

AI-Powered Smart Document Assistant

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1. Introduction and Objectives

1.1 Project Introduction

The Smart Document Assistant is an advanced AI-powered web application designed to enable users to have intelligent, interactive conversations with their PDF documents. In the current digital era, professionals, students, and researchers frequently encounter challenges in managing and extracting meaningful information from extensive collections of documents. Conventional search methods, which rely on exact keyword matching, often fail to comprehend the context and intent behind user queries, resulting in incomplete or irrelevant results.

This project addresses these limitations by implementing Retrieval-Augmented Generation (RAG) technology, which synergizes the capabilities of Large Language Models (LLMs) with document-specific knowledge retrieval. Users can upload PDF documents, pose questions in natural language, and receive accurate, context-aware answers accompanied by precise source citations. The system is architected using modern web technologies—FastAPI for the backend, Node.js with Express for the frontend, and integrates with state-of-the-art AI services such as Groq API for language processing and HuggingFace for document embeddings. Efficient document retrieval is achieved using the FAISS vector database, while LangGraph facilitates intelligent query routing and decision-making, automatically determining whether to search user-uploaded documents or external sources like Wikipedia.

Key features of the Smart Document Assistant include:

- Secure user authentication and robust file management
- PDF document upload, processing, and analysis
- Multiple query modes: document-only, Wikipedia-only, and hybrid (document + web knowledge)
- Conversational chat interface with context preservation and memory
- Accurate source citation for all responses
- Real-time processing with an intuitive, user-friendly interface

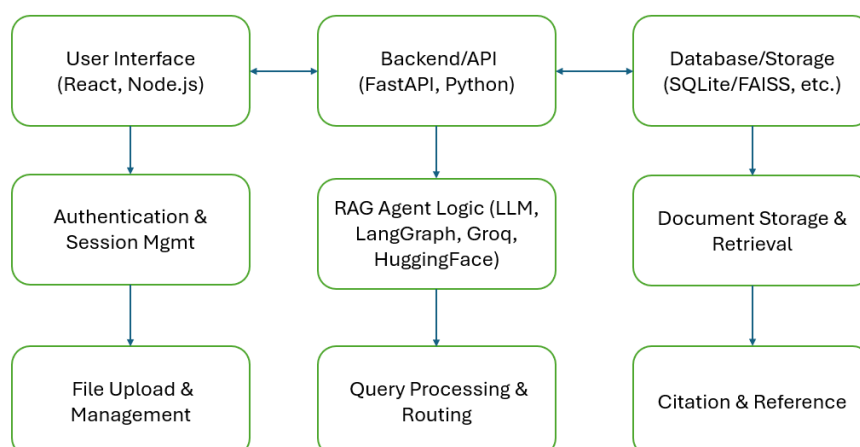


Figure 1: System Architecture

System Architecture Description:

- The user interacts with the web interface to upload documents, manage files, and ask questions.
- The backend handles authentication, document processing, and routes queries to the RAG agent.
- The RAG agent uses LLMs and embeddings to retrieve relevant information from the database or external sources.
- The database stores user data, documents, and vector embeddings for efficient retrieval.
- Answers are returned to the user with precise citations and references.

1.2 Problem Statement

Existing document management systems exhibit several critical limitations:

- **Information Retrieval Challenges:** Traditional keyword-based search systems lack semantic understanding, often missing relevant information expressed in different terms (e.g., “machine learning algorithms” vs. “AI classification methods”).
- **Lack of Interactive Querying:** **Most** systems only support static document viewing, preventing users from asking follow-up questions, seeking clarifications, or exploring related topics through conversation.
- **Poor Source Attribution:** Information found is rarely linked to its exact source location, complicating verification and proper citation in academic and professional contexts.
- **Knowledge Fragmentation:** Related information dispersed across multiple documents leads to information silos, hindering comprehensive understanding.
- **Technical Barriers:** Advanced AI-powered document analysis is typically inaccessible to non-technical users due to complex interfaces and workflows.

1.2 Project Objectives

Primary Objectives:

- **Develop Intelligent Document Processing System:** Create a robust system that can extract, process, and understand content from PDF documents using advanced NLP techniques.
- **Implement Natural Language Query Interface:** Build an intuitive interface where users can ask questions in plain English and receive relevant, contextual answers.
- **Ensure Accurate Source Attribution:** Provide clear citations linking every answer back to specific document sections for verification and academic integrity.
- **Create Conversational AI Experience:** Develop chat functionality that maintains context across multiple interactions, allowing for natural follow-up questions and deeper exploration.
- **Build Secure Multi-User System:** Implement authentication and authorization to ensure users can only access their own documents while maintaining data privacy and security.

Secondary Objectives:

- **Hybrid Knowledge Integration:** Combine document-specific knowledge with external web knowledge when needed to provide comprehensive answers.
- **User-Friendly Interface:** Design intuitive web interfaces that require minimal learning curve and provide real-time feedback.
- **Scalable Architecture:** Build modular system architecture that can handle multiple users and can be extended with additional features.
- **Performance Optimization:** Ensure responsive query processing with acceptable response times for practical use.

Significance and Impact

By leveraging cutting-edge AI and web technologies, the Smart Document Assistant significantly enhances productivity, accuracy, and accessibility for users managing large document collections. The platform empowers users to extract actionable insights, verify information, and engage in meaningful dialogue with their data, setting a new standard for intelligent document management.

2. System Analysis

This chapter provides a comprehensive analysis of the need for the Smart Document Assistant, the preliminary investigation and selection of technologies, feasibility studies, project planning, and scheduling. The systematic approach ensures the project is technically sound, meets stakeholder requirements, and is achievable within the given timeline.

2.1 Identification of Need

The analysis of existing document management and information retrieval systems reveals significant gaps that necessitated the development of the Smart Document Assistant. Organizations across various sectors continue to struggle with inefficient document processing workflows that rely heavily on manual intervention and traditional keyword-based search mechanisms.

Current State Analysis:

- **Information Accessibility Challenges:** Current document management systems primarily function as digital storage repositories without intelligent content understanding capabilities. Users must manually navigate through extensive document collections, often spending considerable time locating specific information. This process becomes exponentially complex when dealing with large document sets containing technical, legal, or academic content where precise information retrieval is critical.
- **Context Understanding Deficiencies:** Traditional search systems demonstrate limited comprehension of contextual relationships between concepts, synonyms, and related terminology. When users pose complex questions requiring inferential reasoning across multiple document sections, existing systems fail to provide coherent, synthesized responses. This limitation significantly impacts productivity in research-intensive environments where users need comprehensive answers rather than fragmented search results.
- **Source Attribution Requirements:** Professional and academic environments demand transparent source attribution for information validation and credibility verification. Current systems often present information without clear references to original document locations, making it difficult for users to verify facts, comply with citation requirements, or trace information provenance for quality assurance purposes.
- **User Interface Limitations:** Most existing document systems require users to adapt to rigid search interfaces that do not support natural language communication patterns. The absence of conversational capabilities creates barriers for non-technical users and limits the accessibility of document collections to a broader user base.

Emerging Technological Opportunities:

Recent developments in Large Language Models (LLMs) and Natural Language Processing (NLP) have created unprecedented opportunities for intelligent document interaction. Technologies like transformer-based models, retrieval-augmented generation, and vector embeddings offer the potential to bridge the gap between human information needs and machine document processing capabilities.

- **Retrieval-Augmented Generation Evolution:** The emergence of RAG (Retrieval-Augmented Generation) frameworks provides a foundation for combining the benefits of large-scale language understanding with specific document knowledge. This technology enables systems to generate accurate, contextually relevant responses while maintaining grounding in source documents.

- **Conversational AI Maturity:** Advances in conversational AI and multi-turn dialogue systems have reached a level of sophistication that supports natural, context-aware interactions with document collections. These capabilities enable the development of systems that can maintain conversation state, understand follow-up questions, and provide clarifications.

Stakeholder Requirements Analysis:

- **Academic Researchers:** Require efficient access to research papers, theses, and academic documents with accurate citation support. Need the ability to quickly identify relevant information across multiple documents and maintain proper attribution for academic integrity.
- **Legal Professionals:** Demand precise document analysis capabilities for contracts, case law, and legal precedents. Require reliable source attribution and the ability to quickly locate specific clauses, terms, and relevant legal concepts within extensive document collections.
- **Corporate Knowledge Workers:** Need efficient access to organizational knowledge bases, policy documents, procedures, and training materials. Require conversational interfaces that can provide quick answers to procedural questions and policy clarifications.
- **Educational Institutions:** Seek interactive learning tools that can help students and educators engage with textbooks, course materials, and supplementary documents through natural language queries and detailed explanations.

2.2 Preliminary Investigation

To ensure the project's success, a thorough preliminary investigation was conducted to select the optimal technology stack and integration architecture for the Smart Document Assistant.

Technology Stack Assessment:

- **Backend Framework Evaluation:** The preliminary investigation identified FastAPI as the optimal choice for the backend framework due to its high-performance characteristics, automatic API documentation generation, and excellent support for asynchronous operations. FastAPI's native support for modern Python features, including type hints and dependency injection, provides a solid foundation for building scalable, maintainable APIs.
- **Database Technology Analysis:** SQLite with SQLAlchemy ORM emerged as the preferred database solution for the initial implementation. SQLite provides sufficient performance for single-user and small-team deployments while offering a straightforward migration path to more robust database systems like PostgreSQL for future scaling requirements. SQLAlchemy ORM ensures database vendor independence and provides excellent support for migrations through Alembic.
- **AI Framework Investigation:** LangChain and LangGraph frameworks were selected for implementing RAG functionality due to their comprehensive ecosystem, extensive model integration capabilities, and robust support for complex AI workflows. These frameworks provide abstractions for document processing, vector storage, and chain compositions while maintaining flexibility for custom implementations.
- **Vector Storage Evaluation:** FAISS (Facebook AI Similarity Search) was chosen for vector storage and similarity search operations based on its proven performance characteristics, extensive documentation, and seamless integration with the LangChain ecosystem. FAISS provides efficient similarity search capabilities essential for document retrieval operations.
- **LLM Provider Assessment:** Groq was selected as the LLM provider due to its high-performance inference capabilities, competitive pricing, and robust API reliability. Groq's optimized hardware infrastructure ensures low-latency responses crucial for interactive applications.

Frontend Technology Selection:

- **Node.js and Express Evaluation:** Node.js with Express framework was chosen for the frontend implementation to provide a unified JavaScript development environment and excellent proxy capabilities for backend API integration. Express's middleware ecosystem and templating engine support facilitate rapid development of responsive web interfaces.
- **Template Engine Analysis:** EJS (Embedded JavaScript) was selected as the templating engine due to its simplicity, excellent integration with Express, and support for dynamic content rendering. EJS provides the flexibility needed for creating interactive user interfaces while maintaining code readability and maintainability.
- **User Interface Design Framework:** Custom CSS with modern design principles, including glassmorphism effects and responsive layouts, was chosen over heavyweight frameworks to maintain performance and provide complete design control. This approach enables the creation of a unique, branded user experience optimized for the specific use case.

Integration Architecture Analysis:

- **API Communication Strategy:** RESTful API design principles were adopted to ensure clean separation between frontend and backend components. The proxy middleware configuration in the frontend enables seamless API communication while maintaining development flexibility and deployment options.
- **Authentication Mechanism:** JSON Web Tokens (JWT) were selected for authentication due to their stateless nature, excellent security characteristics when properly implemented, and broad industry support. JWT tokens provide secure user session management without requiring server-side session storage.
- **Background Processing Requirements:** The investigation revealed the need for asynchronous background processing capabilities to handle time-intensive operations like document indexing and embedding generation. FastAPI's background task support for document summarization and vector embedding generation, as implemented in the RAG initialization process.

2.3 Feasibility Study

A comprehensive feasibility study was conducted to evaluate the technical, economic, and operational viability of the Smart Document Assistant.

