications (MCA) awarded by RAJIV GANDHI PROUDYOGIKI VISHWAVIDALAYA, Bhopal (M.P.).

Dr. Meghna Utmal
HOD (MCA)
GGCT, Jabalpur

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Internal Examiner:
Date:

External Examiner:
Date:

CANDIDATE DECLARATION

I hereby declare that this project report titled "**Study in Woods**" submitted by me in fulfillment for the award of Master of Computer Applications (M.C.A.) by Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal is a result of authentic work under taken by me.

The same has not been submitted by me to this or any other university for any other graduate/post graduate course whatsoever.

Project Submitted By:

Name of Students

1. Sahil Chouksey
2. Rohit Kumar Namdeo
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1. INTRODUCTION

1.1 About the Project

Study in Woods is an AI-powered educational platform that helps students organize academic materials and interact with course content intelligently. The system processes syllabus PDFs using NLP to extract structured information and provides an AI chat interface for study guidance.

1.2 Purpose of the Project

The primary objectives are:

- **Academic Organization:** Centralized platform for managing universities, courses, semesters, and subjects
- **Intelligent Content Extraction:** AI-powered processing of syllabus PDFs with automatic data extraction
- **AI-Assisted Learning:** Conversational AI for answering questions and providing study guidance
- **Exam Preparation:** Past year question paper extraction and categorization linked to syllabus topics
- **Progress Tracking:** Study progress monitoring and personalized study plan management

1.3 System Architecture

The application follows a three-tier microservices architecture:

- **Frontend:** Next.js 15 with React 19 providing responsive UI
- **Backend:** Go (Golang) with Fiber framework handling API and business logic
- **Data Layer:** PostgreSQL for primary storage, Redis for caching and sessions

- **OCR Service:** Python FastAPI microservice for text extraction from scanned documents

1.4 Core Functionalities

1. **User Management:** Secure authentication with role-based access (Admin/Student)
2. **Document Processing:** Syllabus upload with AI-powered content extraction
3. **AI Chat Interface:** Subject-specific conversational assistance
4. **PYQ Management:** Question paper extraction and categorization
5. **Analytics Dashboard:** Usage statistics and performance tracking
6. **RESTful API:** 100+ endpoints for programmatic access

1.5 User Characteristics

Students: MCA or similar program students seeking AI-assisted learning and exam preparation tools.

Administrators: Academic staff managing universities, courses, and system settings with audit capabilities.

1.6 Operating Environment

- **Client:** Modern web browsers (Chrome, Firefox, Safari, Edge) on all devices
- **Server:** Docker containerized deployment on Linux with HTTPS
- **Cloud:** DigitalOcean Spaces for storage, GradientAI (Llama 3.3 70B) for AI features

1.7 Constraints and Dependencies

Constraints: Go/Next.js stack required; PDF-only uploads; must support 1000+ concurrent users.

Dependencies: DigitalOcean services (AI, storage), PostgreSQL, Redis, third-party libraries.

2. PROJECT UNDERSTANDING DOCUMENT

2.1 Problem Statement

In the contemporary educational landscape, students pursuing higher education, particularly in technical fields like Master of Computer Applications (MCA), encounter several critical challenges in managing their academic materials and optimizing their learning processes:

- **Information Overload:** Students receive voluminous course syllabi in PDF format containing complex hierarchical information about course units, topics, and learning outcomes, making manual extraction and organization time-consuming and error-prone.
- **Fragmented Resources:** Academic materials are scattered across multiple platforms - university portals, email attachments, physical documents, and personal storage, leading to inefficient access and retrieval.
- **Limited Study Assistance:** Traditional learning methods lack personalized, on-demand guidance for clarifying doubts and understanding complex topics outside of classroom hours.
- **Exam Preparation Challenges:** Students struggle to systematically organize and categorize previous year questions, making targeted exam preparation difficult.
- **Lack of Progress Tracking:** Absence of integrated tools to monitor study progress, set goals, and manage academic todos results in suboptimal time management.

2.2 Proposed Solution

Study in Woods addresses these challenges through an integrated, AI-powered platform that combines intelligent document processing, conversational AI, and comprehensive academic management capabilities.

2.2.1 Solution Components

Component 1: Intelligent Syllabus Processing

- Automated PDF parsing using advanced NLP techniques
- Hierarchical extraction of units, topics, and subtopics
- Structured storage for easy navigation and retrieval
- Support for multiple syllabus formats across universities

Component 2: AI-Powered Study Assistant

- Context-aware chatbot powered by RAG (Retrieval Augmented Generation)
- Subject-specific knowledge bases for accurate responses
- Natural language query processing for intuitive interaction
- Citation of source materials for verifiable answers

Component 3: Academic Organization System

- University → Course → Semester → Subject hierarchy management
- Document upload and categorization capabilities
- Previous year question paper organization
- Personal notes and resource management

Component 4: Progress Tracking Dashboard

- Visual analytics for study patterns and progress
- Goal setting and achievement tracking
- Todo management for academic tasks
- Performance insights and recommendations

2.3 Project Scope

2.3.1 In Scope

Category	Features Included
User Management	Registration, authentication, profile management, role-based access (Student/Admin)
Academic Structure	University, course, semester, and subject management with full CRUD operations
Document Processing	PDF upload, syllabus extraction, document storage, and retrieval
AI Chat System	Subject-specific chatbot, conversation history, RAG-based responses
Analytics	Usage statistics, study patterns, progress visualization
Administration	User management, system configuration, audit logging

2.3.2 Out of Scope

- Mobile native applications (iOS/Android) - Web responsive design provided instead
- Offline functionality - Requires internet connectivity
- Video content processing - Focus on PDF and text documents
- Real-time collaboration features - Individual study focus
- Payment/subscription management - Free platform for students

2.4 Target Users

2.4.1 Primary Users

Students: MCA and similar postgraduate program students who need:

- Organized access to course syllabi and materials
- AI-assisted study guidance and doubt resolution
- Efficient exam preparation tools
- Progress tracking and goal management

2.4.2 Secondary Users

Administrators: College/university staff responsible for:

- Managing academic structure (universities, courses, subjects)
- Uploading and maintaining syllabus documents
- Monitoring platform usage and user activity
- System configuration and maintenance

2.5 Expected Outcomes

Outcome	Measurement Criteria
Improved Study Efficiency	Reduced time spent searching for academic materials by 60%
Enhanced Understanding	AI chat resolves 80% of student queries without external help
Better Organization	All academic materials accessible from single platform
Exam Readiness	Systematic coverage of syllabus topics with progress tracking
Time Savings	Automated syllabus extraction saves 2+ hours per subject

2.6 Constraints and Assumptions

2.6.1 Constraints

- **Technical:** Dependent on DigitalOcean AI platform availability and API limits
- **Data:** Syllabus extraction accuracy depends on PDF formatting consistency
- **Performance:** AI response generation limited by LLM processing time
- **Storage:** Cloud storage costs scale with document uploads

2.6.2 Assumptions

- Users have reliable internet connectivity
- Syllabus PDFs follow standard academic formatting conventions
- Users possess basic computer literacy skills

- University academic structures follow hierarchical organization
- English is the primary language for academic content

3. REQUIREMENTS

3.1 Functional Requirements

ID	Requirement	Description
FR-1	User Registration	Email/password signup with validation and duplicate prevention
FR-2	JWT Authentication	Secure token-based login with Redis session management
FR-3	Role-Based Access	Student and Admin roles with differentiated permissions
FR-4	Academic Hierarchy	University > Course > Semester > Subject management
FR-5	Document Upload	PDF upload (10MB max) to DigitalOcean Spaces storage
FR-6	AI Syllabus Extraction	Auto-extract units, topics from syllabus PDFs (85% accuracy)
FR-7	Document Indexing	Auto-index documents into subject-specific AI knowledge bases
FR-8	AI Chat Interface	Llama 3.3 70B powered conversational assistant with context
FR-9	PYQ Management	Extract and categorize past year questions by topic/difficulty
FR-10	API Key Management	Encrypted API keys with scopes, rate limiting, and expiration

