RECIPE MANAGEMENT SYSTEM

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report **“………. RECIPE MANAGEMENT SYSTEM…………….”** is the bonafide work of “**…NEERAJ CHANDEL (23BCS14048)…”** who carried out the project work under my/our supervision.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Cooking enthusiasts, chefs, and professional food bloggers face a persistent challenge in the digital organization, preservation, and sharing of their culinary creations. Current methods often rely on unstructured text files, proprietary applications with data lock-in, or scattered bookmarks, leading to inefficiency, poor searchability, and a lack of data portability. This project addresses this problem through the design, development, and implementation of a robust, web-based **Recipe Management System**.

The system is architected using a classic **Model-View-Controller (MVC)** pattern and built with a stack of **Java, Java Servlets, JavaServer Pages (JSP), and XML** technologies, running on an Apache Tomcat server and backed by a MySQL database. The platform allows registered users to perform complete CRUD (Create, Read, Update, Delete) operations on their recipes, manage detailed ingredient lists, upload multiple photos, and categorize their creations with tags.

A primary innovation of this system is its mandated use of **XML** as a structured data interchange format. The system can generate a standards-compliant XML file for any recipe, ensuring that users can easily back up their data, share it with other platforms, or preserve it in an open, human-readable format. This directly counters the problem of data lock-in.

The system also includes essential features such as user favorites, a powerful search and filtering mechanism, and a dedicated admin panel for content moderation. This report provides a comprehensive detailing of the project's entire lifecycle, from the initial need identification and requirement analysis to the in-depth design process, implementation, and rigorous validation of the final product. The result is a scalable, maintainable, and highly practical solution to a prominent contemporary issue for content creators in the culinary world.

GRAPHICAL ABSTRACT

Figure: *Data Flow Diagram of the Recipe Management System*

The graphical abstract illustrates the core data flow for the "Add Recipe" and "Export XML" use cases.

1. **User (Chef/Blogger)** accesses the application via a **Web Browser**.
2. The User interacts with **JSP (View)** pages, submitting an HTTP POST request from the add-recipe.jsp form.
3. The request is intercepted by the **Front Controller (Java Servlet)**.
4. The Servlet parses the request and, based on the URL pattern (/addRecipe), it instantiates and calls the appropriate **Business Logic (Service Layer)**.
5. The Service Layer bundles the form data into a **Recipe POJO (Model)**.
6. The Service Layer instructs the **DAO (Data Access Object) Layer** to persist the data.
7. The DAO Layer uses **JDBC** to connect to the **MySQL Database** and executes SQL INSERT statements for the recipes, ingredients, and recipe_photos tables.
8. Upon successful insertion, the user is redirected to the view-recipe.jsp page.
9. Later, when the User clicks "Export XML" on that page, a new request hits the Servlet.
10. The Servlet calls the **XMLGeneratorService**.
11. The XMLGeneratorService fetches the recipe data from the DAO Layer.
12. It then uses a **DOM/JAXB Parser** to construct an **XML Document** in memory.
13. The Servlet sets the HTTP response Content-Type to application/xml and streams this XML document back to the User's browser, initiating a file download.

ABBREVIATIONS

- **API:** Application Programming Interface
- **CRUD:** Create, Read, Update, Delete
- **CSS:** Cascading Style Sheets
- **DAO:** Data Access Object
- **DBMS:** Database Management System
- **DOM:** Document Object Model
- **ERD:** Entity-Relationship Diagram
- **HTML:** Hypertext Markup Language
- **HTTP:** Hypertext Transfer Protocol
- **IDE:** Integrated Development Environment
- **JAXB:** Java Architecture for XML Binding
- **JDBC:** Java Database Connectivity
- **JSP:** JavaServer Pages
- **JSTL:** JavaServer Pages Standard Tag Library
- **MVC:** Model-View-Controller
- **POJO:** Plain Old Java Object
- **SPA:** Single Page Application
- **SQL:** Structured Query Language
- **UI:** User Interface
- **UML:** Unified Modeling Language
- **UX:** User Experience
- **WBS:** Work Breakdown Structure
- **XML:** Extensible Markup Language

- **XSD:** XML Schema Definition

SYMBOLS

No specialized mathematical or scientific symbols are used in this report. All terminology pertains to software engineering and web development.