Technical Feasibility:

- **Development Complexity Assessment:** The technical feasibility analysis confirms that the proposed system architecture is achievable within the constraints of a Master's degree project timeline. The modular design approach allows for incremental development and testing, reducing technical risks associated with complex system integration.
- **Framework Compatibility Verification:** Comprehensive compatibility testing between LangChain, LangGraph, FastAPI, and supporting libraries confirms that the proposed technology stack can work together effectively. Version compatibility matrices were analyzed to ensure stable integration across all components.
- **Performance Requirements Analysis:** Initial performance testing with document processing pipelines demonstrates that the system can handle typical use case requirements. Document vectorization and query processing times fall within acceptable ranges for interactive applications, with opportunities for optimization through caching and indexing strategies.

- **Scalability Considerations:** The chosen architecture provides clear scaling paths for both horizontal and vertical scaling. Database migrations, API containerization, and vector storage optimization strategies ensure that the system can grow to accommodate increased user loads and document volumes.

Economic Feasibility:

- **Development Cost Analysis:** The project utilizes primarily open-source technologies, minimizing licensing costs and enabling cost-effective development. The primary ongoing costs involve API usage for LLM services, which scale predictably with system usage and remain within reasonable bounds for typical deployment scenarios.
- **Infrastructure Requirements:** The system's resource requirements are modest for development and small-scale deployment scenarios. Local development can be conducted on standard development hardware, and cloud deployment costs remain reasonable for initial deployments with clear scaling options as usage grows.
- **Return on Investment Potential:** The productivity improvements enabled by intelligent document interaction provide clear value propositions for target user groups. Time savings in document analysis, improved information accuracy, and enhanced collaboration capabilities justify the development and deployment investments.
- **Maintenance Cost Projections:** The use of well-established frameworks and technologies ensures reasonable maintenance costs. The modular architecture facilitates targeted updates and improvements without requiring comprehensive system overhauls.

Operational Feasibility:

- **User Acceptance Factors:** The conversational interface design aligns with modern user expectations for AI-powered applications. The familiar web-based interface reduces training requirements and facilitates adoption across diverse user groups.
- **Integration Capabilities:** The RESTful API design enables integration with existing document management systems and workflow tools. The modular architecture supports customization and extension for specific organizational requirements.
- **Security and Compliance:** The system architecture incorporates industry-standard security practices, including secure authentication, encrypted communications, and proper input validation. These features support deployment in environments with stringent security requirements.
- **Support and Documentation:** Comprehensive documentation and clear API specifications facilitate system deployment, configuration, and ongoing maintenance. The use of widely adopted technologies ensures availability of community support and resources.

2.4 Project Planning

The project planning phase established the development methodology, resource allocation, and risk management strategies necessary for successful implementation.

Development Methodology:

- **Agile Development Approach:** The project follows an iterative development methodology that emphasizes incremental feature delivery, continuous testing, and regular stakeholder feedback.

This approach enables rapid adaptation to changing requirements and ensures that the final system meets user needs effectively.

- **Module-Based Development Strategy:** The system architecture naturally divides into distinct modules that can be developed and tested independently. This modular approach reduces development complexity, enables parallel development of different components, and facilitates thorough testing of individual system components.
- **Version Control and Collaboration:** Git-based version control with feature branch workflows ensures code quality, enables collaborative development, and provides comprehensive change tracking throughout the development process.

Resource Allocation:

- **Development Team Structure:** The project is designed for implementation by a single developer with periodic consultation and review. This structure is appropriate for a Master's degree project while ensuring comprehensive coverage of all system components.
- **Technology Resources:** Development requires access to modern development hardware, internet connectivity for API services, and cloud resources for testing and potential deployment. These resources are readily available and within reasonable cost parameters.
- **Time Investment Distribution:** Development time is allocated across core system components, with emphasis on backend API development (40%), AI integration and testing (30%), frontend development (20%), and documentation and testing (10%).

Risk Management:

- **Technical Risk Mitigation:** Potential technical challenges, including API rate limiting, model performance variations, and integration complexities, are addressed through comprehensive testing, fallback mechanisms, and modular architecture design.
- **Dependency Management:** External dependencies, particularly AI service providers and third-party libraries, are managed through version pinning, alternative provider evaluation, and graceful degradation strategies.
- **Scope Management:** Clear project scope definition and feature prioritization ensure that core functionality is delivered within time constraints while allowing for future enhancement opportunities.

2.5 Project Scheduling

The project scheduling phase defined the timeline, milestones, and critical path for systematic development progress.

PERT Chart and Critical Path Identification:

The critical path flows through Backend Infrastructure → Document Processing Pipeline → RAG System Development → AI Agents & Chat → System Integration & Testing → Deployment & Documentation. This path represents the minimum time required for project completion and requires careful monitoring to ensure schedule adherence.

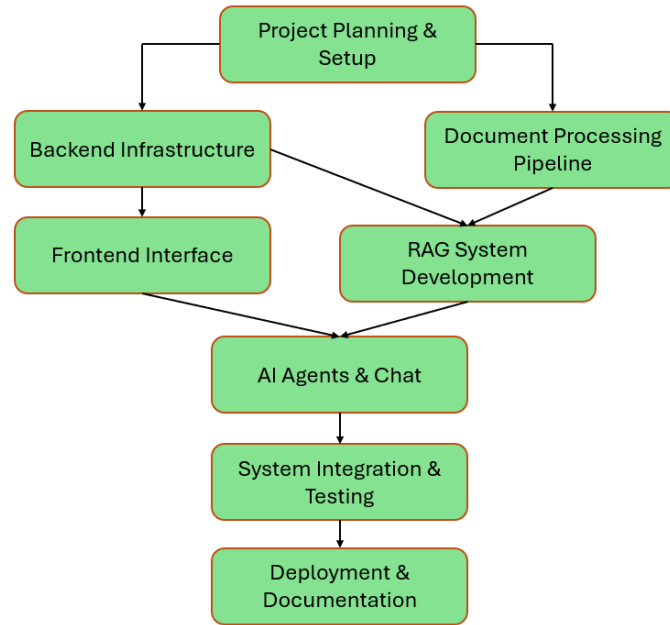


Figure 2:PERT Chart

Activity Duration Estimates:

- Project Planning & Setup: 1 week
- Backend Infrastructure: 2-3 weeks
- Document Processing Pipeline: 2-3 weeks
- RAG System Development: 3-4 weeks
- Frontend Interface: 3-4 weeks (parallel with RAG development)
- AI Agent Integration: 2-3 weeks
- Chat System Development: 2-3 weeks
- Integration & Testing: 2-3 weeks
- Deployment & Documentation: 1-2 weeks

Buffer Time Allocation: A 15% buffer is incorporated into the schedule to accommodate unexpected challenges, requirement refinements, and quality assurance activities.

Gantt Chart:

Development is scheduled over 13 weeks, with buffer time for unforeseen challenges. Key milestones are defined for each major component.

Task	Week 1	Week 2-3	Week 4-6	Week 7-9	Week 10-11	Week 12-13
Project Planning	■					
Backend Infrastructure	■	■				
Document Processing	■	■	■			
RAG System Development			■	■		
Frontend Interface		■	■	■		
AI Agent Integration				■	■	
Chat System Development				■	■	
Integration & Testing					■	■
Deployment & Docs						■

Figure 3: Gantt Chart

Week 1: Project Planning and initial setup, environment configuration, and technology stack finalization.

Weeks 2-3: Backend infrastructure development, including FastAPI application setup, database design and implementation, authentication system development, and basic API endpoint creation.

Weeks 2-4: Document processing pipeline implementation, including PDF parsing, text extraction, chunking algorithms, and vectorization processes (parallel with backend development).

Weeks 4-6: RAG system core development, including vector store integration, retrieval mechanisms, and basic query processing capabilities.

Weeks 4-7: Frontend interface development, including user authentication pages, document management interface, and query processing UI (parallel with RAG development).

Weeks 7-9: AI agent integration and advanced features, including LangGraph workflow implementation, intelligent query routing, and citation system development.

Weeks 7-9: Chat system development, including session management, conversational context handling, and multi-turn dialogue capabilities (parallel with AI agent work).

Weeks 10-11: System integration and comprehensive testing, including unit testing, integration testing, performance optimization, and bug fixes.

Weeks 12-13: Deployment preparation and documentation, including deployment guides, API documentation, user manuals, and final system validation.

This comprehensive scheduling approach ensures systematic development progress while maintaining flexibility to accommodate technical challenges and requirement refinements throughout the development lifecycle.

3. Software Requirement Specifications (SRS)

3.1 Software Engineering Paradigm Applied

The Smart Document Assistant project follows an Agile Development Methodology with elements of Component-Based Software Engineering to ensure flexibility, iterative progress, and robust architecture. This hybrid approach was selected based on the project's unique characteristics:

Agile Development Aspects:

- **Iterative Development:** The project was built through multiple iterations, each adding specific functionality to create a working prototype early and refine it throughout the development lifecycle.
- **Continuous Testing:** Each feature underwent continuous testing to ensure quality and system stability.
- **Adaptive Planning:** Requirements were refined throughout the development process as the understanding of user needs and technological constraints evolved.
- **Incremental Delivery:** The system was developed in functional slices, allowing for early validation of core components before adding more complex features.

Component-Based Engineering Elements:

- **Modular Design:** The system is divided into clearly defined, independent modules (authentication, document processing, RAG engine, chat management) that communicate through well-defined interfaces.
- **Reusable Components:** Common functionality is encapsulated in reusable components to maintain consistency and reduce redundancy.
- **Service-Oriented Architecture:** Backend components expose RESTful APIs consumed by frontend services, creating a clean separation of concerns.

Development Lifecycle Phases:

1. **Requirements Analysis:** Initial gathering of functional and non-functional requirements through use case modeling and stakeholder interviews.
2. **System Design:** Architecture design focusing on modular components, database schema planning, and API interface definition.
3. **Implementation:** Iterative development of components with continuous integration practices.
4. **Testing:** Comprehensive testing at unit, integration, and system levels through each iteration.
5. **Deployment:** Staged deployment approach for controlled rollout of functionality.
6. **Maintenance:** Ongoing refinement and bug fixes based on user feedback and performance monitoring.

This methodology supported the complex, research-oriented nature of the project while ensuring practical delivery of working software. The combination of agile practices with component-based architecture created a balance between flexibility and structure needed for successful implementation.