3.2 Non-Functional Requirements

ID	Category	Requirement
NFR-1	Performance	95% requests under 2s; AI responses stream within 5s
NFR-2	Scalability	1000+ concurrent users; 10,000 requests/minute capacity
NFR-3	Security	JWT RS256, bcrypt hashing, AES-256 encryption, HTTPS enforced
NFR-4	Availability	99.5% uptime with graceful failure handling
NFR-5	Usability	Responsive design (desktop/tablet/mobile), WCAG 2.1 AA compliant
NFR-6	Reliability	ACID compliance, daily backups, 30-day point-in-time recovery
NFR-7	Maintainability	Clean architecture, 70% test coverage, comprehensive logging
NFR-8	Protection	Rate limiting, CORS, input validation against SQL injection/XSS

3.3 Hardware Requirements

3.3.1 Client-Side

Component	Minimum	Recommended
Processor	Dual-core 1.6 GHz	Quad-core 2.4 GHz
RAM	2 GB	4 GB
Network	1 Mbps	5 Mbps broadband
Browser	Chrome 90+, Firefox 88+, Safari 14+, Edge 90+	

3.3.2 Server-Side

Component	App Server	Database	Cache
CPU	4 vCPU	4 vCPU	2 vCPU
RAM	8 GB	8 GB	4 GB
Storage	80 GB SSD	200 GB SSD	40 GB SSD
OS	Ubuntu 22.04 LTS		

3.4 Software Requirements

3.4.1 Frontend Stack

Technology	Version
Next.js	15.5.6
React	19.1.0
TypeScript	5.x
Tailwind CSS	4.0
TanStack Query	5.90.9

3.4.2 Backend Stack

Technology	Version
Go (Golang)	1.24.1
Fiber	2.52.5
GORM	1.31.0
PostgreSQL	15.x
Redis	7.x

3.4.3 Cloud Services

Service	Provider
Compute (Droplets)	DigitalOcean
Object Storage (Spaces)	DigitalOcean
AI Platform (Llama 3.3 70B)	DigitalOcean GradientAI
Knowledge Bases	DigitalOcean AI

3.5 External Interface Requirements

- **User Interface:** Responsive web UI with dashboard, document upload, AI chat, and admin panels
- **API Interface:** RESTful JSON API with JWT authentication, rate limiting, and OpenAPI documentation
- **AI Platform:** DigitalOcean GradientAI API for chat completions and knowledge base management

4. TECHNOLOGY USED

4.1 Technology Stack Overview

The Study in Woods platform uses a modern, scalable technology stack with clear separation between frontend, backend, database, and cloud services layers.

4.2 Frontend Technologies

Technology	Version	Purpose	Key Features
Next.js	15.5.6	React Framework	SSR, SSG, API Routes, Turbopack, Image Optimization
React	19.1.0	UI Library	Server Components, Suspense, Virtual DOM, Hooks
TypeScript	5.x	Type Safety	Static Typing, IntelliSense, Compile-time Errors
Tailwind CSS	4.0	Styling	Utility Classes, JIT Compiler, Dark Mode, Responsive
shadcn/ui	Latest	UI Components	Accessible, Customizable, Radix UI Primitives
TanStack Query	5.90.9	State Management	Caching, Auto-refetch, Optimistic Updates
Framer Motion	12.23.24	Animations	Declarative Animations, Gestures, Layout Transitions
React Hook Form	7.66.0	Form Management	Validation, Performance, Error Handling
Zod	4.1.12	Schema Validation	Type-safe Schemas, Runtime Validation
Axios	1.13.2	HTTP Client	Interceptors, Request Cancellation, Auto JSON

4.3 Backend Technologies

Library	Version	Purpose	Key Capabilities
Go	1.24.1	Programming Language	Goroutines, Channels, Fast Compilation, GC
Fiber	2.52.5	Web Framework	Fasthttp, Middleware, Routing, Context
GORM	1.31.0	ORM	Migrations, Associations, Hooks, Preloading
JWT	5.3.0	Authentication	Token Generation, RS256, Claims Validation
bcrypt	0.43.0	Password Hashing	Adaptive Cost, Automatic Salting
go-redis	9.16.0	Redis Client	Connection Pooling, Pipelining, Pub/Sub
AWS SDK	1.55.8	S3 Client	Multipart Upload, Pre-signed URLs, Retries
Validator	10.28.0	Input Validation	Struct Tags, Custom Validators, Error Messages
Cron	3.0.1	Job Scheduling	Cron Expressions, Job Chains, Error Handling

4.4 Database Technologies

Technology	Version	Type	Primary Use Cases
PostgreSQL	15.x	Relational Database	Permanent data storage, Complex queries, ACID transactions, JSONB support
Redis	7.x	In-Memory Cache	Session storage, Rate limiting, Temporary data, Pub/Sub

4.5 Cloud Services & Infrastructure

DigitalOcean provides the complete cloud infrastructure, selected for its simplicity, transparent pricing, and India-specific infrastructure (Bangalore BLR1 region).

Service	Provider	Purpose	Specifications
Droplets	DigitalOcean	Compute	4 vCPU, 8GB RAM, 100GB SSD, Ubuntu 22.04
Spaces	DigitalOcean	Object Storage	S3-compatible, CDN, BLR1 region, Private ACL
Load Balancer	DigitalOcean	Traffic Distribution	SSL termination, Health checks, WebSocket support
GradientAI	DigitalOcean AI	LLM Inference	Llama 3.3 70B, OpenAI-compatible API
Knowledge Bases	DigitalOcean AI	Vector Database	RAG, Embeddings, Document indexing

4.6 Development & Deployment Tools

Tool	Version	Purpose	Benefits
Docker	24.0+	Containerization	Consistency, Isolation, Easy deployment
Docker Compose	2.x	Multi-container orchestration	Local development, Service dependencies
Air	Latest	Live reload (Go)	Fast feedback, Incremental builds
Turbopack	Integrated	Frontend bundler	5x faster builds, HMR with state preservation
GitHub Actions	Latest	CI/CD	Automated testing, Continuous deployment
Git	2.x	Version control	Collaboration, History, Branching

