Dedication

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Chapter 1

Overview of the Project

1.1 Introduction

The rapid evolution of software development has increased demand for efficient design tools. UML diagrams serve as essential visual representations bridging conceptual design and implementation, facilitating stakeholder communication and providing standardized documentation approaches [1].

Traditional diagramming approaches present productivity barriers through manual effort and technical complexity. AI and natural language processing technologies have opened possibilities for automating diagram generation, transforming how developers create visual system representations [2].

This project addresses the need for an intelligent platform combining textual diagram precision with natural language accessibility, democratizing UML creation while maintaining professional standards.

1.2 Overview of the Host Organization

1.3 Presentation of the Project Context

1.3.1 Problem Statement

UML diagram creation faces challenges across GUI-based tools and textual specification languages.

GUI-Based Tool Challenges:

Traditional graphical tools present steep learning curves, time-consuming manual positioning, collaboration difficulties, and poor version control integration [3]. These limitations impact productivity and create inconsistencies across projects.

Textual Tool Challenges:

Tools like PlantUML and Mermaid require specific syntax knowledge, creating barriers for non-technical users [4]. Complex error debugging and lack of real-time feedback slow the design process.

Workflow Integration Issues:

Both approaches suffer from poor development workflow integration, limited automation capabilities, and inadequate collaboration features [5].

1.3.2 Existing Solutions

Several platforms address textual diagram generation challenges through different approaches.

AI-Powered Platforms:

Diagramming AI tools utilize artificial intelligence to interpret natural language and generate diagrams [6]. These provide conversational interfaces and multi-format support but often lack precision for professional development.

Conversational Tools:

ChatUML and similar tools focus on natural language processing through chat interfaces [7]. They excel at simple diagrams and provide immediate feedback but struggle with complex enterprise requirements.

Current Limitations:

Existing solutions lack comprehensive AI integration, limited community features, and inconsistent output quality that falls short of professional standards [8].

1.3.3 Proposed Solution

Our platform addresses identified challenges through intelligent diagram generation that integrates AI with textual specification technologies.

Core Innovation:

The platform uses natural language processing to interpret user requirements and automatically generate UML diagrams [9]. By combining PlantUML precision with conversational interfaces, we eliminate traditional barriers.

Key Features:

Intelligent requirement interpretation processes natural language descriptions to identify entities and relationships, generating appropriate PlantUML code. Dynamic generation allows conversational refinement with real-time validation ensuring UML standard compliance [10].

Collaboration features enable team-based development with version control, while a community marketplace facilitates template sharing and knowledge exchange.

Technical Architecture:

The microservices architecture separates NLP, diagram generation, and UI components, ensuring scalability and API integration [11].

Competitive Advantages:

Superior AI integration maintains consistency across complex diagrams, community focus creates sustainable knowledge sharing, and professional-grade output meets enterprise standards while remaining accessible to all users.

1.3.3.1 Use of PlantUML

PlantUML selection as core diagram generation engine resulted from comprehensive analysis of textual diagramming tools.

Comparative Analysis:

Table 1.1: Comparison of Textual Diagramming Tools

Criteria	**PlantUML**	**Mermaid**	**Graphviz**
UML Support	Comprehensive	Limited	Minimal
Syntax Complexity	Moderate	Simple	Complex
Output Quality	High	Medium	High
Community Size	Large	Growing	Established
Integration APIs	Excellent	Good	Limited
Enterprise Ready	Yes	Partially	Yes

Selection Rationale:

PlantUML provides comprehensive UML support covering all standard diagram types [12]. Its mature ecosystem includes extensive documentation and proven enterprise stability. The syntax balances expressiveness with readability, suitable for AI-driven generation.

Technical advantages include robust API integration and multiple output formats (PNG, SVG, PDF) [13]. Industry adoption ensures workflow compatibility and reduces learning curves.

The open-source nature allows customization while proven scalability supports enterprise deployment and community innovation [14].

1.4 Methodology

1.4.1 Agile Approach

Agile methodology represents a fundamental shift from traditional waterfall development approaches, emphasizing iterative development, continuous collaboration, and adaptive planning [15]. This approach prioritizes individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan.

Agile methodologies are particularly suited for projects with evolving requirements, where frequent stakeholder feedback and rapid adaptation to changing needs are essential. The iterative nature allows for continuous improvement and risk mitigation throughout the development lifecycle [16].