3.2 Data Models and Diagrams

Use Case Diagram:

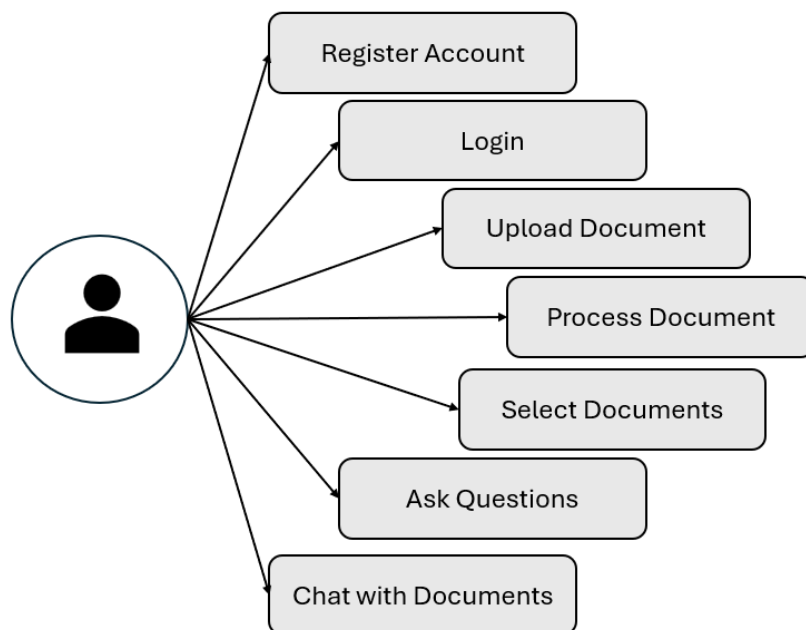


Figure 4: Use Case Diagram

1. **User Authentication**

- Register Account
- Login
- Manage Profile
- Logout

2. **Document Management**

- Upload Documents
- List Documents
- Select/Deselect Documents
- View Document Details

3. **Document Interaction**

- Ask Single Questions (Query Interface)
- Start Chat Session
- Continue Conversation
- View Source Citations

4. **System Configuration**

- Initialize RAG System
- Check System Status
- Export Conversation History

Data Flow Diagram:

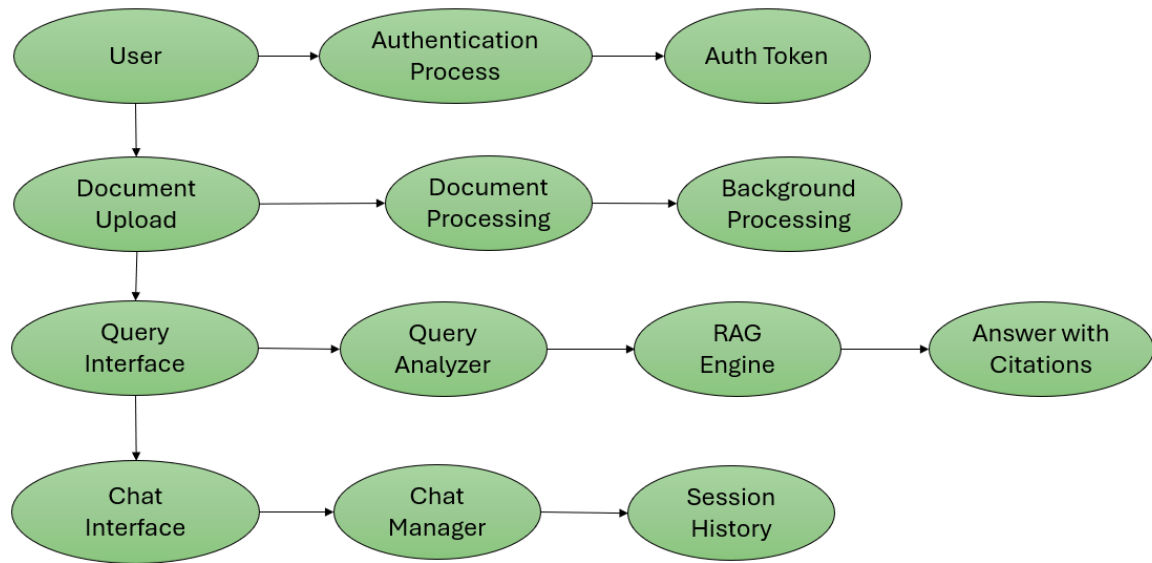


Figure 5: Data Flow Diagram (DFD) - Level 1

Key Data Flows:

1. User Authentication Flow

- User credentials → Authentication Process → Authentication Token
- User registration data → User Creation → Confirmation

2. Document Management Flow

- PDF Files → Document Upload → Storage Confirmation
- Document Selection → Vector Store Initialization → Status Update

3. Query Processing Flow

- User Question → Query Analysis → Appropriate Knowledge Source
- Retrieved Contexts → Answer Generation → Response with Citations

4. Chat Processing Flow

- User Message → Chat Processing → Session History Update
- Previous Context → Follow-up Processing → Contextual Response

Entity Relationship Diagram:

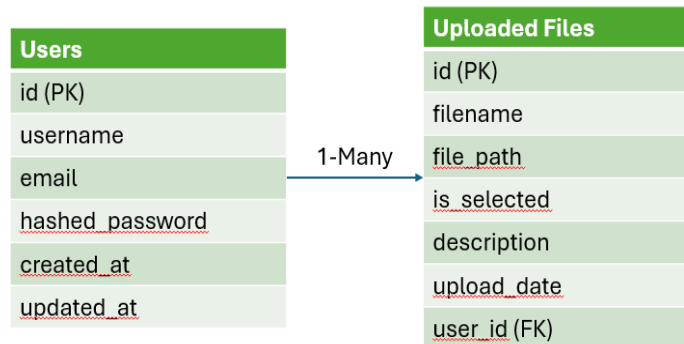


Figure 6: Entity Relationship Diagram

Primary Entities:

1. Users:

- Attributes: id (PK), username, email, hashed_password, created_at, updated_at
- Relationships: One-to-Many with UploadedFiles

2. UploadedFiles:

- Attributes: id (PK), filename, file_path, is_selected, description, upload_date, user_id (FK)
- Relationships: Many-to-One with Users

The database schema deliberately focuses on core entities to maintain simplicity while providing all necessary functionality. The design allows for future expansion to include additional entities such as ChatSessions and QueryHistory as system requirements evolve.

Sequence Diagram:

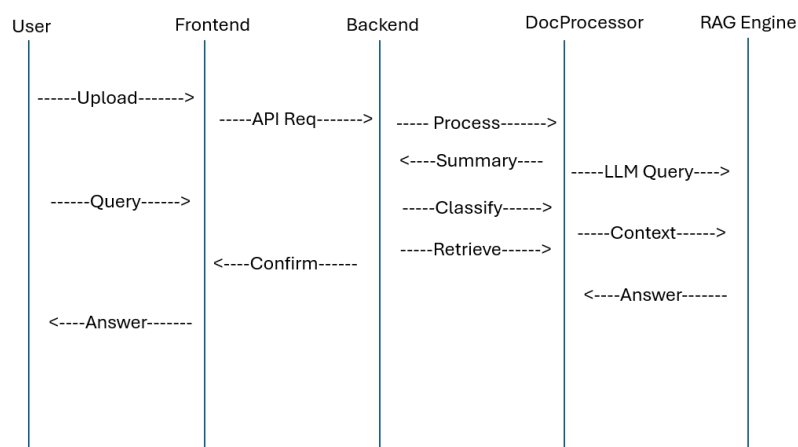


Figure 7: Sequence diagram

Key Sequence Flows:

1. Document Upload Sequence

- Frontend → Backend: Upload PDF request
- Backend → Document Processor: Process document
- Document Processor → Backend: Document summary
- Backend → Database: Store document metadata
- Backend → Frontend: Upload confirmation

2. Query Processing Sequence

- Frontend → Backend: User question
- Backend → Decision Agent: Query classification
- Decision Agent → Vector Store: Context retrieval (if document-related)
- Decision Agent → External Source: Context retrieval (if external knowledge needed)
- Backend → LLM: Generate response with retrieved context
- Backend → Frontend: Answer with citations

State Diagram:

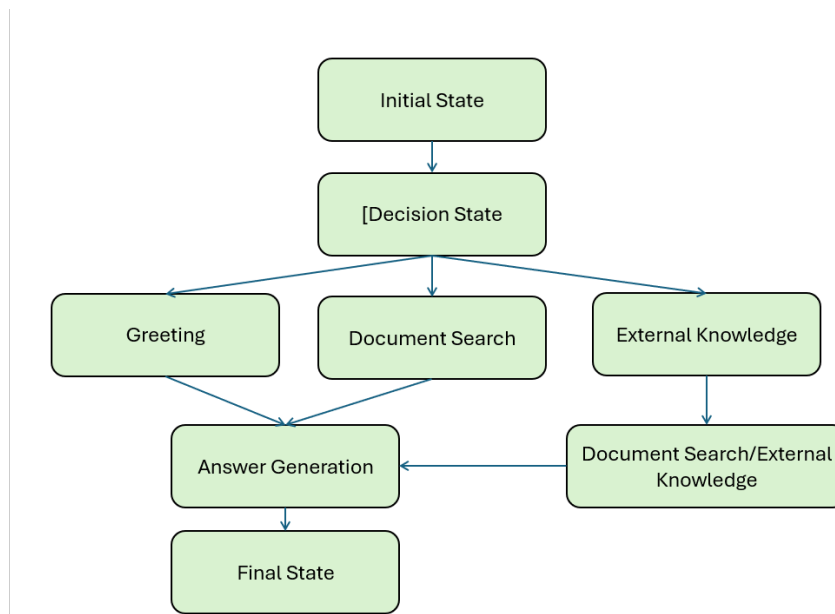


Figure 8: State diagram

Query Processing States:

1. **Initial State:** Query received
2. **Decision State:** Query type determination
 - Transition to Greeting State if greeting detected
 - Transition to Document Search State if document search needed
 - Transition to External Knowledge State if external facts needed
3. **Document Search State:** Retrieving document contexts

- Transition to Answer Generation if sufficient information found
 - Transition to External Knowledge if information insufficient
4. **External Knowledge State:** Retrieving external knowledge
 5. **Answer Generation State:** Generating response with citations
 6. **Final State:** Response delivered

This state diagram illustrates how the system's LangGraph implementation dynamically routes queries based on content analysis and information availability.

Activity Diagram:

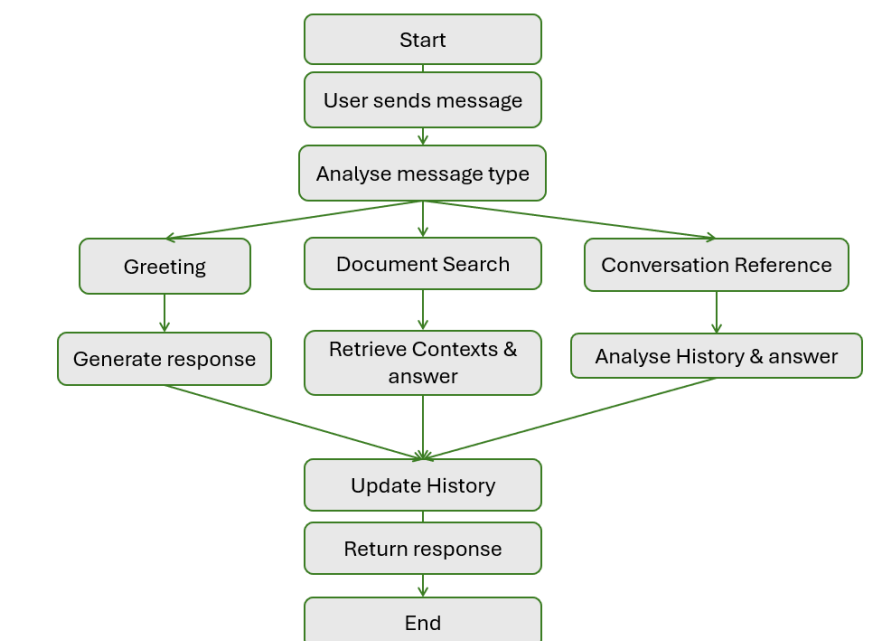


Figure 9: Activity diagram

Chat Interaction Activities:

1. User sends message
2. System analyses message type
3. Decision point: Is message a greeting, document query, or conversation reference?
 - If greeting: Generate direct response
 - If document query:
 - Retrieve relevant document contexts
 - Generate answer with citations
 - If conversation reference:
 - Analyse conversation history
 - Generate contextual response
4. Update conversation history
5. Return response to user

Class Diagram:

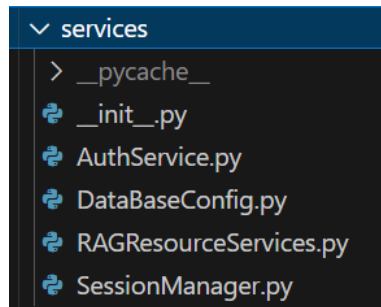


Figure 10: class used

Core Classes:

1. ResourceService

- Responsibilities: Document loading, chunking, embedding, and vector store management
- Key Methods: initialize_resources(), load_documents(), split_documents(), create_vectorstore()