4.7 System Architecture

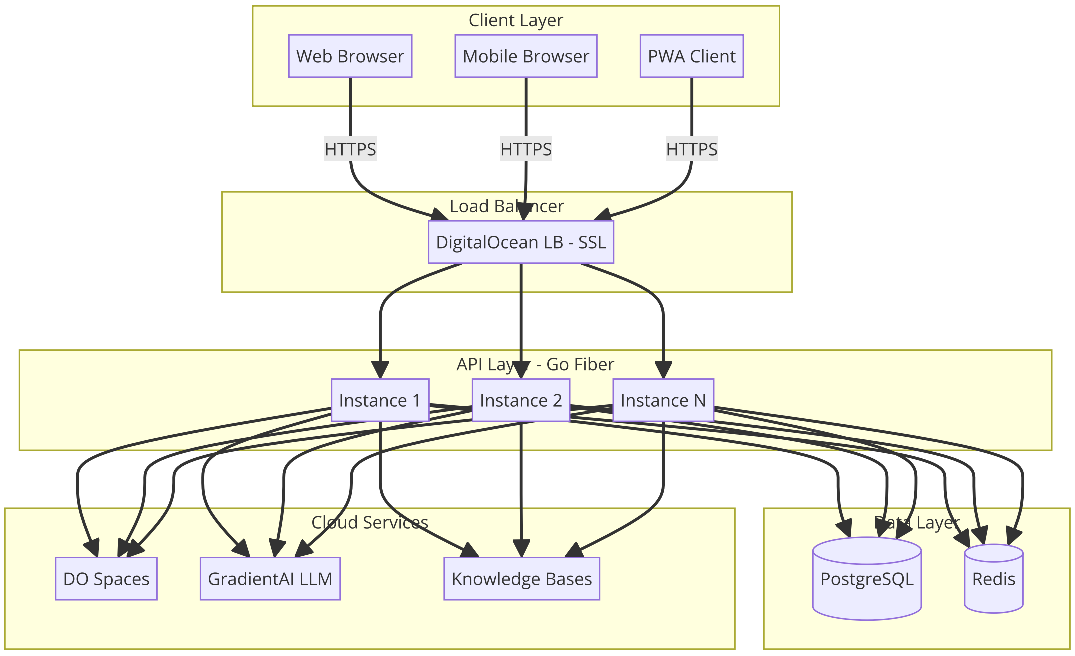


Figure 4.1: System Architecture Overview

4.8 Technology Selection Summary

Decision	Choice	Rationale
Backend Language	Go over Node.js/Python	3x more requests/sec than Node.js, single binary deployment, compile-time error checking
Database	PostgreSQL over MongoDB	Relational data model fits academic hierarchy, ACID guarantees, JSONB for flexibility
Frontend Framework	Next.js over CRA	SSR for SEO, 60% faster initial load, built-in routing and image optimization
Cloud Provider	DigitalOcean over AWS	Transparent pricing, Bangalore data center (15-30ms latency), integrated GradientAI

5. SOFTWARE PROCESS MODEL

5.1 Methodology

The Study in Woods project follows an **Agile** software development methodology, implementing a hybrid approach combining Scrum for sprint management and Kanban for continuous feature flow. This methodology was chosen to enable rapid iteration and the ability to adapt to changing requirements during the academic project timeline.

Development spans 12 phases over 6 months (June - December 2024), with two-week sprints targeting 20-25 story points each. Phases overlap with continuous integration and testing running throughout.

5.2 Sprint Structure

Activity	Frequency	Duration	Deliverables
Sprint Planning	Every 2 weeks	2 hours	Sprint backlog, Story estimates
Sprint Review	Every 2 weeks	1 hour	Working software demo
Backlog Refinement	Weekly	1 hour	Refined user stories

5.3 Development Phases

Phase	Weeks	Key Deliverables	LOC
1: Project Setup	1–2	Monorepo structure, Docker Compose, initial DB schema	~3,500
2: Authentication	3–4	JWT auth, login/register, password reset	
3: Academic Hierarchy	5–6	University/Course/Semester/Subject CRUD	
4: Document Upload	7–8	DigitalOcean Spaces integration, multipart upload	~4,200
5: AI Knowledge Base	9–10	GradientAI KB integration, document indexing	
6: Syllabus Extraction	11–12	Llama 3.3 70B extraction, structured JSON output	
7: Chat Sessions	13–14	Session CRUD, message history	~3,800
8: AI Chat	15–16	SSE streaming, KB-context responses	
9: Citations	17–18	Source document references in responses	
10: PYQ Extraction	19–20	Question extraction from exam papers	~3,000
11: Analytics	21–22	Usage tracking, dashboard charts	
12: Admin Panel	23–24	User management, system settings, deployment	

5.4 CI/CD Pipeline

Automated via GitHub Actions on every push:

- **Linting:** golangci-lint (Go), ESLint (TypeScript)
- **Testing:** Unit tests (70% coverage required), integration tests via Docker Compose

- **Build:** Multi-stage Docker images
- **Deploy:** Zero-downtime deployment to DigitalOcean Droplet on main branch merge

5.5 Version Control

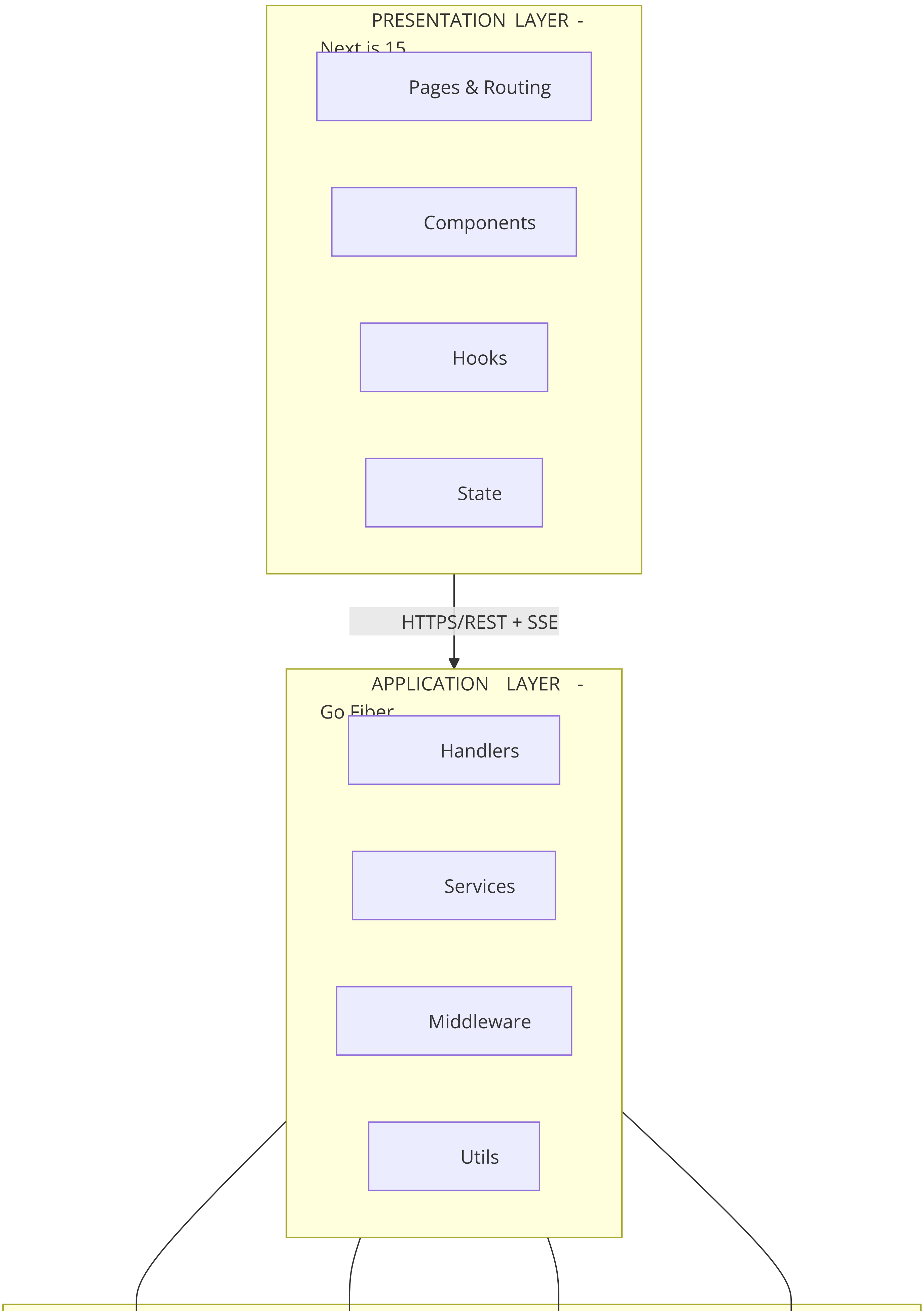
Git Flow branching with Conventional Commits:

- **main:** Production-ready code
- **develop:** Integration branch
- **feature/*:** Individual features
- Semantic versioning (MAJOR.MINOR.PATCH) for releases

6. DESIGN

6.1 System Architecture

Three-tier architecture: Presentation (Next.js), Application (Go Fiber API), Data (PostgreSQL, Redis, DigitalOcean Spaces). Communication via RESTful APIs, SSE for streaming, S3 for storage.