1.4.2 Comparison of Agile Methods

Table 1.2: Comparison of Agile Methodologies

Criteria	**Scrum**	**Kanban**	**XP**	**Lean**
Structure	High	Low	Medium	Medium
Roles Definition	Clear	Flexible	Defined	Minimal
Sprint Planning	Fixed	Continuous	Fixed	Continuous
Documentation	Minimal	Minimal	Low	Minimal
Team Size	5-9 members	Flexible	Small	Flexible
Learning Curve	Moderate	Low	High	Low
Feedback Frequency	Regular	Continuous	High	Continuous
Change Adaptation	High	Very High	High	Very High

Based on the comparative analysis, Scrum emerges as the optimal choice for our diagram generation platform project. Scrum provides the necessary structure and clear role definitions essential for coordinating AI development and user interface design components. The fixed sprint planning aligns well with iterative development of complex features, while regular feedback cycles ensure continuous validation of AI-generated diagram quality and user experience [17].

1.4.3 Scrum Framework

1.4.3.1 Key Principles of Scrum

Scrum operates on fundamental principles that promote transparency, inspection, and adaptation [18]. Transparency ensures all team members have visibility into project progress and challenges. Inspection involves regular examination of artifacts and progress toward sprint goals. Adaptation enables teams to adjust their approach based on inspection outcomes.

The framework emphasizes empirical process control, where decisions are based on observation and experimentation rather than detailed upfront planning. This approach is particularly valuable for AI-driven projects where outcomes can be difficult to predict [19].

1.4.3.2 Roles

Scrum defines three primary roles that are pivotal for the effective execution of projects and maintaining seamless communication with stakeholders [20]:

- **Product Owner**: The Product Owner is the voice of the stakeholders and is responsible for managing the product backlog. They prioritize features and tasks to ensure the team focuses on delivering maximum business value and addressing user needs effectively.
- **Scrum Master**: Acting as a facilitator, the Scrum Master ensures that the Scrum framework is followed. They remove obstacles, enable team productivity, and help the team adhere to Scrum principles for continuous improvement.
- **Development Team**: This is a group of cross-functional professionals responsible for delivering potentially shippable increments of the product. The team collaborates closely and takes ownership of the work, ensuring high-quality deliverables.

These roles collectively foster accountability, streamlined communication, and adaptability, which are essential for navigating complex technical projects, such as those involving artificial intelligence and user experience design.

1.4.3.3 Events

Scrum events provide structured opportunities for inspection, adaptation, and planning [21]. Sprint Planning establishes sprint goals and selects backlog items for development. Daily Standups facilitate communication and identify impediments. Sprint Reviews demonstrate completed work to stakeholders and gather feedback. Sprint Retrospectives enable team reflection and process improvement.

These time-boxed events ensure regular progress assessment and continuous alignment with project objectives while maintaining development momentum.

1.4.3.4 Artifacts

Scrum artifacts provide transparency and opportunities for inspection and adaptation [22]. The Product Backlog contains prioritized requirements and features. The Sprint

Backlog includes selected items for the current sprint and tasks needed for completion. The Product Increment represents potentially shippable functionality delivered each sprint.

These artifacts ensure stakeholder visibility into project progress and facilitate informed decision-making throughout the development process.

1.5 Modeling Language

1.5.1 Definition

Modeling languages provide standardized notations for representing system structures, behaviors, and requirements [23]. Unlike programming languages that instruct computers, modeling languages communicate design concepts among stakeholders and document system architecture.

Figure 1.1: UML Official Logo

UML distinguishes itself from other modeling languages through comprehensive standardization, widespread industry adoption, and extensive tool support. While domain-specific languages like BPMN focus on business processes and SysML targets systems engineering, UML provides broad coverage suitable for software-intensive systems [24].

1.5.2 UML Overview

UML (Unified Modeling Language) serves as the industry standard for software system modeling, offering a comprehensive set of diagram types that address various aspects of system design and analysis [25]. UML's value proposition lies in its ability to bridge communication gaps between technical and non-technical stakeholders while providing sufficient precision for implementation guidance.

UML 2.5 encompasses fourteen diagram types organized into two primary categories [26]. Structure diagrams capture static aspects of systems, including Class Diagrams for object-oriented design, Component Diagrams for system architecture, and Deployment Diagrams for physical system configuration. Behavior diagrams represent dynamic aspects, featuring Use Case Diagrams for functional requirements, Sequence Diagrams for interaction modeling, and Activity Diagrams for process flows.