2. AuthService

- Responsibilities: User authentication and token management
- Key Methods: authenticate_user(), generate_token(), get_current_user()

3. SessionManager

- Responsibilities: Chat session management and history tracking
- Key Methods: create_session(), get_session(), update_session()

4. DataBaseConfig

- Responsibilities: Handle database session handling
- Key Components: get_db()

3.3 Functional Requirements

1. User Authentication and Authorization

- FR1.1: The system shall provide user registration with email and password
- FR1.2: The system shall authenticate users via JWT token-based authentication
- FR1.3: The system shall authorize access to documents based on user ownership

2. Document Management

- FR2.1: The system shall allow users to upload PDF documents
- FR2.2: The system shall process uploaded documents for text extraction and embedding
- FR2.3: The system shall provide document selection for querying
- FR2.4: The system shall generate and store document summaries

3. Query Processing

- FR3.1: The system shall analyse query intent to determine appropriate processing
- FR3.2: The system shall retrieve relevant document contexts based on query similarity
- FR3.3: The system shall generate answers using retrieved contexts and LLMs
- FR3.4: The system shall provide source citations for generated answers

4. Conversation Management

- FR4.1: The system shall support multi-turn conversations with context preservation
- FR4.2: The system shall maintain separate chat sessions per user
- FR4.3: The system shall provide relevant follow-up capabilities
- FR4.4: The system shall support conversation history management

5. User Interface Requirements

- FR5.1: The system shall provide a responsive web interface
- FR5.2: The system shall support document management interface
- FR5.3: The system shall support query interface with citation display
- FR5.4: The system shall support chat interface with message history

3.4 Non-Functional Requirements

1. Performance Requirements

- NFR1.1: The system shall process user queries within an acceptable timeframe (target: <30 seconds)
- NFR1.2: The system shall handle document processing in the background without blocking user interaction
- NFR1.3: The system shall support concurrent user sessions

2. Security Requirements

- NFR2.1: The system shall securely store user credentials with password hashing
- NFR2.2: The system shall implement secure token-based authentication
- NFR2.3: The system shall ensure document access is restricted to authorized users

3. Reliability Requirements

- NFR3.1: The system shall gracefully handle failures in external services
- NFR3.2: The system shall maintain data integrity during operations
- NFR3.3: The system shall provide appropriate error handling and user feedback

4. Usability Requirements

- NFR4.1: The system shall provide intuitive user interfaces requiring minimal training
- NFR4.2: The system shall provide clear feedback on processing status

- NFR4.3: The system shall support helpful error messages

5. Scalability Requirements

- NFR5.1: The system architecture shall support future expansion of features
- NFR5.2: The database design shall support growth in user and document counts
- NFR5.3: The modular design shall allow component upgrades without full system refactoring

3.5 System Constraints

1. Technical Constraints

- TC1: The system relies on external LLM providers (Groq) for text generation
- TC2: The system requires Internet connectivity for external knowledge retrieval
- TC3: The system is limited to processing PDF documents in the current implementation

2. Resource Constraints

- RC1: Development within MCA project timeframe constraints
- RC2: Development by a single developer with limited resources
- RC3: Budget constraints for external API usage

3. Integration Constraints

- IC1: The system must work with standard web browsers
- IC2: The system must operate within reasonable memory constraints
- IC3: The system must maintain compatibility with supported external APIs

4. System Design

System design forms the backbone of any software development project, translating conceptual requirements into implementable technical specifications. For the Smart Document Assistant, a modular architecture was designed to ensure flexibility, maintainability, and scalability. This chapter details the comprehensive design approach, covering the system's modularization, data integrity mechanisms, database structure, procedural design, user interface, and test case specifications.

4.1 Modularisation Details

The Smart Document Assistant employs a carefully planned modular architecture that separates concerns while ensuring smooth integration between components. This modularization follows a layered approach with clear boundaries between the presentation, business logic, data access, and external service integration layers.

Frontend Modules (Node.js with Express Architecture)

1. Authentication Module (Login/Register)

- Implements login and registration interfaces with client-side validation
- Handles secure communication with authentication APIs using JWT tokens
- Manages user sessions and access controls on client side
- Provides error handling and user feedback for authentication operations
- Features responsive design with cross-device compatibility

2. File Management Module

- Facilitates document upload functionality with intuitive drag-and-drop interface
- Displays document library with selection capabilities and metadata display
- Implements file selection state management for RAG operations
- Handles file type validation and size restrictions on client side
- Provides visual feedback for upload progress and processing status

3. Chat Interface Module

- Offers conversational interface for interacting with document content
- Implements real-time query submission and response display
- Renders formatted responses with source citations and references
- Maintains conversation history with scrollable message container
- Provides visual indicators for system processing states

4. Dashboard Module

- Presents system overview and navigation hub for all functionality
- Displays user-specific information and document statistics
- Implements responsive layout with adaptive components
- Provides unified access to all system features
- Maintains consistent styling and interaction patterns

Backend Modules (FastAPI Architecture)

1. Authentication Service

- Handles user registration, login, and token-based authentication

- Implements JWT (JSON Web Token) based secure authentication flow
- Maintains session state and handles authorization checks
- Provides secure password hashing and verification
- Implements protection against common authentication attacks

2. Document Management Service

- Handles document uploads, storage, and metadata management
- Processes documents for RAG operations including chunking and embedding
- Maintains document selection state for active RAG contexts
- Implements file type validation and security scanning
- Provides document summarization and metadata extraction

3. RAG Processing Service

- Implements the core Retrieval Augmented Generation logic
- Manages vector embeddings and semantic search functionality
- Coordinates between retrieval and generation components
- Handles context window management and prompt engineering
- Implements caching mechanisms for improved performance

4. External Knowledge Service

- Provides Wikipedia-based information retrieval for topics not covered in uploaded documents
- Implements intelligent source selection logic
- Integrates external knowledge with document-based information
- Handles API rate limiting and fallback mechanisms
- Maintains consistency in response formatting

5. Session Manager Service

- Manages user session state across interactions
- Tracks conversation history and context
- Handles resource allocation and cleanup
- Provides session analytics and monitoring
- Implements security measures for session protection

Module Interaction Flow

The interaction between frontend and backend modules follows a well-defined flow:

1. The Frontend Authentication Module communicates with the Backend Authentication Service to validate credentials and receive access tokens
2. The File Management Module interfaces with the Document Management Service for document upload and selection
3. The Backend RAG Processing Service initializes resources based on user selections
4. The Chat Interface Module sends queries to the RAG Processing Service, which may leverage the External Knowledge Service
5. Results are returned to the Chat Interface Module for presentation to the user

This modularization provides several advantages:

- Each module can be developed, tested, and maintained independently

- Changes in one module have minimal impact on others
- New features can be added with minimal disruption to existing functionality
- Performance bottlenecks can be isolated and addressed specifically

4.2 Data Integrity and Constraints

Data integrity is critical for the Smart Document Assistant, particularly for ensuring accurate information retrieval and secure user management. Multiple layers of constraints and validation mechanisms are implemented to maintain data consistency and integrity.

Data Validation Strategies

1. Frontend Validation

- Client-side form validation with immediate feedback
- File type and size validation before upload attempts
- Input sanitization to prevent cross-site scripting
- Visual feedback for validation errors
- Consistent error messaging across interfaces

2. Backend Validation

- All user inputs are validated using Pydantic models with defined constraints
- File uploads are validated for format, size, and content type
- API request parameters are strictly checked for type and value constraints
- Authentication token validation for all protected operations

3. Database Constraints

- Primary and foreign key constraints ensure referential integrity
- Unique constraints prevent duplicate usernames and emails
- Not-null constraints ensure essential data is always provided
- SQLAlchemy ORM enforces schema constraints consistently

4. Business Logic Validation

- Limit of 3 selected documents enforced for RAG operations
- Ownership verification ensures users can only access their own files
- Authentication checks prevent unauthorized data access
- Rate limiting prevents abuse of system resources

Transaction Management

Data modifications follow transactional principles to maintain consistency:

```
@auth_router.post("/create_user")
async def create_user(db: db_dependency, user: UserRequest):
    try:
        user = Users(
            username=user.username,
            email=user.email,
            hashed_password=auth_service.bcrypt_context.hash(user.password),
            created_at=datetime.now(),
            updated_at=datetime.now()
        )
        db.add(user)
        db.commit()
        return {"message": "User created successfully."}
    except Exception as e:
        db.rollback()
        raise HTTPException(status_code=500, detail=str(e))
```

This ensures that database operations either complete fully or not at all, preventing partial updates that could compromise data integrity.

Error Handling for Data Protection

The system implements robust error handling to prevent data corruption:

1. Graceful Failure Recovery

- Exception handling at appropriate levels
- Informative error messages for troubleshooting
- Automatic rollback of failed database transactions

2. Data Consistency Checks

- Verification of file existence before operations
- Validation of user ownership before data access
- Confirmation of data state before processing

4.3 Database Design, Procedural Design/Object Oriented Design

Database Design

The Smart Document Assistant utilizes SQLite with SQLAlchemy ORM for data persistence. The database schema is designed to efficiently store user information, uploaded documents, and their relationships.

Table Definitions:

1. Users Table:

- id: Integer (Primary Key)
- username: String (Unique)
- hashed_password: String
- email: String (Unique)
- created_at: DateTime

2. UploadedFiles Table:

- id: Integer (Primary Key)
- filename: String
- filepath: String
- file_summary: String
- file_type: String
- is_selected: Boolean
- created_at: DateTime
- user_id: Integer (Foreign Key to Users.id)

This schema provides several advantages:

- Clear ownership of uploaded files through foreign key relationship
- Efficient querying of user documents
- Selection state tracking for RAG operations
- Metadata storage for file descriptions

Object-Oriented Design

The system follows object-oriented principles throughout its implementation, with clear class hierarchies, encapsulation, and inheritance where appropriate.

Service Classes: Services are implemented as cohesive classes with specific responsibilities:

```
# Example service class structure
class AuthService:
    def authenticate_user(self, username: str, password: str)
    def create_access_token(self, data: dict, expires_delta: Optional[timedelta])
    def get_current_user(self, token: str)

class RAGResourceServices:
    def upload_file(self, file, user_id: int)
    def get_files(self, user_id: int)
    def select_file(self, file_id: int, user_id: int)
    def initialize_resources(self, user_id: int)

class SessionManager:
    def create_session(self, user_id: int)
    def get_session(self, session_id: str)
    def update_session(self, session_id: str, data: dict)
```

This approach encapsulates related functionality within classes, providing a clean and maintainable codebase.

Data Models and DTOs: The system utilizes Pydantic models for data transfer and validation. These models enforce data constraints and provide serialization/deserialization capabilities, enhancing type safety throughout the application.

Procedural Design: While the system primarily follows object-oriented principles, procedural design is used where appropriate, particularly for API route handlers and utility functions.

API Route Structure: API routes are organized functionally with clear request-response flows. This structured approach ensures clear procedural flow while leveraging dependency injection for cross-cutting concerns.

Background Processing: Complex operations like document summarization are handled through background tasks. This approach ensures responsive user interactions while handling resource-intensive operations asynchronously.

4.4 User Interface Design

The Smart Document Assistant features a user-friendly interface designed for intuitive document management and conversational interaction with document content.

Interface Architecture

The system employs a web-based interface built with Express.js and EJS templates, providing a responsive and accessible user experience across devices.