PRESENTATION LAYER - Next.js 15
Pages & Routing
Components
Hooks
State
HTTPS/REST + SSE
APPLICATION LAYER - Go Fiber
Handlers
Services
Middleware
Utils

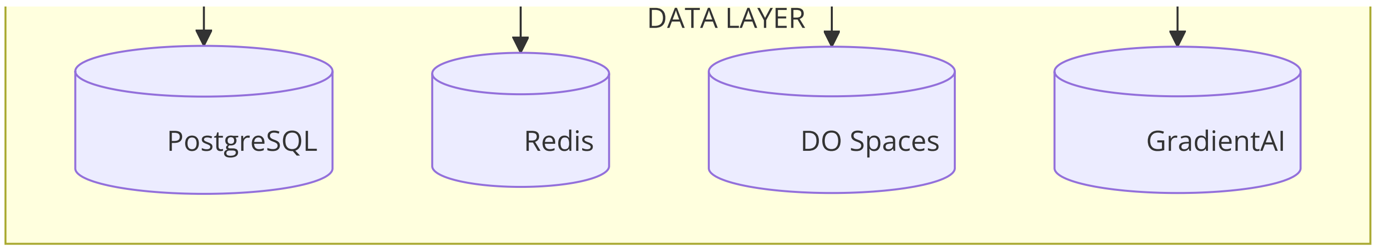


Figure 6.1: Three-tier System Architecture

6.2 Design Patterns Used

Pattern	Description
Repository Pattern	GORM-based data access layer abstracts database operations
Service Layer	Business logic separated from handlers and data access
Middleware Chain	JWT auth, CORS, rate limiting, logging as composable middleware
Provider Pattern	React context providers for auth, theme, and query state
Observer Pattern	SSE for real-time streaming of AI responses and job status
Factory Pattern	Service initialization with dependency injection

6.3 Data Flow Summary

6.3.1 Context Diagram (Level 0)

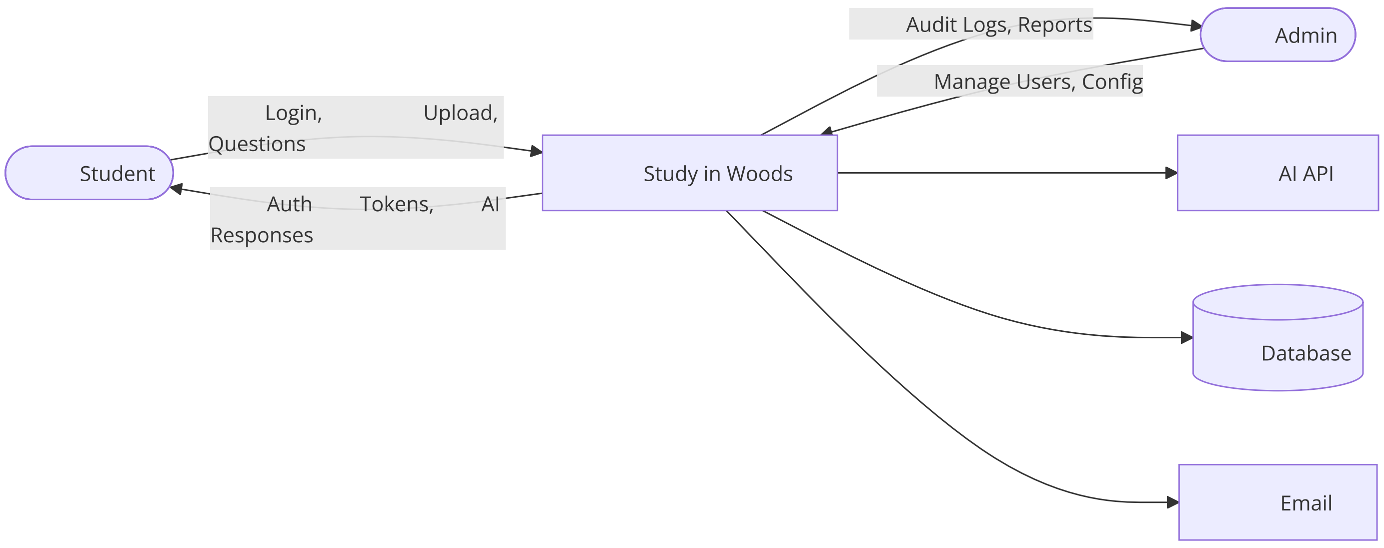


Figure 6.2: Context Diagram (Level 0 DFD)