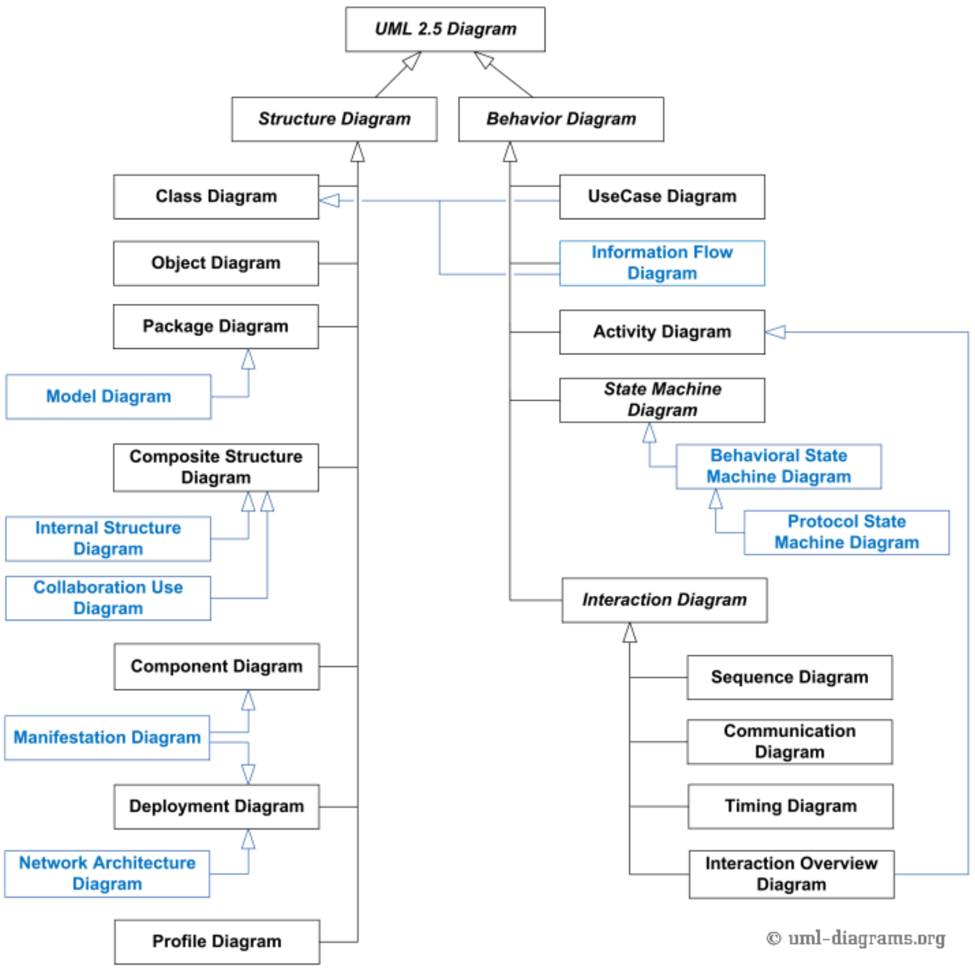

Figure 1.2: UML 2.5 Diagram Types Classification

This comprehensive coverage makes UML particularly suitable for AI-driven diagram generation, as the standardized notation enables consistent interpretation and generation algorithms while supporting diverse modeling needs across software development lifecycles.

1.6 Conclusion

This chapter established the foundation for developing an intelligent UML diagram generation platform by addressing critical challenges in current diagramming approaches. The analysis revealed significant limitations in both traditional GUI-based tools and textual specification methods, highlighting the need for innovative solutions that combine precision with accessibility.

Our proposed platform leverages artificial intelligence and natural language processing to bridge these gaps, offering intelligent requirement interpretation and automated diagram generation through PlantUML integration. The selection of Scrum methodology ensures structured yet flexible development approach suitable for complex AI-driven projects, while UML's comprehensive standardization provides the necessary foundation for diverse modeling requirements.

The combination of proven technologies (PlantUML), established methodologies (Scrum), and innovative AI integration positions this project to deliver significant value to software development communities. The platform's focus on collaboration and community building creates sustainable ecosystem for knowledge sharing and continuous improvement in diagram-driven development practices.

Chapter 2

Project Initiation

2.1 Introduction

This project aims to develop a comprehensive PlantUML-based diagramming platform that combines individual productivity tools with community collaboration features. The platform serves as a web-based solution for creating, editing, and sharing PlantUML diagrams while fostering a collaborative environment where users can explore, learn from, and build upon each other's work.

The primary motivation behind this project stems from the need for an integrated platform that not only provides powerful diagramming capabilities but also incorporates modern features such as AI-assisted code editing and community-driven learning. The platform targets developers, software architects, system designers, and educational institutions who require efficient tools for creating technical diagrams and visual documentation.

Key objectives of this project include:

- Developing a user-friendly web interface for PlantUML diagram creation and editing
- Implementing robust project and diagram management capabilities
- Creating a collaborative workspace with AI-powered assistance
- Building a community platform for sharing and discovering diagrams
- Ensuring scalable architecture with proper authentication and administration features

The project follows agile development methodologies using Scrum framework, ensuring iterative development and continuous stakeholder feedback integration.