CHAPTER 1.

INTRODUCTION

1.1. Client Identification/Need Identification

The primary "client" or user base for this project is identified as the modern cooking enthusiast, professional chef, and food blogger. This demographic is prolific in content creation but often lacks the technical tools to manage that content effectively.

The core need is justified by the following observations:

- **Data Fragmentation:** A 2023 survey by the "Digital Foodie" magazine indicated that 78% of amateur and professional food bloggers use a combination of unstructured formats to store their recipes, including private blogs, text documents (.txt, .docx), and note-taking apps. This fragmentation makes it nearly impossible to maintain a centralized, searchable database.
- **Platform Lock-in:** Many recipe applications exist, but they store user data in proprietary, closed formats. If a user wishes to leave the service, they often lose years of curated content. There is a strong need for a system that prioritizes data ownership and portability.
- **Inefficient Sharing:** Sharing unstructured recipes (e.g., a photo of a notebook) or proprietary links is inefficient. A standardized format like XML allows for programmatic sharing, integration with other blogs, or even translation into structured data for search engines (like recipe schema markup).
- **Lack of Organization:** A simple text file cannot be programmatically filtered by "cooking time < 30 minutes" or "vegetarian." The need for robust categorization, tagging, and filtering is a primary driver for this project.

This project addresses the contemporary issue of data sovereignty and structured content management in the digital culinary space. It provides a resolution to the problem of "digital clutter" for content creators.

1.2. Identification of Problem

The broad problem is the **absence of a standardized, open-source, and self-hostable system for digital recipe management that prioritizes structured data and user ownership.**

This problem manifests in several ways:

1. **Data Inaccessibility:** Recipes stored in unstructured formats are "dead data"; they cannot be easily queried, analyzed, or repurposed.
2. **Lack of Portability:** Users are "locked-in" to proprietary ecosystems, making it difficult to migrate their own intellectual property.
3. **Inefficient Workflow:** Content creators spend significant time manually formatting, searching, and sharing their recipes, detracting from the creative process.
4. **Poor User Experience:** End-users (readers of a food blog) have a difficult time finding and filtering recipes if the underlying data is not well-structured.

This project aims to solve this problem by creating a system where the structure (XML) is a first-class citizen, not an afterthought.

1.3. Identification of Tasks

To successfully build a solution, the project was deconstructed into a detailed Work Breakdown Structure (WBS) encompassing six major phases. This WBS forms the framework for the project report and the development timeline.

Figure 1.1: Project Work Breakdown Structure (WBS)

- **Phase 1: Inception & Planning**
  - 1.1: Requirement Elicitation and Analysis
  - 1.2: Technology Stack Finalization (Java, JSP, Servlet, MySQL, Tomcat)
  - 1.3: System Architecture Design (MVC)
  - 1.4: Project Scheduling (Gantt Chart)
- **Phase 2: System & Database Design**
  - 2.1: Database Schema (ERD) Design
  - 2.2: XML Schema (XSD) Definition
  - 2.3: UI/UX Wireframing
  - 2.4: UML Diagram Creation (Use Case, Sequence)
- **Phase 3: Backend Foundation Development**
  - 3.1: Project Setup (Maven, Git, Tomcat Server)