6.3.2 System Decomposition (Level 1)

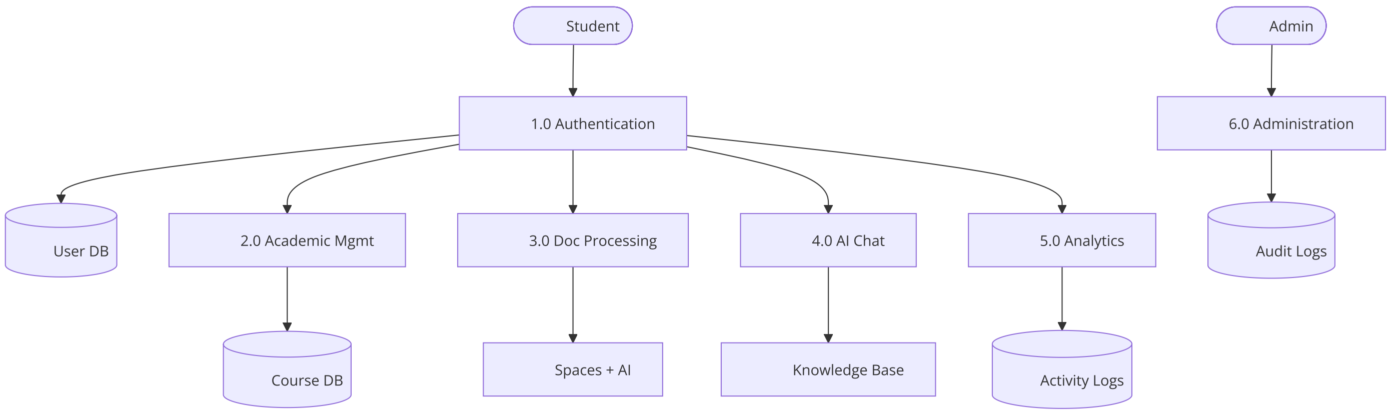
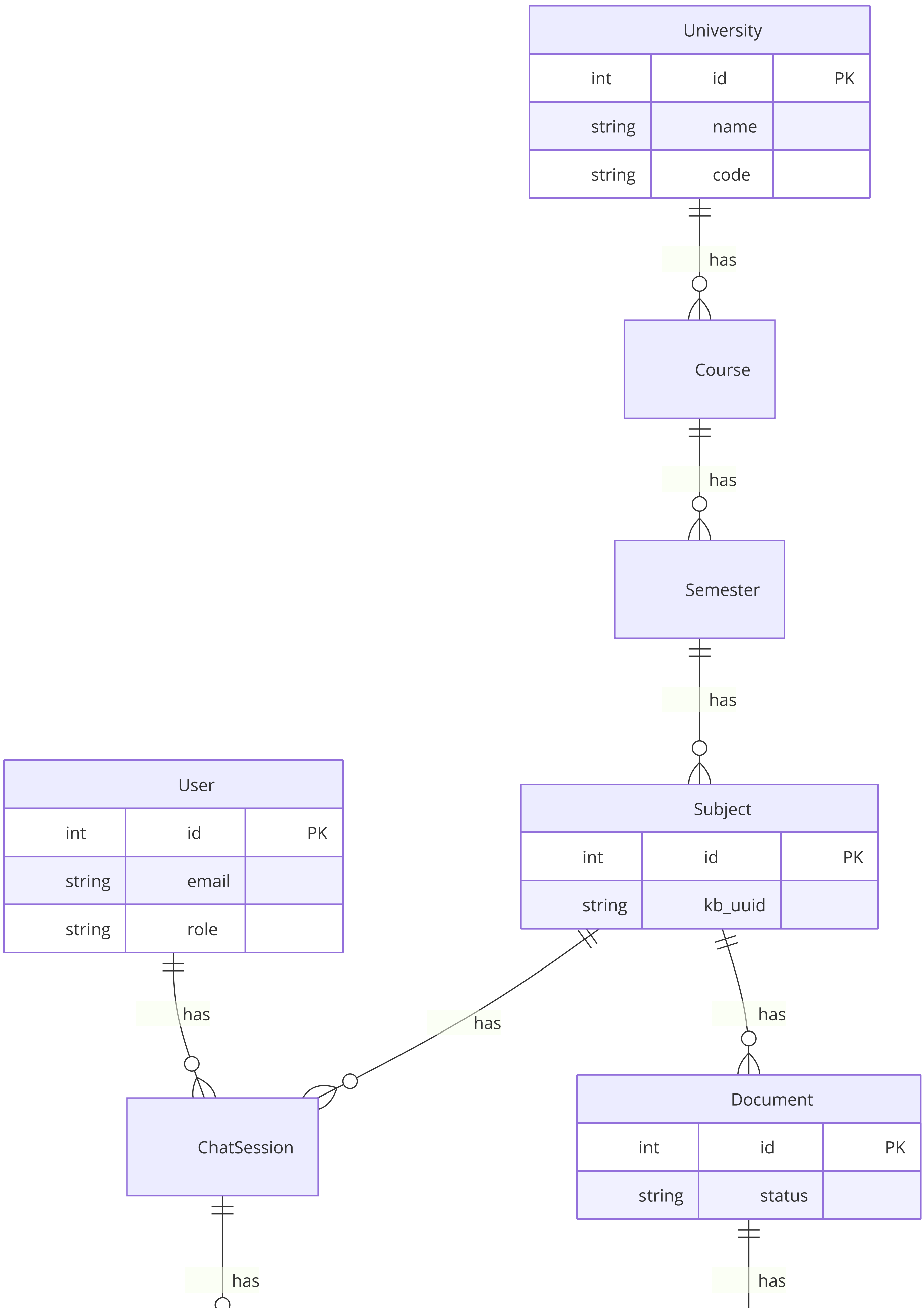


Figure 6.3: System Decomposition (Level 1)

6.4 Entity Relationship Diagram

Database: 30+ tables. Core hierarchy: University → Course → Semester → Subject → Documents/ChatSessions.


University
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Course
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Semester
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User
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Subject
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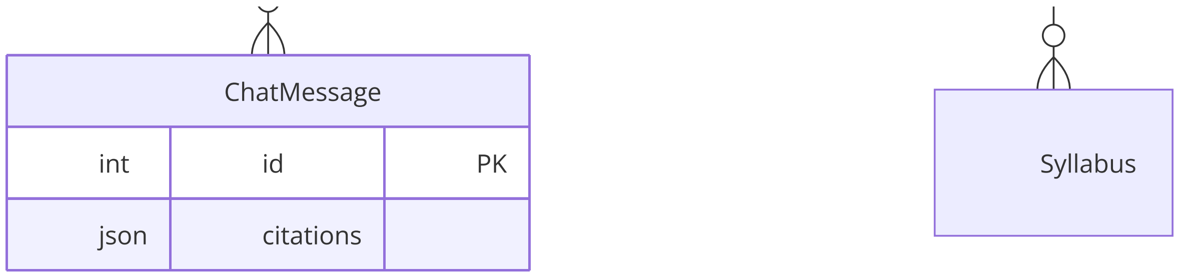