2.2 Analysis and Specification of Requirements

2.2.1 Identification of Actors

Through comprehensive analysis of the system requirements and user stories, we have identified the following actors who will interact with the PlantUML platform:

Primary Actors (Human Users):

- **User**: Authenticated individuals who can create, manage, and share diagrams and projects. They have full access to the platform's features including workspace management, community interaction, and profile customization.
- **Visitor**: Unauthenticated users who have limited access to the platform. They can explore the landing page and browse community content but cannot create or modify diagrams.
- **Administrator**: System administrators with elevated privileges responsible for platform maintenance, user management, content moderation, and overall system integrity.

Secondary Actors (System Components):

- **AI System**: An intelligent assistant that responds to user requests and provides code editing assistance for diagram creation and modification.
- **PlantUML Server**: External service responsible for rendering PlantUML code into visual diagram representations.

2.2.2 Identification of Requirements

2.2.2.1 Functional Requirements

The functional requirements have been categorized based on the main feature areas of the platform:

Authentication and Security:

- Support for OAuth authentication via Google and GitHub accounts
- Cross-device authentication persistence
- Secure logout functionality
- Administrative authentication with elevated privileges

Project and Diagram Management:

- Complete CRUD operations for projects and diagrams
- Project organization and categorization capabilities
- Bulk download functionality for project diagrams
- Individual diagram export in multiple formats
- Project sharing and collaboration features

Workspace and Editing:

- Interactive code editor for PlantUML syntax
- Split-view workspace with customizable layouts
- Real-time diagram rendering and preview
- AI-powered code assistance and suggestions
- Syntax highlighting and error detection

Community Features:

- Public project exploration and discovery
- Comment system with full CRUD operations
- Like/unlike functionality for projects and comments
- Project forking and copying capabilities
- Social sharing features

Profile and Administration:

- User profile management and customization
- Public project portfolio display
- Comprehensive administrative dashboard
- User and content management tools

2.2.2.2 Non-Functional Requirements

Performance Requirements:

- Page load times should not exceed 3 seconds under normal conditions
- Diagram rendering should complete within 5 seconds for standard-sized diagrams
- The system should support concurrent access by up to 1000 users
- Real-time editor updates should have latency below 100ms

Security Requirements:

- All data transmission must be encrypted using HTTPS/TLS
- User authentication must follow OAuth 2.0 security standards
- Input validation and sanitization for all user-generated content
- Protection against common web vulnerabilities (XSS, CSRF, SQL injection)

Usability Requirements:

- Intuitive user interface following modern web design principles
- Responsive design supporting desktop, tablet, and mobile devices
- Accessibility compliance with WCAG 2.1 Level AA standards
- Multilingual support with initial focus on English

Reliability and Availability:

- System uptime of 99.5% excluding scheduled maintenance
- Automated backup systems with 24-hour recovery point objective
- Graceful error handling with meaningful user feedback
- Fault tolerance for external service dependencies

Scalability Requirements:

- Horizontal scaling capability for increased user load
- Database optimization for efficient query performance
- CDN integration for static asset delivery
- Microservices architecture for independent component scaling

2.3 Project Management with Scrum

2.3.1 Scrum Roles

The project adopts the Scrum framework with clearly defined roles and responsibilities:

Role	**Member(s)**
Product Owner	Issam Mekni
Scrum Master	Issam Mekni
Development Team	Issam Mekni, Souhaieb Askri

Table 2.1: Scrum roles and their respective members

Roles in the Scrum Team:

2.3.2 Product Backlog

The product backlog represents a prioritized list of features and requirements derived from stakeholder needs and market analysis. Each backlog item follows the user story format and includes priority classification using MoSCoW method (Must have, Should have, Could have, Won't have this time).

Table 2.2: Product Backlog with User Stories and Priorities (Imported from backlog.csv)

ID	**Feature**	**Sub-ID**	**User Story**	**Priority**
1	Authentication	1.1	As a user; I want to authenticate using my Google account so that I can log in easily.	M
		1.2	As a user; I want to authenticate using my GitHub account so that I can log in with my developer profile.	M
		1.3	As a user; I want to stay authenticated across multiple devices so that I can access my account anywhere.	S
		1.4	As a user; I want to log out from my account so that my information is secure when I finish.	M
2	Explore Landing Page	2.1	As a user; I want to explore the landing page so that I can understand the platform's features and benefits.	M