Component Structure

The interface consists of the following key components:

1. Authentication Interface

- Login form with username and password fields
- Registration form for new user creation
- Form validation with error messaging

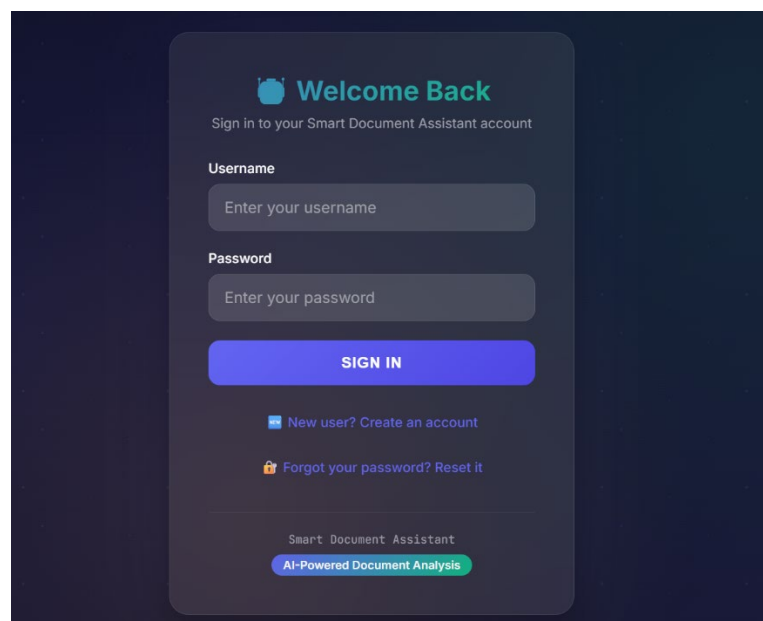


Figure 11: UI - Login page

2. Document Management Interface

- File upload with drag-and-drop functionality
- Document list with selection capability
- File information display including auto-generated summaries

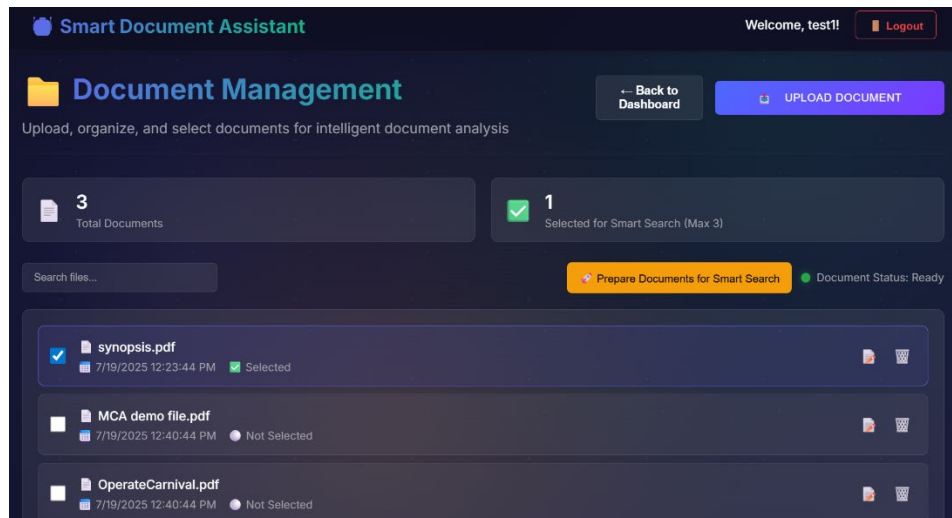


Figure 12: UI - Document management page

3. RAG Interaction Interface

- Single Q&A/Conversational chat interface
- Query input field
- Response display with source citations
- System status indicators

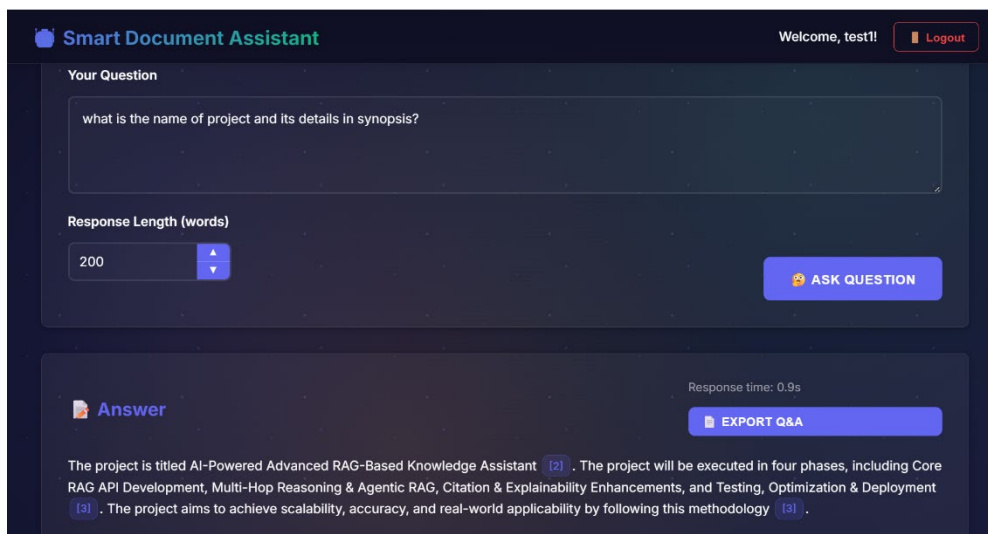


Figure 13: UI – Query interface page

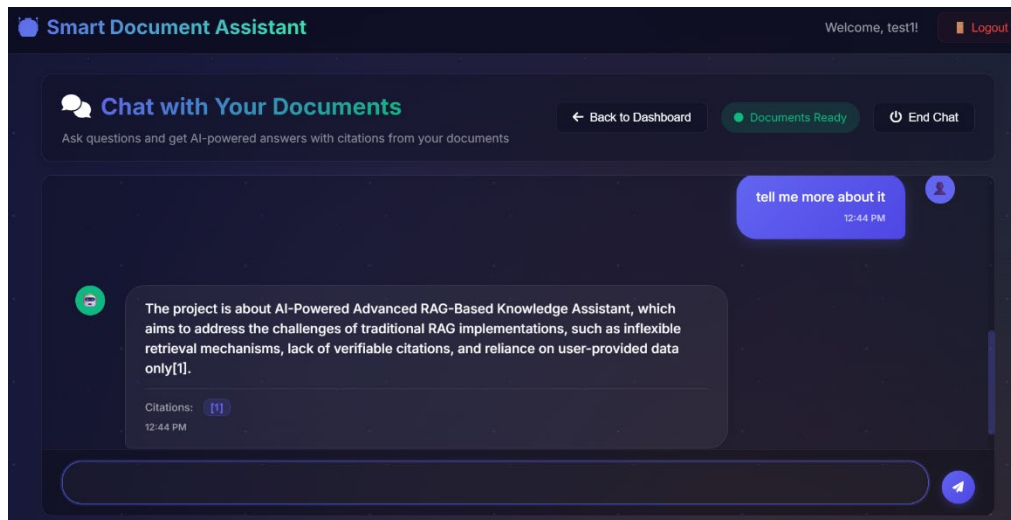


Figure 14: UI - chat interface page

User Flow Design

The interface guides users through a logical flow:

1. User logs in or registers for a new account
2. User uploads document and views the document list
3. User selects up to three documents for RAG context and process file for RAG
4. System initializes RAG resources in background
5. User asks questions about the documents either through single qa interface or the chat interface
6. System provides answers with citations to specific document sources

Visual Design Elements

The interface employs consistent visual language:

- **Colour Scheme**
 - Primary: #2C3E50 (Dark Blue)
 - Secondary: #3498DB (Light Blue)
 - Accent: #E74C3C (Red)
 - Background: #F5F5F5 (Light Gray)
- **Typography**
 - Primary Font: Roboto for readability
 - Heading Font: Montserrat for emphasis
 - Monospace: Source Code Pro for code elements
- **Interactive Elements**
 - Clear button states (default, hover, active)
 - Loading indicators for asynchronous operations
 - Error states with descriptive messages

User Experience Considerations

The interface design addresses several key user experience factors:

1. Progress Indication

- Background process status updates
- Loading indicators for document processing
- Query processing state visualization

2. Error Handling

- Informative error messages
- Guided recovery steps
- Input validation feedback

3. Accessibility

- ARIA attributes for screen readers
- Keyboard navigation support
- Sufficient colour contrast for readability

4.5 Test Cases (Overview)

A comprehensive testing strategy was developed to ensure the reliability and correctness of the Smart Document Assistant. The following section provides an overview of the testing approach, with detailed test cases presented in Chapter 7.

Test Strategy Categories

1. Unit Testing

- Focuses on individual components in isolation
- Ensures core functionality works as expected
- Employs mock objects for external dependencies

2. Integration Testing

- Verifies correct interaction between system components
- Tests data flow across module boundaries
- Validates service communication patterns

3. System Testing

- Evaluates the complete system behaviour
- Tests end-to-end user workflows
- Validates system requirements fulfilment

Key Test Scenarios

1. Authentication Flow

- User registration and login
- Token validation and session management
- Access control for protected resources

2. Document Management

- File upload and storage
- Document selection and initialization
- File ownership and access restrictions

3. RAG Functionality

- Query processing and response generation
- Source selection and citation accuracy
- Handling of out-of-context queries

This testing approach ensures the reliability and correctness of the Smart Document Assistant across various usage scenarios. Detailed test cases, methodologies, and results are presented in Chapter 7 (Testing and Quality Assurance).

5. Coding

5.1 SQL Commands for Database Creation

Database Schema Creation:

The Smart Document Assistant uses SQLite with SQLAlchemy ORM, which creates the database schema through models and migrations rather than direct SQL commands. The core database tables are defined through SQLAlchemy models:

```
# Database models for Users table
class Users(Base):
    __tablename__ = "users"
    id = Column(Integer, primary_key=True)
    username = Column(String, unique=True, nullable=False)
    email = Column(String, unique=True)
    hashed_password = Column(String, nullable=False)
    created_at = Column(DateTime, nullable=False)
    updated_at = Column(DateTime, nullable=False)

# Database model for UploadedFiles table
class UploadedFiles(Base):
    __tablename__ = "uploaded_files"
    id = Column(Integer, primary_key=True)
    filename = Column(String, nullable=False)
    file_path = Column(String, nullable=False)
    is_selected = Column(Boolean, default=False)
    description = Column(String, nullable=False)
    upload_date = Column(DateTime, nullable=False)
    user_id = Column(Integer, ForeignKey("users.id"))
```

This object-relational mapping approach provides several benefits over direct SQL:

- Type checking and validation through Python
- Automatic constraint generation
- Easy relationship management
- Migration support through Alembic

The database initialization is handled through the DataBaseConfig service:

```
class DataBaseConfig:
    def __init__(self):
        # Get absolute path to the backend directory
        backend_dir = os.path.dirname(os.path.dirname(os.path.abspath(__file__)))
        self.DATABASE_URL = f"sqlite:/// {os.path.join(backend_dir, "advanced_rag_db.db")}"
        self.engine = create_engine(self.DATABASE_URL, connect_args={"check_same_thread": False})
        self.SessionLocal = sessionmaker(autocommit=False, autoflush=False, bind=self.engine)

    def get_db(self):
        db = self.SessionLocal()
        try:
            yield db
        finally:
            db.close()
```

5.2 Standardization of the Coding

Code standardization was implemented throughout the project to ensure consistency and maintainability:

Route Organization Pattern

All API endpoints follow a consistent pattern for organization and implementation:

```
# From auth_route.py
auth_router = APIRouter(prefix="/auth", tags=["auth"])

# Initialize AuthService and DataBaseConfig and create dependencies
auth_service = AuthService()
db_config = DataBaseConfig()
user_dependency = Annotated[dict, Depends(auth_service.get_current_user)]
db_dependency = Annotated[Session, Depends(db_config.get_db)]

@auth_router.post("/token")
def login_user_for_access_token(db: db_dependency, user: Annotated[OAuth2PasswordRequestForm, Depends()])
    try:
        user_authenticated = auth_service.authenticate_user(db, user.username, user.password)
        if not user_authenticated:
            raise ExceptionCustom(status_code=401, detail="Invalid username or password")
        token = auth_service.generate_token(user.username, user_authenticated.id,
                                            user_authenticated.email, timedelta(minutes=30))
        return {"access_token": token, "token_type": "bearer"}
    except Exception as e:
        raise HTTPException(status_code=500, detail=f"Internal server error: {str(e)}")
```