Figure 6.4: Entity Relationship Diagram

6.5 Key Sequence Flows

6.5.1 Authentication Flow

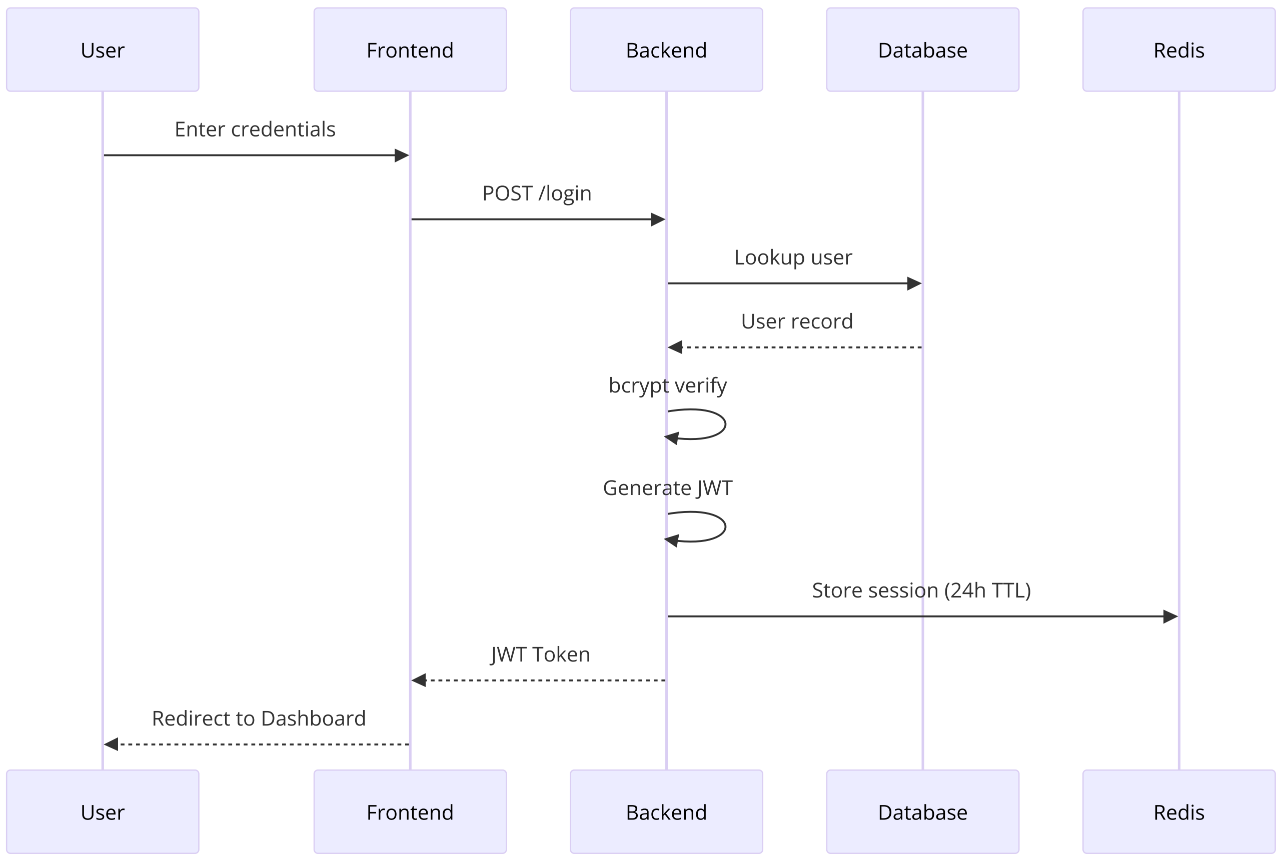

Figure 6.5: Authentication Sequence Diagram

6.5.2 Document Upload & AI Extraction

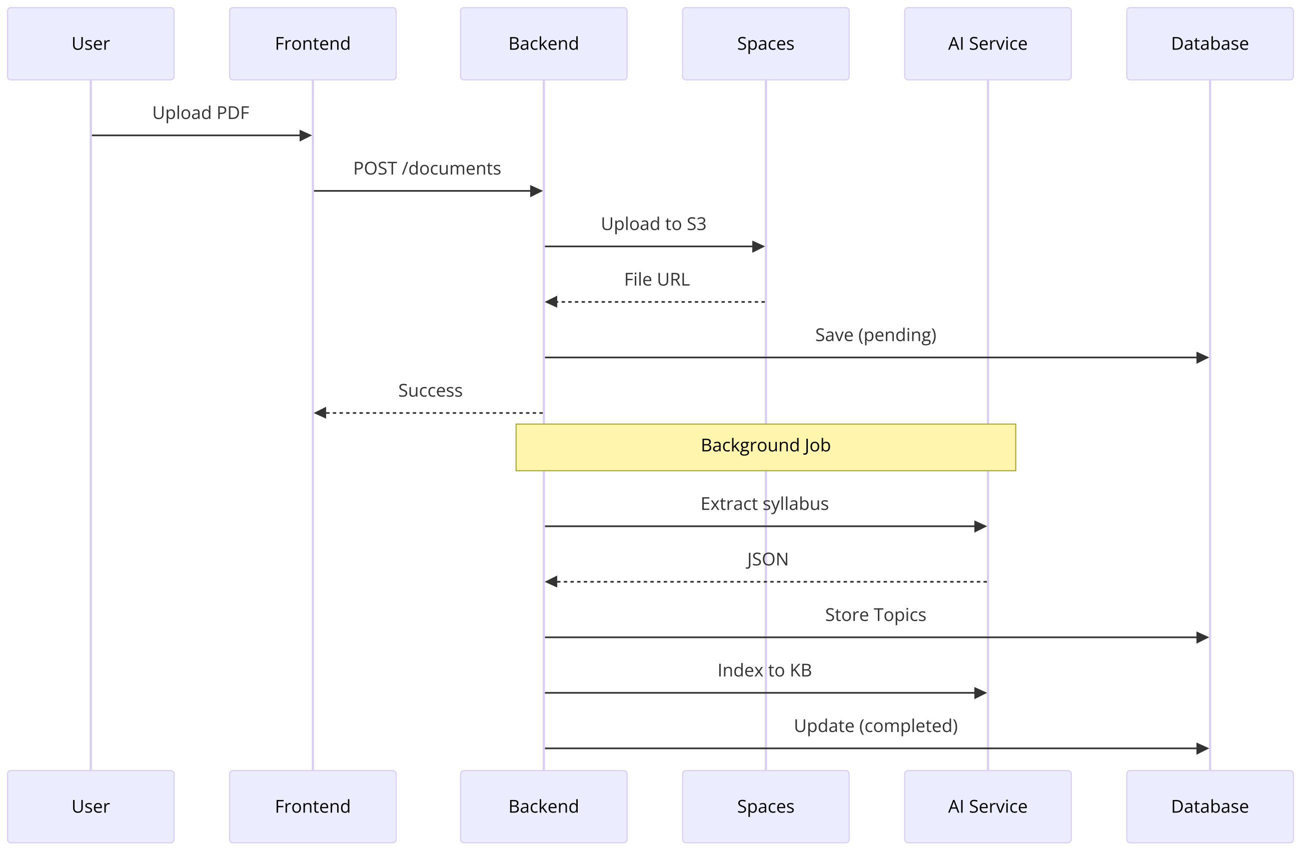

Figure 6.6: Document Upload and AI Extraction Flow

6.5.3 AI Chat with RAG

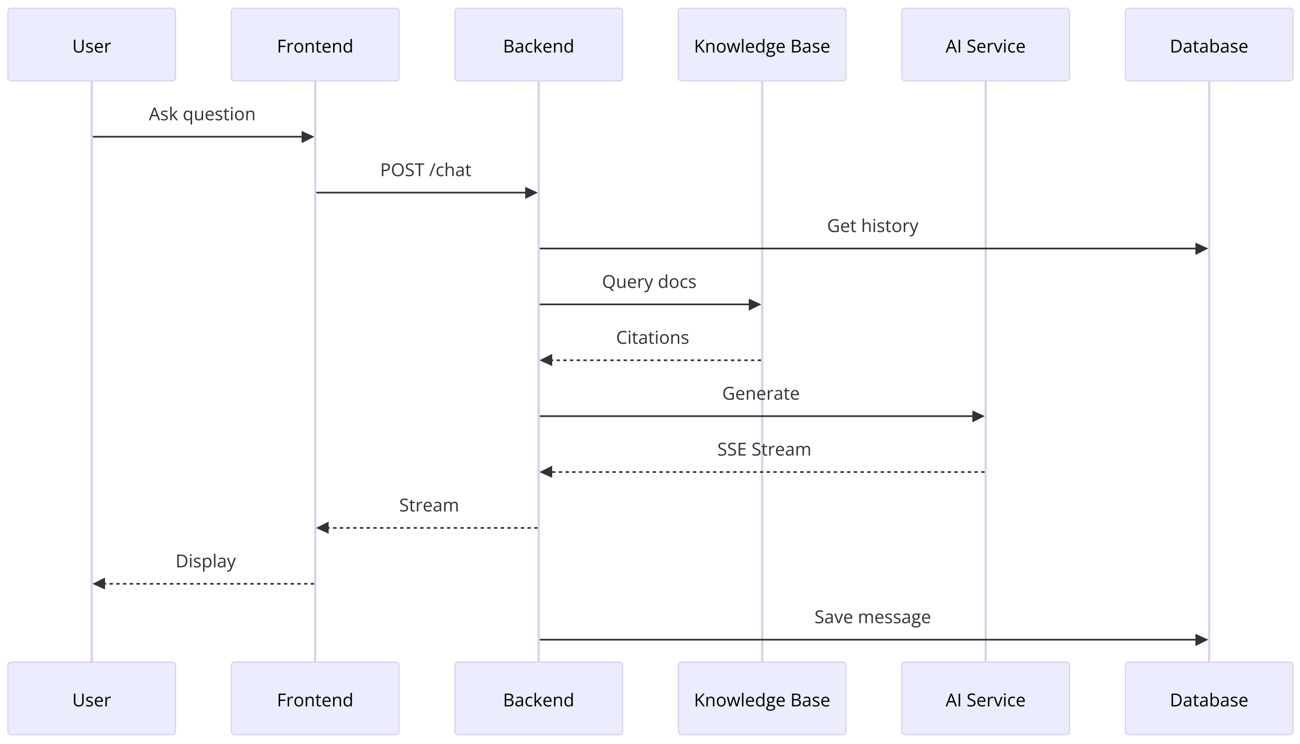

Figure 6.7: AI Chat with RAG Flow

6.6 Component Architecture

6.6.1 Backend Layers

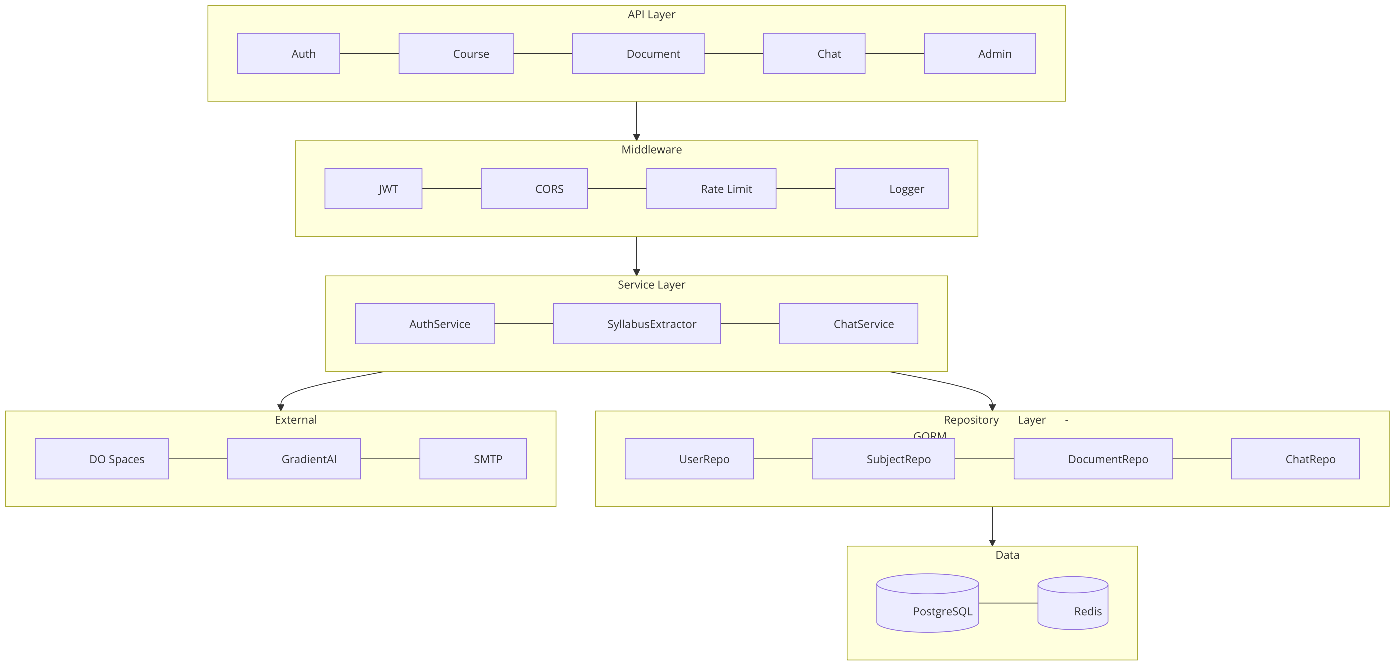

Figure 6.8: Backend Layered Architecture

6.6.2 Frontend Structure

The Next.js 15 frontend follows a modular architecture with clear separation of concerns:

Layer	Components	Purpose
App Router	Next.js 15 App Directory	File-based routing with layouts
Layout	Header, Sidebar, Footer	Consistent UI shell across pages
Auth Pages	/login, /register	User authentication flows
Dashboard	Stats, Activity, Actions	Overview and quick actions
Academic	/universities, /courses, /subjects	Academic hierarchy management
Chat	/chat/[subjectId]	AI chat with sessions, messages, citations
Analytics	Charts, Stats, Activity Table	Usage insights and metrics
Admin	Users, Settings, Audit Logs	System administration

Layer	Components	Purpose
Providers	Query, Theme, Auth	Global state and context
Utils	API Client (Axios), Hooks, Zod	Shared utilities and validation

Figure 6.9: Frontend Application Structure

7. DATABASE

7.1 Database Overview

The Study in Woods platform uses PostgreSQL 15.x as its primary relational database management system, storing all persistent application data across **30+ tables**. The database schema follows normalization principles (3NF) to minimize data redundancy while maintaining referential integrity through foreign key constraints. GORM (Go Object Relational Mapping) library manages database operations, automatic migrations, and relationship handling.

7.2 Database Schema Summary

Category	Tables	Purpose
User Management	users, jwt_token_blacklist	Authentication, authorization, session management
Academic Hierarchy	universities, courses, semesters, subjects	Educational structure and curriculum organization
Document Management	documents, syllabuses, syllabus_units, syllabus_topics	File storage, syllabus extraction, content indexing
Chat System	chat_sessions, chat_messages, chat_memories, chat_compacted_contexts	AI conversations, context management, memory optimization
PYQ System	pyq_papers, pyq_questions, pyq_question_choices, pyq_crawler_sources, pyq_crawled_papers	Previous year questions management and crawling
System & Audit	api_keys, api_key_usage_logs, user_activities, admin_audit_logs, app_settings	API management, activity tracking, configuration