Continued on next page

Table 2.2 – continued from previous page

ID	Feature	Sub-ID	User Story	Priority
3	Manage Projects	3.1	As a user; I want to create a new project so that I can organize my diagrams.	M
		3.2	As a user; I want to view my project details so that I can track my work.	M
		3.3	As a user; I want to update project details so that I can keep information current.	M
		3.4	As a user; I want to delete a project so that I can remove unwanted content.	M
		3.5	As a user; I want to download project diagrams as images in a compressed ZIP file so that I can use them offline.	S
		3.6	As a user; I want to share my project with others so that I can collaborate or showcase my work.	S
4	Manage Diagrams	4.1	As a user; I want to create a new diagram so that I can visualize my ideas.	M
		4.2	As a user; I want to view my diagram so that I can review my work.	M
		4.3	As a user; I want to update diagram details so that I can improve my designs.	M
		4.4	As a user; I want to delete a diagram so that I can remove unwanted content.	M
		4.5	As a user; I want to download diagram images in appropriate formats so that I can use them in other applications.	S
5	Manage Workspace	5.1	As a user; I want to control and split views in my workspace so that I can work efficiently.	S
		5.2	As a user; I want to edit diagram code in an interactive editor so that I can create diagrams efficiently.	M
		5.3	As a user; I want to chat with an AI model to edit diagram code so that I can get assistance with complex diagrams.	C
		5.4	As an AI system; I need to respond to user requests and help edit diagram code so that users can create better diagrams.	C

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Table 2.2 – continued from previous page

ID	Feature	Sub-ID	User Story	Priority
		5.5	As a PlantUML Server; I need to render diagram code into diagram images so that users can visualize their work.	M
6	Community Interaction	6.1	As a user; I want to explore the community so that I can discover interesting projects.	S
		6.2	As a visitor; I want to explore the community so that I can see what the platform offers.	S
		6.3	As a user; I want to comment on projects so that I can provide feedback to other users.	C
		6.4	As a user; I want to like/unlike projects so that I can show appreciation for good work.	C
		6.5	As a user; I want to share projects so that I can promote interesting content.	C
		6.6	As a user; I want to update my comments so that I can correct or improve my feedback.	C
		6.7	As a user; I want to delete my comments so that I can remove inappropriate or outdated feedback.	C
		6.8	As a user; I want to like/unlike comments so that I can engage in community discussions.	C
		6.9	As a user; I want to copy community projects to my workspace so that I can learn from and build upon others' work.	S
7	Profile Management	7.1	As a user; I want to edit my profile so that I can keep my information current.	S
		7.2	As a user; I want to view public projects on profiles so that I can see others' work.	S
8	Administration	8.1	As an admin; I want to authenticate with elevated privileges so that I can manage the platform.	M
		8.2	As an admin; I want to manage all platform data so that I can maintain system integrity and user safety.	M

2.3.3 Global Use Case Diagram

The global use case diagram provides a comprehensive overview of the system's functionality and actor interactions. It illustrates the relationships between different use cases and demonstrates how various actors engage with the platform's features.