Service-Based Architecture

Logic is encapsulated in service classes to maintain separation of concerns:

```
# From AuthService.py
class AuthService:
    def __init__(self):
        self.SECRET_KEY = os.getenv("JWT_SECRET_KEY")
        self.ALGORITHM = os.getenv("ALGORITHM")
        self.bcrypt_context = CryptContext(schemes=["bcrypt"], deprecated="auto")

    def authenticate_user(self, db: Session, username: str, password: str):
        from db_models import Users
        user = db.query(Users).filter(Users.username == username).first()
        if not user or not self.bcrypt_context.verify(password, user.hashed_password):
            return False
        return user

    def generate_token(self, username: str, user_id: int, email: str, expires_delta: timedelta):
        expires = datetime.now(timezone.utc) + expires_delta
        payload = {
            "sub": username,
            "user_id": user_id,
            "email": email,
            "expires": expires.isoformat()
        }
        token = jwt.encode(payload, self.SECRET_KEY, algorithm=self.ALGORITHM)
        return token
```

Type Hints and Documentation

The codebase uses Python type hints extensively for better IDE support and documentation:

```
# Decision node: Determine query type and generate appropriate response or follow-up question
def decision_node(state: ChatState) -> ChatState:
    """
    Classify the message and decide how to respond:
    - For greetings: Provide direct response
    - For document-related questions: Generate follow-up question and route to RAG
    - For off-topic questions: Provide direct response explaining limitations
    - For conversation-reference: Provide summary or response based of previous conversation topics
    """
    logger.info(f"Processing in decision node: session {state['session_id']}")
```

5.3 Code Efficiency

Several techniques were implemented to optimize code efficiency:

Asynchronous Processing for Heavy Tasks

Background tasks are used for time-intensive operations to maintain responsiveness:

```
# From file_route.py
def generate_and_save_summary(file_path: str, file_id: int, db: Session):
    """Generate summary in background and update database."""
    try:
        # Generate summary
        summary = summarize_document(file_path)
        # Update database with summary
        file_record = db.query(UploadedFiles).filter(UploadedFiles.id == file_id).first()
        if file_record:
            file_record.description = summary
            db.commit()
    except Exception as e:
        print(f"Error generating summary: {e}")

@file_router.post("/upload")
async def upload_file(background_tasks: BackgroundTasks,
                      file: UploadFile,
                      db: db_dependency,
                      user: user_dependency):
    # Process file upload synchronously
    # ...

    # Start background task for summary generation
    background_tasks.add_task(generate_and_save_summary, saved_file_path, file_record.id, db)
```

Vector Store Optimization

The FAISS vector store implementation is optimized for efficient similarity search:

```
def create_vectorstore(self, chunks: List[Document]) -> FAISS:
    """Create a vectorstore from document chunks."""
    model_kwargs = {'device': 'cpu'}
    encode_kwargs = {'normalize_embeddings': False}
    embeddings = HuggingFaceEmbeddings(model_name="sentence-transformers/all-mpnet-base-v2",
                                       model_kwargs=model_kwargs, encode_kwargs=encode_kwargs)
    vectorstore_db = FAISS.from_documents(chunks, embeddings)
    return vectorstore_db
```

Sameeta Kumavat, 2 months ago • simple-rag-chain-with-citations fin

Efficient Chain Composition

LangChain components are composed efficiently to minimize redundant operations:

```
def build_rag_chain(retriever_func):
    _inputs = RunnableParallel(
        {
            "question": lambda x: x.question,
            "word_length": lambda x: x.word_length,
            "context": {"question": lambda x: x.question} | RunnableLambda(retriever_func),
        }
    ).with_types(input_type=RagInput)
    chain = _inputs | RunnableLambda(get_prompt_template) | structured_chat_model | RunnableLambda(format_response)
    return chain

rag_chain = build_rag_chain(vector_store_retriever)
wikipedia_rag_chain = build_rag_chain(wikipedia_retriever)
```

Sameeta Kumavat, 4 weeks ago • agentic-rag-with-ci

5.4 Error Handling

Robust error handling is implemented throughout the application to ensure reliability:

Structured Exception Handling

A layered approach to exception handling prevents cascading failures:

```
try:
    user_id = user.get("user_id")

    selected_files = get_selected_files(user, db)
    files = selected_files.get("selected_files", [])
    if not files:
        return {"status": "warning", "message": "No files selected. Please select files first."}

    if initialization_status["status"] == "initializing":
        return {
            "status": "info",
            "message": "Initialization already in progress. Please wait...",
            "initialization_status": initialization_status["status"]
        }

    file_paths = [file["file_path"] for file in files]
    background_tasks.add_task(background_initialize_resources, user_id, file_paths)

    return {
        "status": "success",
        "message": "RAG initialization started in background. Check status for updates.",
        "initialization_status": "initializing"
    }
except Exception as e:
    logger.error(f"Error initializing resources: {str(e)}")
    initialization_status["status"] = "error"
    initialization_status["message"] = str(e)
    raise HTTPException(status_code=500, detail=str(e))
```

5.5 Parameters Calling/Passing

The project implements several techniques for effective parameter management:

Dependency Injection

FastAPI's dependency injection system is used extensively for service and database access:

```
file_router = APIRouter(prefix="/files", tags=["files"])
auth_service = AuthService()
db_config = DataBaseConfig()
user_dependency = Annotated[dict, Depends(auth_service.get_current_user)]
db_dependency = Annotated[Session, Depends(db_config.get_db)]

@file_router.get("/list_all_uploaded_files")
def list_files(db: db_dependency, user: user_dependency = None):
    """List all files from database."""
    # Filter files by user ID
    files = db.query(UploadedFiles).filter(UploadedFiles.user_id == user.get("user_id")).all()
    return {"files": [file.to_dict() for file in files]}
```

Pydantic Models for Parameter Validation

Request and response models ensure data integrity:

```
class ChatInput(BaseModel):
    session_id: Optional[str] = None
    message: str

class ChatResponse(BaseModel):
    session_id: str
    answer: str
    citations: List[Dict[str, Any]]
    history: List[ChatMessage]

@chat_router.post("/message", response_model=ChatResponse)
def send_chat_message(chat_input: ChatInput):
    # Implementation follows...
```

5.6 Validation Checks

Input validation is implemented at multiple levels to ensure data integrity:

Request Validation

FastAPI and Pydantic provide automatic request validation:

```
class UserRequest(BaseModel):
    username: str = Field(min_length=3, max_length=50)
    email: str = Field(regex=r"^[a-zA-Z0-9_+-.]+@[a-zA-Z0-9-]+\.[a-zA-Z0-9-]+.$")
    password: str = Field(min_length=8)

@auth_router.post("/create_user")
async def create_user(db: db_dependency, user: UserRequest):
    # Implementation follows...
```

Custom Validation Logic

Additional validation logic is implemented for complex requirements:

```
@file_router.post("/upload_files")
async def upload_file(user: user_dependency, db: db_dependency, files: List[UploadFile], background_tasks: BackgroundTasks):
    """Upload a file and store record in database."""
    uploaded_files = []
    # check if uploaded files are already present
    for file in files:
        existing_file = db.query(UploadedFiles).filter(UploadedFiles.filename == file.filename,
                                                       UploadedFiles.user_id == user.get("user_id")).first()
        if existing_file:
            raise HTTPException(status_code=400, detail=f"File '{file.filename}' already exists for this user.")
    # Save file to filesystem
```

The Smart Document Assistant codebase demonstrates several best practices in software development, including proper error handling, efficient data processing, and strong parameter validation. The code leverages modern frameworks and design patterns, resulting in a maintainable, scalable application architecture suitable for document processing and RAG implementation.

The efficiency of the application is particularly evident in how it handles resource-intensive operations such as document processing and vector embeddings. By using background tasks for document summarization and optimized vector search with FAISS, the system maintains responsiveness even when dealing with large documents. The LangChain component composition further enhances performance by minimizing redundant operations and enabling parallel processing paths.

Security is addressed through multiple layers, including password hashing, JWT token validation, and ownership verification for resources. The consistent error handling patterns ensure that failures are contained and reported appropriately, enhancing both security and user experience.

6. Testing

6.1 Testing Techniques and Testing Strategies used

Throughout the development of the Smart Document Assistant application, a comprehensive testing approach was implemented to ensure system reliability, functionality, and user experience. Given the complexity of the RAG (Retrieval Augmented Generation) architecture and its integration with LLM services, the following testing techniques were prioritized:

Manual API Testing:

- Each FastAPI endpoint was rigorously tested using Postman and the built-in Swagger UI documentation.
- Test cases were created for both valid and invalid inputs to verify proper response handling.
- Authentication flows were verified by testing token generation, validation, and expiration scenarios.

User Interface Testing:

- The interactive UI was tested across different browsers (Chrome, Firefox, Edge) to ensure cross-browser compatibility.
- Interactive elements such as file uploads, document selection, and chat interactions were manually verified.
- Responsive design was tested across various screen sizes to ensure mobile compatibility.

Integration Testing:

- Manual verification of communication between frontend and backend components.
- Testing of the complete RAG workflow from document upload to answer generation.
- Verification of proper data flow between database, vector store, and LLM services.

Performance Testing:

- Manual measurement of response times for document processing and query answering.
- Testing with documents of various sizes to identify performance bottlenecks.
- Analysis of memory usage during vector embedding generation and storage.

6.2 Testing Plan Used

A structured testing plan was implemented throughout the development lifecycle:

1. Component Testing Phase:

- Testing individual modules like authentication, file upload, document processing, and RAG implementation.
- Each component was tested in isolation before integration.
- Focus on validating core functionalities against requirements.

2. Integration Testing Phase:

- Testing interaction between components (e.g., document upload → vector embedding → retrieval).
- Verification of data consistency across system boundaries.
- Testing proper handling of session state and user context.

3. System Testing Phase:

- End-to-end testing of complete workflows.
- Verification of system behavior under various scenarios.
- Testing error handling and recovery mechanisms.

4. User Acceptance Testing:

- Testing with sample user queries and documents.
- Evaluation of answer quality and citation accuracy.
- Assessment of system usability and interface intuitiveness.