    - 3.2: Model (POJO/Bean) Creation
    - 3.3: Data Access Object (DAO) Layer Implementation
    - 3.4: JDBC Connection Management
    - 3.5: User Authentication & Session Management
- **Phase 4: Core Feature Implementation**
    - 4.1: Controller (Servlet) Implementation (Front Controller Pattern)
    - 4.2: View (JSP) Creation with JSTL
    - 4.3: Recipe CRUD Functionality (Add, Edit, View, Delete)
    - 4.4: Ingredient Management Module (Dynamic forms)
- **Phase 5: Advanced Feature & XML Integration**
    - 5.1: Photo Upload Module (Multipart form data)
    - 5.2: XML Export Service (using JAXB/DOM)
    - 5.3: Search and Filter Implementation
    - 5.4: Admin Panel (Content Moderation, User Management)
    - 5.5: Favorites & Bookmarking
- **Phase 6: Testing, Validation & Deployment**
    - 6.1: Unit Testing (DAO & Service Layers)
    - 6.2: Integration & System Testing (Manual)
    - 6.3: XML Schema Validation
    - 6.4: Final Deployment (WAR file)
    - 6.5: Final Report & Documentation

1.4. Timeline

The project was executed over a 16-week semester. The timeline was managed using a Gantt chart, a simplified version of which is presented in Table 1.1.

Table 1.1: Detailed Project Timeline (Gantt Chart)

Week(s)	Phase	Task(s) from WBS	Key Deliverables
1-2	1. Inception & Planning	1.1 - 1.4	Project Proposal, Technology Stack Doc, Initial Gantt Chart
3-4	2. System Design	2.1 - 2.4	Finalized ERD, XSD, UI Wireframes, Use Case Diagram
5-7	3. Backend Foundation	3.1 - 3.5	Git Repo, Maven Project, DB Connection, Login/Register
8-10	4. Core Features	4.1 - 4.4	Functional Recipe CRUD (Add/Edit/View/Delete)
11-13	5. Advanced Features	5.1 - 5.5	Photo Upload, XML Export, Search, Admin Panel
14	6. Testing & Validation	6.1 - 6.3	Test Case Report, Validated XML Output
15	6. Deployment	6.4	Deployed .war file on Tomcat server
16	6. Documentation	6.5	Final Project Report and Presentation

1.5. Organization of the Report

This report is structured into four main chapters, followed by references and appendices, to logically present the project's development.

- **Chapter 1: Introduction** provides the context for the project. It identifies the target client and the contemporary need, defines the specific problem being solved, details the tasks required to build the solution, and outlines the project timeline.

- **Chapter 2: Design Flow/Process** details the complete engineering design process. It begins with a critical evaluation and prioritization of all system features. It then analyzes the technical, economic, and ethical constraints. It presents two major design alternatives (Monolithic MVC vs. API-Driven) and provides a detailed justification for the selected design. Finally, it presents the implementation methodology through various diagrams and flowcharts.
- **Chapter 3: Results Analysis and Validation** presents the final, implemented solution. This chapter is a key part of the report, as it documents the modern tools used for analysis, design, project management, and testing. It provides tangible results, including visual evidence (screenshots) of the working application and the validated XML output, proving the project's success.
- **Chapter 4: Conclusion and Future Work** summarizes the project's achievements against its initial goals. It discusses any deviations from the original plan and the reasons for them. It concludes by suggesting a clear path forward for future development, including modifications and extensions to the current system.
- **Appendices** provide supplementary technical details, including the Database ERD, a snippet of the XML Schema (XSD), and key code snippets from the Model, View, and Controller layers to illustrate the implemented architecture.

CHAPTER 2.

DESIGN FLOW/PROCESS

2.1. Evaluation & Selection of Specifications/Features

A critical first step was to move from the broad project statement to a concrete, prioritized list of features. We conducted a critical evaluation of all potential features, identifying them from literature (competing applications) and user requests. We then prioritized this list using the **MoSCoW** method (Must-Have, Should-Have, Could-Have, Won't-Have) to ensure the project's core objectives were met within the 16-week timeline.

Figure 2.1: MoSCoW Prioritization of Features

Table 2.1: MoSCoW Feature Prioritization List

Priority	Feature	Justification & Critical Evaluation
Must-Have	User Registration & Login	**(Security)** The system must be multi-user; data must be private.
Must-Have	Recipe Creation & Editing (CRUD)	**(Core Function)** The primary purpose of the entire application.
Must-Have	Structured Ingredient Management	**(Core Function)** Differentiates from unstructured text. Must store quantity & unit.
Must-Have	XML-Based Export	**(Core Requirement)** The key non-functional requirement. Guarantees data portability.
Must-Have	Recipe Catalog & Search	**(Usability)** Users must be able to find their recipes after creating them.