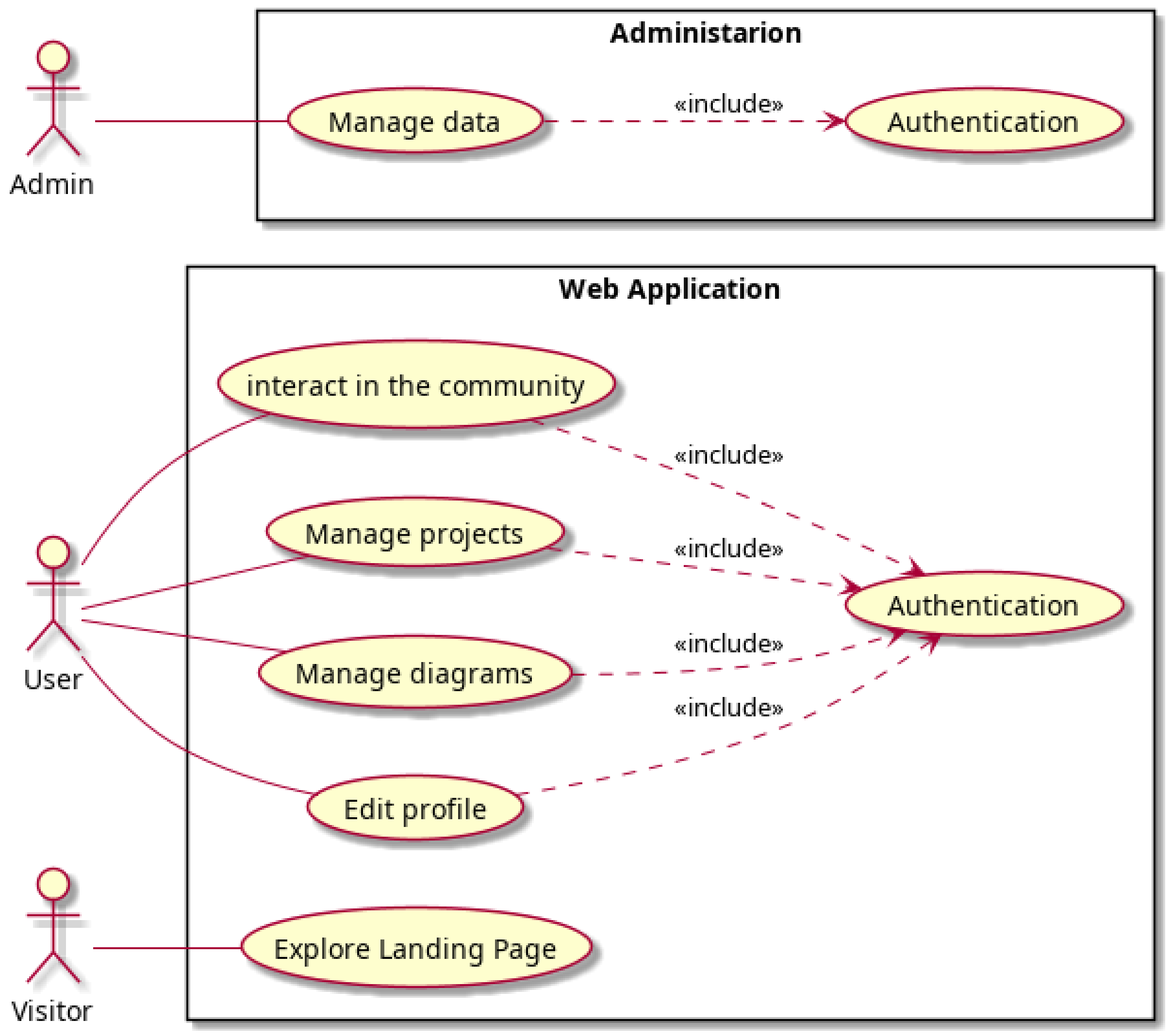

Figure 2.1: Global Use Case Diagram

2.3.4 Sprint Planning

The project is organized into six strategic sprints, each focusing on specific functional areas and building upon previous deliverables. The total project duration is designed to fit within 3.5 months (14 weeks) with efficient resource allocation and parallel development activities.

2.4 Deployment diagram

The deployment diagram illustrates the system's architecture at the deployment level, showing how components are deployed and how they interact with external systems and

Sprint	Focus Area	Backlog Features	Estimated Duration (Week
I	Infrastructure Setup	N/A	2
II	Authentication and Landing Page	1,2	2
III	Project Management	3	3
IV	Diagram and Project Management	4,5	3
V	Community Interaction and Profiles	6 ,7	3
VI	Administration	8	1

Table 2.3: Scrum Sprint Planning with Estimated Durations

services.

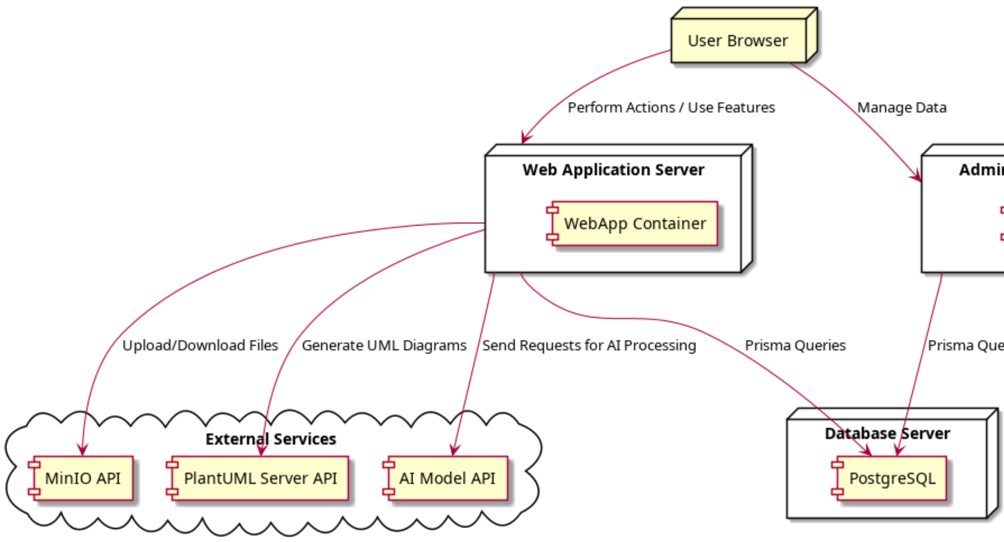

Figure 2.2: Deployment diagram

2.5 Technological Architecture of the Project

2.6 Tools and Environment

2.7 Conclusion

The project initiation phase has established a solid foundation for the development of the platform through comprehensive requirement analysis, stakeholder identification, and strategic planning. The adoption of Scrum methodology ensures iterative development with regular feedback incorporation and continuous improvement.