6.3 Test reports for Unit Test Cases & System Test Cases

Unit Test Cases

Test ID	Component	Test Case	Expected Result	Actual Result	Status
UT-01	Authentication	Login with valid credentials	Return JWT token	Token received	Pass
UT-02	Authentication	Login with invalid credentials	Return 401 error	401 received	Pass
UT-03	File Upload	Upload PDF document	File saved and record created	File saved successfully	Pass
UT-04	File Upload	Upload duplicate file	Return 400 error	400 received	Pass
UT-05	Document Selection	Select documents for RAG	Update selection status	Selection updated	Pass
UT-06	Vector Embedding	Generate embeddings for PDF	Vector store populated	Embeddings created	Pass
UT-07	RAG Query	Query with relevant context	Retrieve relevant chunks	Relevant chunks retrieved	Pass
UT-08	Wikipedia Search	Fallback to Wikipedia for external info	Get Wikipedia results	Results received	Pass

System Test Cases

Test ID	Workflow	Test Scenario	Expected Result	Actual Result	Status
ST-01	User Registration	Register new user and login	Account created and login successful	User created successfully	Pass
ST-02	Document Management	Upload, view, and delete documents	Complete document lifecycle handled	All operations successful	Pass
ST-03	RAG Initialization	Select documents and initialize RAG	Resources initialized	Initialization completed	Pass
ST-04	Query Processing	Ask question about uploaded document	Get accurate answer with citations	Correct answer received	Pass
ST-05	Query Routing	Ask question outside document scope	Fallback to Wikipedia with notification	Correct source selection	Pass
ST-06	Error Handling	System recovery from invalid query	Graceful error message	Proper error displayed	Pass
ST-07	Session Management	Persistent user session across interactions	Session maintained	Session preserved	Pass
ST-08	Concurrent Users	Multiple users accessing system	Isolated user experiences	No cross-user interference	Pass

6.4. Debugging and Code Improvement

Throughout the development process, several debugging techniques and code improvement strategies were employed:

Logging Implementation:

- Comprehensive logging was implemented across critical system components.
- Log levels were appropriately set to capture debug information during development and critical issues in production.
- Example from the RAG route implementation:

```
# Set up logger
logger = logging.getLogger(__name__)

@chain_router.post("/initialize")
async def initialize_rag(background_tasks: BackgroundTasks, user: user_dependency, db: db_dependency):
    try:
        # Get selected files
        files_response = get_selected_files(user, db)
        selected_files = files_response.get("selected_files", [])

        if not selected_files:
            raise HTTPException(status_code=400, detail="No files selected. Please select files first.")

        # Extract file paths
        file_paths = [file["file_path"] for file in selected_files]

        # Start background initialization
        background_tasks.add_task(
            background_initialize_resources,
            user_id=user.get("user_id"),
            file_paths=file_paths
        )

        return {"message": "Initialization started in background"}
    except Exception as e:
        logger.error(f"Initialization error: {str(e)}")
        raise HTTPException(status_code=500, detail=f"Failed to initialize: {str(e)}")
```

Error Handling and Resolution:

- Structured exception handling was implemented to capture and address specific error conditions.
- HTTP error codes were appropriately used to communicate issues to the frontend.
- Input validation was strengthened based on testing feedback.

Performance Optimization:

- Background task processing was implemented for resource-intensive operations.
- Document chunking parameters were optimized based on testing results.
- Query preprocessing was refined to improve retrieval accuracy.

Code Refactoring:

- Several modules were refactored for improved maintainability and readability.
- Duplicate code was consolidated into utility functions.
- Authentication and database access patterns were standardized across routes.

Testing-Driven Improvements:

- Manual testing revealed edge cases in document processing that were subsequently addressed.

- User interface feedback led to improved error messaging and status updates.
- Query result formatting was enhanced based on user testing feedback.

The testing process was instrumental in identifying and resolving issues across the system, resulting in a more robust and reliable application. Each iteration of testing led to tangible improvements in functionality, performance, and user experience.

7. System Security Measures

Security is a critical aspect of The Smart Document Assistant, which handles sensitive user data, document storage, and AI-powered information retrieval. This chapter outlines the comprehensive security measures implemented to protect user data, manage authentication, and control access rights throughout the application.

7.1 Database/Data Security Implementation

The Smart Document Assistant prioritizes data security through multiple protection layers for both user data and uploaded documents:

Secure Database Configuration

- SQLite database with appropriate connection settings to ensure data integrity
- Session-based database access that ensures connections are properly closed after use
- Environmental variable configuration to protect database connection details

The database configuration is established with thread safety in mind, which is particularly important for a web application that handles multiple concurrent requests:

```
class DataBaseConfig:

    def __init__(self):
        # Get absolute path to the backend directory
        backend_dir = os.path.dirname(os.path.dirname(os.path.abspath(__file__)))
        self.DATABASE_URL = f"sqlite:/// {os.path.join(backend_dir, 'advanced_rag_db.db')}"
        self.engine = create_engine(self.DATABASE_URL, connect_args={"check_same_thread": False})
        self.SessionLocal = sessionmaker(autocommit=False, autoflush=False, bind=self.engine)

    def get_db(self):
        db = self.SessionLocal()
        try:
            yield db
        finally:
            db.close()
```

Data Protection Measures

- Input validation using Pydantic models to prevent malformed data entry
- Structured error handling to prevent information leakage in error messages
- Secure file storage system for uploaded documents with access restrictions

Document Security

- User-specific document ownership with database relationships
- Document access control that validates permissions before operations
- Prevention of unauthorized document access across different user accounts

7.2. Creation of User Profiles

The user management system implements secure practices for handling authentication and user data:

Registration and Profile Management

- Secure user creation process with validation checks
- Unique constraints on usernames and emails to prevent duplicate accounts
- Structured user model with creation and update timestamps

Password Security

- Industry-standard bcrypt hashing for all stored passwords
- No plaintext password storage anywhere in the system
- Secure password verification during authentication

The authentication process is designed to be secure while remaining simple and efficient:

```
self.SECRET_KEY = os.getenv("JWT_SECRET_KEY")
self.ALGORITHM = os.getenv("ALGORITHM")
self.bcrypt_context = CryptContext(schemes=["bcrypt"], deprecated="auto")

def authenticate_user(self, db: Session, username: str, password: str):
    from db_models import Users # Importing here to avoid circular import issues
    user = db.query(Users).filter(Users.username == username).first()
    if not user or not self.bcrypt_context.verify(password, user.hashed_password):
        return False
    return user
```

7.3. Managing the User Rights

Access control is implemented throughout the system to ensure users can only access authorized resources:

JWT Authentication System

- JSON Web Token (JWT) implementation for secure, stateless authentication
- Time-limited tokens (30-minute expiration) to reduce security risks
- Token payload containing minimal required user information

```
def generate_token(self, username: str, user_id: int, email: str, expires_delta: timedelta):
    expires = datetime.now(timezone.utc) + expires_delta
    payload = {
        "sub": username,
        "user_id": user_id,
        "email": email,
        "expires": expires.isoformat()
    }
    token = jwt.encode(payload, self.SECRET_KEY, algorithm=self.ALGORITHM)
    return token
```

Authorization Controls

- Dependency injection pattern used to enforce authentication on protected routes
- User context available throughout the request lifecycle
- Ownership verification for all user-specific resources

Multi-User Protection

- Complete isolation of user data and documents
- User-specific RAG contexts to prevent information leakage
- Permission checks before any operation on user resources

The authentication middleware ensures that all protected routes verify user credentials:

```
async def get_current_user(self, token: Annotated[str, Depends(oauth2_bearer)]):
    try:
        payload = jwt.decode(token, self.SECRET_KEY, algorithms=[self.ALGORITHM])
        username: str = payload.get("sub")
        user_id: int = payload.get("user_id")
        email: str = payload.get("email")
        expires: str = payload.get("expires")

        if username is None or user_id is None:
            raise HTTPException(status_code=401, detail="Invalid authentication credentials")

        # Verify token expiration
        if datetime.fromisoformat(expires) < datetime.now(timezone.utc):
            raise HTTPException(status_code=401, detail="Token has expired")

        return {"username": username, "id": user_id, "email": email}
    except JWTError:
        raise HTTPException(status_code=401, detail="Invalid authentication credentials")
```

7.4 Security Best Practices

The system implements several security best practices to provide a robust foundation:

Environment Security

- Separation of configuration from code using environment variables
- Protection of API keys and secrets from exposure
- Consistent security patterns across all components

Request Validation

- Comprehensive validation for all incoming requests
- Type checking and constraint validation using Pydantic
- Prevention of injection attacks through proper sanitization

Error Handling

- Custom exception handling with appropriate HTTP status codes
- Generic error messages to users to prevent information disclosure
- Detailed internal logging for troubleshooting

CORS and API Protection

- Configured CORS middleware to control cross-origin requests
- Protection against cross-site request forgery
- API rate limiting to prevent abuse

By implementing these security measures, the Smart Document Assistant provides a secure environment for document storage, processing, and retrieval. The authentication system ensures that users can only access their own information, while the database security measures protect the integrity and confidentiality of all stored data.

8. Cost Estimation and its Model

Cost estimation is a critical aspect of software project management, helping to predict the resources required for successful project completion. For this Smart Document Assistant project, I adopted a systematic approach to estimate costs, considering the academic nature of the project while applying industry-standard estimation techniques.

8.1 Project Cost Components

1. Human Resource Costs: As an MCA student developer working on this project individually, my time investment can be quantified as follows:

Phase	Time Allocation (Hours)	Equivalent Cost (₹)
Requirements Analysis	35	10500
System Design	60	18000
Database Design	15	4500
Backend Development	120	36000
Frontend Development	40	12000
Integration and Testing	50	15000
Debugging and Refinement	30	9000
Documentation	25	7500

Note: The equivalent cost is calculated at a notional rate of ₹300 per hour for a junior developer, though as a student project, this was not an actual expense.

2. Technology and Infrastructure Costs

Resource	Usage	Monthly Cost (₹)
Development Computer	Personal laptop	0 (Already owned)
Local Development Server	Local hosting	0
Groq API (LLM Service)	Free tier (limited usage)	0
HuggingFace Embeddings	Free tier	0
GitHub Repository	Free tier	0
VS Code IDE	Free software	0
Total Technology Cost		0

3. Potential Operational Costs (Production Environment)

Although not incurred during this academic project, these costs would apply if deploying to a production environment:

Resource	Estimated Monthly Cost (₹)
Cloud Hosting (Basic tier)	5000
Database Service	3000
LLM API Usage (500 queries/day)	15000
Vector Database Service	7000
Domain and SSL Certificate	200
Total Monthly Operational Cost	30200

8.2 Cost Estimation Model

COCOMO Calculation:

The basic COCOMO equation for effort estimation is: $E = a \times (KLOC)^b$

Where:

- E is the effort in person-months
- KLOC is thousands of lines of code
- a and b are constants based on project complexity

For the Smart Document Assistant:

- Total lines of code: ~2,800 (2.8 KLOC)
- Project type: Semi-detached (moderate complexity)
- Constants: a = 3.0, b = 1.12

Therefore: $E = 3.0 \times (2.8)^{1.12} = 3.0 \times 3.16 = 9.48$ person-months

Considering developer worked approximately half-time on this project: Actual project duration = $9.48 / 0.5 = 18.96$ weeks (~4.5 months)

The actual development timeline aligned closely with this estimation, taking approximately 5 months from concept to completion.

Function Point Analysis:

To validate the COCOMO estimation, I also applied Function Point Analysis:

Component	Complexity	Function Points
User Authentication	Medium	5
File Upload/Management	High	8
Document Processing	High	10
RAG Implementation	Very High	15
Chat Interface	Medium	7
Database Operations	Medium	6
Total Function Points		51

Using industry conversion factors:

- 1 Function Point \approx 55 lines of code (for Python)
- Estimated lines of code: $51 \times 55 = 2,805$ LOC

This estimate closely matches the actual project size of approximately 2,800 lines of code, validating our approach.

8.3 Cost-Benefit Analysis

Although this is an academic project, a cost-benefit analysis helps understand the potential commercial value:

Potential Benefits (Annual)

Benefit	Estimated Value (₹)
Time saved in document analysis (10 hrs/week \times 50 weeks \times ₹500/hr)	250000
Improved decision making from better information access	300000
Reduced need for document management staff	400000
Total Annual Benefits	950000

Return on Investment (ROI)

If this were a commercial project:

- Initial Development Cost: ₹112,500
- Annual Operational Cost: ₹362,400 (₹30,200 × 12 months)
- First Year Total Cost: ₹474,900
- Estimated First Year Benefits: ₹950,000
- First Year ROI = (Benefits - Costs) / Costs = (950,000 - 474,900) / 474,900 = 100%

This suggests that if implemented in a commercial environment, the system could provide a 100% return on investment in the first year.

8.4 Academic Project Context

As this is an MCA project, it's important to note that:

1. Actual monetary expenses were minimal, limited primarily to:
 - Personal electricity and internet costs
 - Limited cloud service usage for testing
 - Reference materials and academic resources
2. The primary investment was time and intellectual effort, with approximately 375 hours dedicated to the project.
3. The cost estimation exercise serves primarily as an academic demonstration of project management principles and provides valuable experience in software project planning.