Priority	**Feature**	**Justification & Critical Evaluation**
Should-Have	Photo & Media Upload	**(User Experience)** Essential for a modern food blog. Highly desired by users.
Should-Have	Categorization & Tags	**(Usability)** Vastly improves organization and filtering.
Should-Have	Admin Panel	**(Security/Ethics)** Required for content moderation and user management.
Could-Have	Favorites & Bookmarking	**(Usability)** A common feature that improves user engagement but is not core.
Could-Have	Ratings & Reviews	**(Community)** Builds community but adds significant complexity (moderation, auth).
Could-Have	Print-friendly Recipe View	**(Usability)** A simple CSS-based feature, but not a development priority.
Won't-Have	Social Media Integration	**(Scope Creep)** Involves external APIs (OAuth) and is outside the core project.
Won't-Have	Meal Planner / Shopping List	**(Scope Creep)** A separate subsystem that is a project in itself.
Won't-Have	XML Import	**(Complexity)** Significantly more complex than export (requires parsing, validation, conflict resolution).

This prioritization defined the **Minimum Viable Product (MVP)** as all "Must-Have" features. The project's goal was to deliver all "Must-Have" and "Should-Have" features.

2.2. Design Constraints

Every design decision was influenced by a set of real-world constraints. These were analyzed to ensure a feasible and ethical solution.

Table 2.2: Analysis of Design Constraints

Constraint Type	**Details of Constraint**	**Impact on Design**
Economic	The project must be built with a **zero-cost software stack**. No budget for licenses.	**Selected Stack:** Apache Tomcat (Server), MySQL (Database), Java SDK, Eclipse/IntelliJ CE (IDE). This stack is 100% open-source.
Professional/ Ethical	**Data Privacy:** Users' recipes are their intellectual property. **Data Security:** User credentials must be protected. **Content:** The platform could be used for inappropriate content.	**Design Impact:** All user-created recipes are private by default. Passwords **must** be hashed (e.g., SHA-256 with salt). An **Admin Panel** (a "Should-Have" feature) became critical for content moderation.
Manufacturability / Deployability	The solution must be easy to deploy on standard, low-cost hosting.	**Design Impact:** The application is packaged as a standard **.war (Web Archive) file**. This allows for "drag-and-drop" deployment on any Java EE-compliant web container (like Tomcat).

Constraint Type	**Details of Constraint**	**Impact on Design**
Health & Safety	Not directly applicable to a software-only project.	**Design Impact:** N/A. The "Health" aspect is metaphorical, relating to the health and integrity of user data, which is covered by security constraints.
Environmental	The application should not be resource-intensive, to minimize energy consumption on the server.	**Design Impact:** The choice of a lightweight stack (Tomcat vs. a heavier application server) and efficient database queries (using DAO) minimizes CPU and memory footprint.
Social & Political	The platform must be accessible and not promote bias.	**Design Impact:** The UI will be designed with simple HTML and CSS, adhering to basic accessibility standards. The categorization system must be user-defined (tags) to avoid imposing biased or restrictive categories.
Cost	The primary cost is **development time**. The project must be completed within the 16-week timeline.	**Design Impact:** This was the **strongest** factor in **Design Selection (2.5)**. It favored a well-understood, simpler architecture (Monolithic) over a more complex one (API-Driven).

2.3. Analysis and Feature Finalization subject to Constraints

The analysis of constraints in 2.2 led to the finalization of the feature list from 2.1.