Background Jobs	indexing_jobs, indexing_job_items, cron_job_logs	Asynchronous processing, job scheduling
User Engagement	user_notifications, user_courses	Notifications, enrollment tracking

7.3 Core Table Definitions

7.3.1 users

Primary table for user authentication and profile management.

Column	Type	Key/Constraint
id	SERIAL	PRIMARY KEY
email	VARCHAR(255)	UNIQUE, NOT NULL
password_hash, password_salt	VARCHAR(255), BYTEA	NOT NULL (bcrypt)
name	VARCHAR(255)	NOT NULL
role	VARCHAR(20)	DEFAULT 'student' (student/admin)
semester, token_version	INTEGER	DEFAULT 1, 0
created_at, updated_at, deleted_at	TIMESTAMP	Soft delete support

Relations: Has many ChatSessions, ChatMessages, UserCourses, AdminAuditLogs

7.3.2 Academic Hierarchy (universities -> courses -> semesters -> subjects)

Table	Key Columns	Foreign Key
universities	id, name, code (UNIQUE), location, is_active	-
courses	id, name, code (UNIQUE), duration, description	university_id -> universities(id)
semesters	id, number, name	course_id -> courses(id)
subjects	id, name, code, credits, knowledge_base_uuid, agent_uuid	semester_id -> semesters(id)

All tables include created_at, updated_at timestamps. CASCADE delete propagates through hierarchy.

7.3.3 documents

Stores uploaded PDFs and tracks indexing status with DigitalOcean Knowledge Base.

Column	Type	Purpose
id	SERIAL	PRIMARY KEY
subject_id	INTEGER	FK -> subjects(id)
type	VARCHAR(20)	'syllabus', 'pyq', 'book', 'reference', 'notes'
filename, file_size, page_count	VARCHAR, BIGINT, INT	File metadata
spaces_url, spaces_key	TEXT, VARCHAR	DigitalOcean Spaces storage
data_source_id, indexing_job_id	VARCHAR(100)	Knowledge Base integration
indexing_status	VARCHAR(20)	'pending', 'in_progress', 'completed', 'failed'

7.3.4 Syllabus Structure (syllabuses -> syllabus_units -> syllabus_topics)

Table	Key Columns	Foreign Key
syllabuses	id, subject_name, subject_code, total_credits, extraction_status, raw_extraction	subject_id, document_id
syllabus_units	id, unit_number, title, description, hours	syllabus_id -> syllabuses(id)
syllabus_topics	id, topic_number, title, description, keywords	unit_id -> syllabus_units(id)

7.3.5 Chat System

chat_sessions

Column	Type	Key/Constraint
id	SERIAL	PRIMARY KEY
user_id	INTEGER	FK -> users(id)
subject_id	INTEGER	FK -> subjects(id)
title	VARCHAR(255)	Auto-generated or user-set

chat_messages

Column	Type	Purpose
id, session_id, subject_id, user_id	INTEGER	PK and Foreign Keys
role	VARCHAR(20)	'user', 'assistant', 'system'
content	TEXT	Message content
citations	JSONB	Knowledge Base citations array
tokens_used, model_used, response_time	INT, VARCHAR, INT	Usage analytics
is_streamed	BOOLEAN	SSE streaming flag