Key achievements of this initiation phase include:

- Clear identification of system actors and their interactions
- Comprehensive functional and non-functional requirements specification

- Well-structured product backlog with prioritized user stories
- Detailed sprint planning with realistic timelines and deliverables
- Established project management framework using Scrum principles

The systematic approach to requirement gathering and analysis has revealed the complexity and scope of the platform while ensuring that all stakeholder needs are addressed. The priority-based classification of requirements enables focused development on core functionality while maintaining flexibility for future enhancements.

The sprint-based development approach provides clear milestones and deliverables, facilitating progress tracking and stakeholder communication. The incremental nature of the development process allows for early feedback integration and risk mitigation.

Moving forward, the project is well-positioned to proceed with the technical architecture design and implementation phases, building upon the solid foundation established during this initiation phase. The comprehensive documentation created during this phase will serve as a reference throughout the development lifecycle, ensuring consistency and alignment with project objectives.

Chapter 3

Study and Implementation of Sprint I: Infrastructure Setup

Contents

3.1 Introduction

The first sprint of our project focuses on establishing a robust and scalable infrastructure foundation. This sprint is crucial as it sets up the development environment and core services that will support the entire application ecosystem. The infrastructure includes containerized services for database management, file storage, diagram generation, and the main web application framework.

Our approach emphasizes modern DevOps practices using Docker containerization to ensure consistency across different development environments and facilitate easy deployment. This chapter documents the planning, implementation, and outcomes of Sprint I, providing insights into the technical decisions made and lessons learned during the infrastructure setup phase.

3.2 Sprint Planning

3.2.1 Objectives of Sprint I

The primary objectives of Sprint I are centered around creating a solid foundation for the development process:

- Establish a containerized development environment using Docker Compose
- Set up PostgreSQL database with proper configuration and data persistence
- Configure MinIO object storage for file management capabilities
- Deploy PlantUML server for automated diagram generation
- Create a Next.js application structure with Prisma ORM integration
- Implement authentication system using NextAuth.js with Google OAuth
- Configure environment variables and security settings
- Ensure all services communicate effectively within the Docker network

3.2.2 Backlog of Sprint I

The sprint backlog was organized into distinct components, each representing a critical piece of the infrastructure:

1. **Database Setup**: Configure PostgreSQL container with persistent storage and proper networking
2. **Object Storage**: Set up MinIO service for file storage and management
3. **Diagram Service**: Deploy PlantUML server for automated diagram generation
4. **Web Application**: Initialize Next.js project with TypeScript and Tailwind CSS
5. **ORM Configuration**: Set up Prisma with PostgreSQL integration
6. **Authentication**: Implement NextAuth.js with Google OAuth provider

7. **Environment Configuration**: Secure configuration of all environment variables
8. **Integration Testing**: Verify all services work together seamlessly

3.3 Technologies and Tools Used

3.3.1 PostgreSQL

PostgreSQL was chosen as our primary database management system due to its robust feature set, ACID compliance, and excellent support for complex queries. As an open-source relational database, it provides enterprise-level performance while maintaining flexibility for development. The containerized deployment ensures consistent database behavior across different environments and simplifies backup and migration processes.

3.3.2 MinIO

MinIO serves as our object storage solution, providing S3-compatible API for file management. This choice enables seamless integration with existing S3-based workflows while maintaining full control over our storage infrastructure. MinIO's lightweight nature and excellent performance make it ideal for development environments and can scale effectively for production use.

3.3.3 PlantUML Server

The PlantUML server provides automated diagram generation capabilities, essential for maintaining up-to-date system documentation. By containerizing this service, we ensure consistent diagram rendering and enable programmatic generation of architectural diagrams, sequence diagrams, and other technical documentation.

3.3.4 Next.js with Prisma

Next.js framework was selected for its full-stack capabilities, excellent developer experience, and built-in optimization features. Combined with Prisma ORM, it provides type-safe database access and seamless integration with PostgreSQL. This combination enables rapid development while maintaining code quality and performance.

3.3.5 Docker and Docker Compose

Docker containerization ensures environment consistency and simplifies deployment processes. Docker Compose orchestrates multiple services, making it easy to manage complex multi-container applications. This approach facilitates both development and production deployments while maintaining service isolation and scalability.

3.4 Deliverables of Sprint I

3.4.1 Database Infrastructure

The PostgreSQL database service has been successfully containerized with the following configuration:

```
postgres:
  image: postgres:16
  container_name: my_postgres
  environment:
    POSTGRES_USER: user
    POSTGRES_PASSWORD: password
    POSTGRES_DB: database
  ports:
    - "5432:5432"
  volumes:
    - postgres_data:/var/lib/postgresql/data
```

This configuration provides persistent data storage through Docker volumes and exposes the database on the standard PostgreSQL port. The database supports the main application's data requirements and includes proper backup capabilities.