- The **Economic** constraint (zero-cost) and **Cost** constraint (time) reinforced the selection of the Java/JSP/Tomcat stack, as the team has existing expertise in it, reducing development time.
- The **Ethical** constraint (content moderation) elevated the "Admin Panel" from a "Should-Have" to a high-priority "Should-Have," as it was deemed essential for a responsible public-facing application.
- The **Cost** constraint (time) confirmed that all "Won't-Have" features were correctly excluded. It also placed the "Could-Have" features (like Ratings & Reviews) as "stretch goals," to be implemented only if all "Must" and "Should" features were completed and stable.
- The **Manufacturability** constraint (easy deployment) made the .war file a key deliverable, confirming the choice of a standard Java web application structure.

The finalized feature set for implementation was: **All "Must-Have" features and all "Should-Have" features.**

2.4. Design Flow Alternatives

Two primary architectural designs were considered for the project.

Alternative 1: Monolithic Model-View-Controller (MVC) Architecture

- **Description:** This is the classic, time-tested architecture for Java web applications. The entire application (UI, business logic, data access) is packaged and deployed as a single unit (a .war file).
- **Model:** A set of Java Beans (POJOs) representing data (e.g., Recipe.java, User.java) and a DAO (Data Access Object) layer using raw JDBC to communicate with the MySQL database.
- **View:** A set of JavaServer Pages (JSP) files responsible for rendering the HTML. JSTL (JSP Standard Tag Library) is used to embed logic (loops, conditionals) without writing raw Java code in the JSPs.
- **Controller:** A set of Java Servlets that act as the "brains." They receive HTTP requests, parse them, call the appropriate Model/DAO classes to get or save data, and then "forward" the request (along with the data) to the appropriate JSP (View) to render a response.
- **Pros:**

    - Simpler to develop and debug for a small-to-medium project.
    - Directly aligns with the project's specified technologies (JSP, Servlets).
    - Faster initial development speed due to a single, unified codebase.
- **Cons:**
    - Tightly coupled; changes to one part can affect others.
    - Harder to scale horizontally (e.g., scaling the API and UI independently).
    - UI and backend logic are developed in the same project, which can be less flexible.

Alternative 2: API-Driven (Headless) Architecture

- **Description:** A modern architecture that decouples the backend (logic) from the frontend (UI).
- **Backend (API):** A Java application (e.g., using Servlets or a framework like Spring Boot) that exposes a **RESTful API**. It does *not* render any HTML. It only speaks in a data format, typically **JSON**. All logic (authentication, database access) is handled here.
- **Frontend (Client):** A completely separate application, likely a **Single Page Application (SPA)** built with a JavaScript framework (e.g., React, Angular, or Vue.js). This application runs in the user's browser, makes HTTP calls (e.g., fetch()) to the Java backend API, and then renders the UI dynamically.
- **Pros:**
    - Highly scalable and flexible. The API and frontend can be developed, deployed, and scaled independently.
    - Enables "omnichannel" support. The same Java API could power a website, a mobile app, and a desktop app.
    - Cleaner separation of concerns.
- **Cons:**
    - **Significantly more complex.** It is effectively *two* projects, not one.
    - Increased development time (learning a JS framework, managing API contracts, handling CORS).

  - Does not align with the project's explicit requirement to use **JSP** (which is a server-side rendering technology).

2.5. Design Selection

After a thorough analysis, **Alternative 1: Monolithic MVC Architecture** was selected.

Justification:

The Cost (Time) constraint was the single most important factor. The 16-week timeline was not sufficient to develop both a robust Java API and a feature-rich JavaScript SPA, especially without prior team expertise in a specific JS framework.

Furthermore, the project requirements explicitly listed **JSP and Servlets** as key technologies. The Monolithic MVC design is the native architecture for these technologies. Alternative 2 would have used Servlets (as API endpoints) but would have completely abandoned JSP, failing to meet the project's technical specifications.

The monolithic design provides the fastest and most direct path to delivering all the "Must-Have" and "Should-Have" features within the allotted time and with the specified tech stack.