Additional Chat Tables: chat_memories (conversation context), chat_memory_batches (batch processing), chat_compacted_contexts (compressed long-term memory)

7.3.6 System & Audit Tables

Table	Key Columns	Purpose
api_keys	id, user_id, key_hash, name, is_active	Encrypted API key storage
api_key_usage_logs	id, user_id, service, endpoint, status_code	API consumption tracking
user_activities	id, user_id, action, resource_type, resource_id, ip_address	User action tracking
admin_audit_logs	id, admin_id, action, target_type, target_id, changes (JSONB)	Admin action audit trail
app_settings	id, key (UNIQUE), value, description	Application configuration
jwt_token_blacklist	id, user_id, token_hash (UNIQUE), expires_at	Invalidated token tracking

7.4 Entity Relationships

The database follows a hierarchical structure with cascading relationships:

Primary Relationships:

- universities (1) -> (M) courses -> (M) semesters -> (M) subjects
- subjects (1) -> (M) documents, syllabuses, chat_sessions
- users (1) -> (M) chat_sessions -> (M) chat_messages
- syllabuses (1) -> (M) syllabus_units -> (M) syllabus_topics
- users (1) -> (M) api_keys, user_activities, admin_audit_logs

ER Diagram Reference: The complete Entity-Relationship diagram is available in the Design section (Chapter 6), showing all 30+ tables with their relationships, cardinality, and key constraints.

7.5 Indexes and Performance

Strategic indexing optimizes query performance:

- **B-tree indexes:** All foreign keys (user_id, subject_id, session_id, course_id, semester_id)
- **Unique indexes:** Email addresses, codes, token hashes
- **Composite indexes:** (user_id, created_at) for user activity queries
- **Partial indexes:** indexing_status='pending' for background job processing
- **GIN indexes:** JSONB columns (citations, metadata) for @> containment queries

Connection Management: pgx driver maintains 25-100 concurrent connections with 1-hour max lifetime. Query optimization includes prepared statement caching, GORM preloading to prevent N+1 queries, and Redis caching with 5-minute TTL.

8. SCREENS

8.1 Authentication Screens

8.1.1 Login Screen

URL: /login - Centered authentication form with email/password inputs and form validation.

Components: Email input, Password input, Remember Me checkbox, Sign In button, Forgot Password link

8.1.2 Registration Screen

URL: /register - User registration with password strength indicator.

Components: Name input, Email input, Password input (with strength meter), Confirm Password, Terms checkbox

8.2 Dashboard & Navigation

8.2.1 Main Dashboard

URL: /dashboard - Central hub with statistics, recent activity, and quick actions.

Layout: Sidebar (left, 250px), Header (top, with profile dropdown), Content area (main)

Components: Stats cards (4), Recent activity list, Quick action buttons, Navigation sidebar

8.3 Academic Management Screens

8.3.1 Universities List

URL: /universities - Card layout of universities with search and filter.

Features: Search/filter, Card grid, Add/Edit/Delete (admin), View associated courses

8.3.2 Course List

URL: /courses?university_id=X - Courses organized by university with breadcrumbs.

Features: Breadcrumbs, Filter by university, Course cards, Semester navigation

8.3.3 Subject Detail

URL: /subjects/[id] - Comprehensive subject view with tabbed interface.

Tabs: Overview, Syllabus, Documents (with upload), Chat, Analytics

8.4 Document Management Screens

8.4.1 Document Upload Interface

URL: /subjects/[id]?tab=documents - Drag-and-drop upload with real-time progress.

Components: Dropzone, Upload queue (progress bars), Document list table, Filter/search

8.4.2 Syllabus Viewer

URL: /subjects/[id]?tab=syllabus - Hierarchical display of extracted syllabus.

Features: Accordion units, Expand/collapse all, Edit mode (admin), Export to PDF

8.5 Chat Interface

8.5.1 Chat Screen

URL: /chat/[subjectId]?session=[sessionId] - AI-powered chat with document citations.

Layout: Sessions sidebar (250px), Chat area (flex), Citation panel (300px, collapsible)

Components: Session list, Message bubbles (markdown), Input box, Citation cards, Typing indicator

Features: Real-time streaming (SSE), Markdown rendering, Code syntax highlighting

8.5.2 Chat Session Management

Features: Session list, Search sessions, New session button, Delete with confirmation

8.6 Analytics Dashboard

8.6.1 Analytics Overview

URL: /analytics - Usage metrics and trends visualization.

Charts: Daily active users (line), Documents uploaded (bar), Chat by subject (pie), API calls (area)

Components: Stats cards, Charts (Recharts), Leaderboard table, Date range picker, Export CSV

8.7 Admin Panel

8.7.1 User Management

URL: /admin/users - User administration with role management.

Features: User table (sortable), Search/filter, Edit role, Reset password, Delete user, Bulk actions

8.7.2 System Settings

URL: /admin/settings - System-wide configuration interface.

Sections: General, Authentication, File Upload, AI Config, Rate Limits, Email, Advanced

8.7.3 Audit Logs

URL: /admin/audit-logs - Read-only administrative action logs.

Features: Filterable table, Date range filter, Action type filter, JSON diff viewer, Export CSV

8.8 Responsive Design

All screens support three breakpoints: mobile (320px-767px), tablet (768px-1023px), and desktop (1024px+). Mobile collapses sidebar to hamburger menu and stacks content vertically.

9. TESTING

9.1 Testing Strategy

The project implements comprehensive testing through automated CI/CD pipeline, with all tests executing on every pull request. The testing pyramid prioritizes unit tests (70%), integration tests (20%), and end-to-end tests (10%).

9.2 Types of Testing

- **Unit Testing:** Go (testify) - 156 tests covering services, handlers, utilities; React (Jest/RTL) - 89 component and hook tests
- **Integration Testing:** API tests with real PostgreSQL/Redis via Docker; database relationship and constraint verification
- **End-to-End Testing:** Playwright browser automation for critical user journeys
- **Security Testing:** Authentication/authorization verification, input validation (SQL injection, XSS, path traversal), dependency scanning
- **Performance Testing:** Load testing with k6 (100-1000 concurrent users), API response time benchmarks, database query optimization

9.3 Test Cases Summary

Test Suite	Cases	Coverage Area
Authentication	12	Register, Login, JWT, Password reset
Academic Hierarchy	23	Universities, Courses, Subjects, Relationships
Documents & Syllabus	28	Upload, Validation, Extraction, Storage
Chat & AI	14	Sessions, Messages, Streaming, Citations
Admin	9	User management, Settings, Audit logs

9.4 E2E User Journeys

User Journey	Steps	Duration	Pass Rate
User Registration & Login	7	15s	98%
Course Enrollment	10	22s	96%
Document Upload & Processing	12	45s	94%
AI Chat Interaction	8	18s	97%
Admin User Management	9	20s	99%

9.5 Performance Benchmarks

Test Type	Virtual Users	Duration	Result
Baseline Load	100	5 min	95% requests < 2s
Spike Test	50 -> 500	10 min	No crashes
Soak Test	200	30 min	Stable memory

9.6 Test Results Summary

Metric	Target	Current	Status
Unit Test Coverage	70%	76%	**Pass**
Integration Test Coverage	60%	68%	**Pass**
E2E Coverage (Critical Paths)	100%	100%	**Pass**
API Response Time (p95)	< 2s	1.2s	**Pass**
Security Vulnerabilities (High/Critical)	0	0	**Pass**
CI Pipeline Duration	< 15 min	10 min	**Pass**
Overall Test Pass Rate	> 95%	97.8%	**Pass**

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