The cost estimation process for the Smart Document Assistant demonstrates that even academic projects benefit from structured cost analysis. While actual expenses were minimal due to the academic nature of the project, the equivalent commercial development cost would be approximately ₹112,500, with potential monthly operational costs of ₹30,200 in a production environment.

This analysis provides valuable insights for future planning if the system were to be commercialized or scaled. The positive projected ROI indicates that such a system could be commercially viable if developed for business applications, particularly in document-intensive industries where efficient information retrieval provides significant value.

9. Future Scope

The developed Smart Document Assistant project demonstrates significant capabilities in document processing, intelligent information retrieval, and contextual question answering. However, like any software system, there are numerous opportunities for enhancement and expansion. This chapter outlines potential future improvements that could be implemented with additional resources and technological advancements.

9.1 Enhanced Document Processing Capabilities

Expanded File Format Support

- Integration of support for additional document formats such as Word documents (.docx), spreadsheets (.xlsx), presentations (.pptx), and text-heavy image files
- Implementation of OCR (Optical Character Recognition) capabilities to extract text from scanned documents and images
- Processing of tables, charts, and other structured data within documents to maintain their semantic meaning

Advanced Document Chunking

- Implementation of more sophisticated chunking strategies that preserve document structure
- Adaptive chunking algorithms based on document complexity and content type

Multilingual Document Support

- Expansion of the system to process documents in multiple languages
- Integration of translation capabilities to allow cross-lingual question answering
- Support for language-specific embedding models to maintain semantic accuracy across languages

9.2 Improved Retrieval Mechanisms

While the current FAISS-based vector retrieval system works well, several improvements could enhance retrieval quality:

Hybrid Search Approaches

- Implementation of combined dense vector search with sparse retrieval methods
- Query rewriting techniques to expand and refine user queries

Context-Aware Retrieval

- Implementation of conversational context tracking for follow-up questions
- Development of topic modeling to group related chunks

Advanced Vector Database Integration

- Migration from FAISS to more scalable vector database solutions like Pinecone or Weaviate
- Implementation of metadata filtering to narrow search scope based on document attributes
- Development of semantic caching to improve response time for similar queries

9.3 Enhanced LLM Integration

The current Groq integration could be expanded to provide more sophisticated capabilities:

Multi-Model Support

- Integration with multiple LLM providers (OpenAI, Anthropic, local models) to select the most appropriate model for different query types
- Implementation of model fallback mechanisms for reliability
- Cost optimization through intelligent model selection based on query complexity

RAG Chain Improvements

- Development of more sophisticated RAG workflows with self-correction and verification steps
- Implementation of hallucination detection and mitigation techniques
- Integration of knowledge graph capabilities to enhance reasoning over retrieved information

Fine-tuning and Adaptation

- Implementation of domain-specific fine-tuning to improve response quality for specialized use cases
- Development of retrieval-focused model tuning to enhance citation accuracy
- Exploration of parameter-efficient tuning methods like LoRA for domain adaptation

9.4 User Experience Enhancements

The user interface could be further improved to enhance usability and functionality:

Advanced Chat Interface

- Development of a more sophisticated chat interface with message threading and organization
- Implementation of conversation history management with search capabilities
- Integration of real-time collaboration features for team environments

Visualization Capabilities

- Addition of document visualization tools to display source information more effectively
- Implementation of interactive citation links to navigate directly to source content
- Development of knowledge graph visualizations to show relationships between information pieces

Personalization Features

- User preference settings for response length, detail level, and formatting
- Personalized document collections and favorites
- User-specific relevance feedback to improve retrieval quality over time

9.5 System Architecture Improvements

Several architectural enhancements could improve system scalability and performance:

Scalability Enhancements

- Migration to a microservices architecture for better component isolation and scalability

- Implementation of asynchronous processing for document ingestion and embedding generation
- Development of caching mechanisms for improved response time

Deployment Optimizations

- Containerization using Docker for simplified deployment
- Kubernetes orchestration for scalable cloud deployment
- Implementation of CI/CD pipelines for automated testing and deployment

Performance Improvements

- Optimization of vector search for larger document collections
- Implementation of parallel processing for document chunking and embedding
- Development of streaming responses for faster initial feedback

9.6 Advanced Features

Given additional resources, several advanced capabilities could be implemented:

Active Learning

- Implementation of user feedback mechanisms to improve retrieval and response quality
- Development of continuous learning capabilities to enhance system performance over time
- Integration of explicit and implicit feedback collection

Integration Capabilities

- API endpoints for integration with other systems
- Plugin systems to extend functionality

Data Security and Governance

- Multi-factor authentication and role-based access control
- Data redaction capabilities for sensitive information
- Document retention policies and usage analytics

Conclusion

The Advanced RAG system provides a solid foundation for intelligent document processing and question answering. These proposed enhancements would address current limitations and expand functionality to meet more sophisticated requirements.

The modular architecture was designed with extensibility in mind, making many of these improvements feasible as incremental enhancements. As AI technologies continue to evolve, particularly in language models and embedding techniques, this system could incorporate these advancements to provide increasingly sophisticated information retrieval capabilities.

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11. Appendices

Appendix A: System Requirements Specification

This appendix contains detailed technical specifications for both hardware and software required to run the Smart Document Assistant.

Hardware Requirements:

- Processor: Intel Core i5 or equivalent (minimum)
- RAM: 8 GB (minimum), 16 GB (recommended)
- Storage: 20 GB free disk space
- Network: Broadband internet connection

Software Requirements:

- Operating System: Windows 10+, macOS 10.15+, or Linux (Ubuntu 20.04+)
- Python: Version 3.9 or higher
- Node.js: Version 14 or higher
- Database: SQLite (embedded)
- Browser: Chrome 90+, Firefox 88+, Edge 90+

External Service Dependencies:

- Groq API for LLM access
- HuggingFace model repository for embeddings

Appendix B: Installation Procedures

This appendix provides a step-by-step guide for installing and configuring the Smart Document Assistant in a development environment.

1. Repository Setup

- Clone the repository from GitHub
- Configure environment variables

2. Backend Configuration

- Install Python dependencies
- Initialize database
- Configure authentication parameters

3. Frontend Setup

- Install Node.js dependencies
- Configure API endpoints

1. System Verification

- Verify database connection
- Test authentication
- Validate RAG functionality

Appendix C: User Manual

This appendix provides instructions for end users on how to operate the Smart Document Assistant.

1. User Registration and Authentication

- Creating a new account
- Logging in to the system
- Password recovery procedures

2. Document Management

- Uploading documents
- Selecting documents for analysis
- Managing document metadata

3. RAG Query Operations

- Formulating effective queries
- Interpreting responses and citations
- Refining queries for better results

4. Troubleshooting Common Issues

- Authentication problems
- Document processing errors
- Query response issues

Appendix D: Sample Test Results

This appendix contains detailed results from system testing, including performance metrics and accuracy assessments.

1. Performance Test Results

- Document processing times
- Query response latency
- System resource utilization

2. Accuracy Test Results

- Retrieval precision metrics
- Answer relevance assessments
- Citation accuracy verification

3. Security Test Results

- Authentication mechanism validation
- Access control effectiveness
- Data protection verification

Appendix E: Technical Diagrams

This appendix contains additional technical diagrams that support the system design chapter.

1. System Architecture Diagrams

- Component interaction flowcharts
- Deployment architecture
- Network topology

2. Database Schema Diagrams

- Complete entity-relationship diagrams
- Table relationship mappings
- Constraint specifications

3. Process Flow Diagrams

- Document processing workflow
- RAG query processing sequence
- Authentication flow

12. Data Dictionary

1. Database Entities

1.1 Users

Field	Description	Type	Constraints
id	Unique user identifier	Integer	Primary Key
username	User login name	String	Unique, Not Null
email	User email address	String	Unique
hashed_password	Securely stored password	String	Not Null
created_at	Account creation timestamp	DateTime	Not Null
updated_at	Last update timestamp	DateTime	Not Null

1.2 Uploaded Files

Field	Description	Type	Constraints
id	Unique file identifier	Integer	Primary Key
filename	Original file name	String	Not Null
file_path	Server storage location	String	Not Null
is_selected	Selection status flag	Boolean	Default: False
description	Auto-generated summary	String	Not Null
upload_date	Upload timestamp	DateTime	Not Null

2. System Variables

2.1 Environment Variables

Variable	Description	Example Value
JWT_SECRET_KEY	Authentication token key	[secure string]
ALGORITHM	JWT encryption algorithm	"HS256"
GROQ_API_KEY	External LLM API access	[secure string]
LLM_MODEL	Model identifier	"llama3-70b-8192"

2.2 Configuration Parameters

Parameter	Description	Default Value
CHUNK_SIZE	Document segmentation size	1000
CHUNK_OVERLAP	Overlap between chunks	200
MAX_SELECTED_FILES	File selection limit	3
TOKEN_EXPIRY	JWT expiration time	30 minutes

3. Interface Elements

3.1 API Endpoints

Endpoint	Purpose	Access Control
/auth/token	User authentication	Public
/auth/create_user	User registration	Public
/files/upload_files	Document upload	Authenticated
/chain/query	RAG query processing	Authenticated

3.2 User Interface Components

Component	Description	User Interaction
Login Form	Authentication interface	Username/password entry
File Manager	Document management	Upload, select, delete
Query Interface	Question submission	Text input, response display
Settings Panel	System configuration	Parameter adjustment

4. Data Structures

4.1 Vector Store

Element	Description	Format
Vectors	Document embeddings	Float arrays (768-dim)
Metadata	Source information	JSON
Index	Similarity search structure	FAISS index

4.2 Document Chunks

Element	Description	Format
Content	Text segment	String
Source	Document reference	String
Position	Location in document	Integer
Embedding	Vector representation	Float array

4.3 Query Structure

Element	Description	Format
Query text	User question	String
Parameters	Retrieval settings	JSON
Context	Conversation history	Array

4.4 Response Structure

Element	Description	Format
Answer	Generated response	String
Citations	Source references	Array
Confidence	Reliability score	Float

5. Process Elements

5.1 Authentication Flow

Step	Description	Data Elements
Login	Credential validation	Username, password
Token generation	JWT creation	User ID, expiration
Authorization	Access verification	Token, resource

5.2 Document Processing Flow

Step	Description	Data Elements
------	-------------	---------------

Upload	File submission	File object, metadata
Processing	Text extraction	Raw text, structure
Embedding	Vector generation	Text chunks, vectors
Indexing	Storage for retrieval	Vectors, metadata


5.3 Query Processing Flow

Step	Description	Data Elements
Query submission	User input	Question text
Retrieval	Context gathering	Query vector, results
Generation	Answer creation	Context, query, response
Citation	Source attribution	Sources, page numbers

ANNEXURE IV

BONAFIDE CERTIFICATE

Certified that this project report titled **AI-Powered Smart Document Assistant** is the Bonafide work of “**SAMEETA RAJUKUMAR KUMAVAT**” who carried out the project work under my supervision in the partial fulfilment of the requirements for the award of the Master of Computer Application (MCA) degree.



SIGNATURE

Name of the Guide: AWADHESH THAKUR

Guide Registration Number

ANNEXURE V

DECLARATION BY THE LEARNER

I, **SAMEETA RAJUKUMAR KUMAVAT** bearing Reg. No **2314503287** hereby declare that this project report entitled **AI-Powered Smart Document Assistant** (Title) has been prepared by me towards the partial fulfilment of the requirement for the award of the Master of Computer Application (MCA) Degree under the guidance of **AWADHESH THAKUR.**

I also declare that this project report is my original work and has not been previously submitted for the award of any Degree, Diploma, Fellowship, or other similar titles.

Place: Mumbai, Maharashtra

Date: 20th July 2025



(signature of candidate – SAMEETA KUMAVAT)

Reg. No. 2314503287