3.4.1.1 Database Schema Design

The database schema has been designed to support the application's core functionality. The following class diagram illustrates the main entities and their relationships:

Database Entity Relationship Diagram

Class diagram located at: diagrams/class/g1.svg

Note: Convert SVG to PDF format for LaTeX compatibility

Figure 3.1: Database Entity Relationship Diagram

The schema implements proper normalization principles and includes indexes for optimal query performance. Foreign key constraints ensure data integrity, while the design allows for future scalability and feature additions.

3.4.2 Object Storage Service

MinIO object storage has been configured to provide S3-compatible file management:

```
minio:
  image: minio/minio
  container_name: minio
  ports:
    - "9000:9000"   # API
    - "9001:9001"   # Web UI
  volumes:
    - ./minio-data:/data
  environment:
    MINIO_ROOT_USER: minioadmin
    MINIO_ROOT_PASSWORD: minioadmin
  command: server /data --console-address ":9001"
```

The service provides both API access on port 9000 and a web management interface on port 9001. Local data persistence is ensured through volume mounting, making it suitable for development and testing scenarios.

3.4.3 Diagram Generation Service

PlantUML server deployment enables automated diagram generation:

```
plantuml:
  image: plantuml/plantuml-server
  container_name: plantuml_server
  ports:
    - "3030:8080"
  restart: unless-stopped
```

This service processes PlantUML markup and generates various diagram formats, supporting the documentation and visualization needs of the project.

3.4.4 Web Application Container

The Next.js application has been containerized with proper development workflow support:

```
FROM node:20-alpine

WORKDIR /app

COPY package*.json ./
COPY prisma ./prisma/

RUN npm install
RUN npx prisma generate

COPY . .

EXPOSE 3000

CMD ["npm", "run", "dev"]
```

This configuration ensures consistent Node.js environment, proper dependency management, and Prisma client generation during the build process.

3.5 Environment Configuration

The application requires several environment variables for proper operation:

Listing 3.1: Environment Variables Configuration

```
GOOGLE_CLIENT_SECRET=**********************
GOOGLE_CLIENT_ID=**********************
NEXTAUTH_URL=http://localhost:3000
NEXTAUTH_SECRET="**********************"
DATABASE_URL=postgresql://user:password@localhost:5434/database?
    schema=public
PLANTUML_SERVER=http://localhost:3030
GEMINI_API_KEY=**********************
```

These variables configure authentication services, database connections, external APIs, and service endpoints. Proper security measures have been implemented to protect sensitive configuration data.

3.6 Retrospective of Sprint I

3.6.1 Achievements

Sprint I successfully accomplished all primary objectives:

- Complete infrastructure setup with all services running in containers
- Successful integration between PostgreSQL, MinIO, PlantUML, and Next.js application
- Working authentication system with Google OAuth integration

- Proper environment configuration and security implementation
- Database schema design and Prisma ORM integration
- Comprehensive documentation of all configurations

The infrastructure provides a solid foundation for subsequent development sprints and supports all planned application features.

3.6.2 Challenges and Lessons Learned

Several challenges were encountered and resolved during the sprint:

Port Conflicts: Initial configuration had port conflicts between services, resolved by careful port mapping and documentation.

Database Connectivity: Networking between containers required adjustment of connection strings and proper service naming.

Environment Variable Management: Ensuring secure handling of sensitive data while maintaining development workflow efficiency.

Prisma Schema Synchronization: Managing database migrations and schema generation in containerized environment required careful coordination.

3.6.3 Areas for Enhancement

Future improvements identified for the infrastructure:

- Implementation of health checks for all services
- Addition of logging and monitoring solutions
- Database backup automation
- SSL/TLS configuration for production readiness
- Performance optimization for development workflow
- Integration of CI/CD pipeline preparation

3.7 Conclusion

Sprint I has successfully established a comprehensive development infrastructure that provides all necessary services for the project. The containerized approach ensures consistency, scalability, and ease of deployment across different environments. The integration of PostgreSQL, MinIO, PlantUML, and Next.js creates a powerful foundation for building modern web applications.

The infrastructure setup demonstrates best practices in DevOps, security, and software architecture. All services are properly configured, documented, and tested, providing a reliable foundation for subsequent development phases. The lessons learned during this sprint will inform future infrastructure decisions and improvements.

The successful completion of Sprint I enables the development team to focus on business logic and user features in upcoming sprints, knowing that the underlying infrastructure is robust, scalable, and well-documented. This foundation supports both current development needs and future scaling requirements.

Chapter 4

Study and Implementation of Sprint II: Authentication & Landing Page

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