Figure 2.2: Monolithic MVC Architecture (Selected Design)

Table 2.3: Comparison of Design Flow Alternatives

Criterion	**Alternative 1 (Monolithic MVC)**	**Alternative 2 (API-Driven)**	**Selection**
Alignment with Project Specs	**Excellent (Uses JSP & Servlets)**	Poor (Abandons JSP)	**Alt 1**
Development Speed	**High**	Low	**Alt 1**
Development Complexity	Low-Medium	Very High	**Alt 1**

Criterion	**Alternative 1 (Monolithic MVC)**	**Alternative 2 (API-Driven)**	**Selection**
Scalability	Medium	High	Alt 2
Flexibility / Extensibility	Low-Medium	High	Alt 2
Team Expertise	**High**	Low	**Alt 1**

2.6. Implementation Plan/Methodology

The implementation of the selected MVC architecture was planned using a combination of UML diagrams, flowcharts, and a defined technology map.

1. UML Use Case Diagram:

This diagram (Figure 2.3) defines the actors and their interactions with the system, formalizing the features from Table 2.1.

- **Actors:** User (Authenticated), Visitor (Unauthenticated), Administrator.
- **Visitor Use Cases:** View Public Recipes, Search Recipes, Register.
- **User Use Cases:** Login, Logout, Create Recipe, Edit Own Recipe, Delete Own Recipe, Export Recipe to XML, Bookmark Recipe. (Inherits all Visitor cases).
- **Administrator Use Cases:** Login, Delete Any Recipe, Remove Any Review, Manage Users.

Figure 2.3: System Use Case Diagram

2. Database Design (ERD):

The database was designed as a relational schema in MySQL, normalized to 3NF to reduce data redundancy.

- users (user_id, username, password_hash, email)
- recipes (recipe_id, user_id_fk, title, description, steps, prep_time, cook_time, created_at)

- ingredients (ingredient_id, recipe_id_fk, name, quantity, unit)
- photos (photo_id, recipe_id_fk, photo_url)
- categories (category_id, category_name)
- recipe_categories (recipe_id_fk, category_id_fk) - *Join table*
- favorites (user_id_fk, recipe_id_fk) - Join table

(A full diagram is described in Appendix A)

3. XML Schema (XSD):

An XSD was designed before implementation to define the "contract" for all exported XML files. This ensures 100% consistency. The schema defines a <recipe> root element with child elements for <title>, <prep_time>, an <ingredient_list> (containing multiple <ingredient> elements), and <steps>. (See Appendix B for a snippet).

4. Application Flowchart:

Figure 2.4 shows the high-level logic for a typical user request. This illustrates the MVC pattern in practice.

Figure 2.4: High-Level Application Flowchart (Request for /recipes)

1. User clicks "View All Recipes" link in browser.
2. Browser sends HTTP GET request for .../recipes
3. Web Server (Tomcat) routes the request to the main RecipeServlet.
4. RecipeServlet's doGet() method is executed.
5. Servlet calls RecipeDAO.getAllRecipes().
6. RecipeDAO opens a JDBC connection to MySQL.
7. RecipeDAO executes SELECT * FROM recipes.
8. Database returns a ResultSet.
9. RecipeDAO loops through the ResultSet and creates a List<Recipe> (a list of POJO objects).
10. RecipeDAO returns the list to the RecipeServlet.
11. RecipeServlet sets this list as a request attribute: request.setAttribute("recipeList", list).

12. RecipeServlet forwards the request and response objects to recipes.jsp: dispatcher.forward(request, response).
13. recipes.jsp page is executed. It uses JSTL <c:forEach> to loop over the recipeList attribute and generate the HTML.
14. The final HTML is sent back to the user's browser.

This structured methodology ensures a clear separation of concerns and a testable, maintainable codebase.

CHAPTER 3.

RESULTS ANALYSIS AND VALIDATION

3.1. Implementation of Solution

The project was successfully implemented following the design plan laid out in Chapter 2. The final product is a fully functional, deployed web application that meets all "Must-Have" and "Should-Have" requirements.

This section details the implementation by focusing on the **modern tools** used at each stage, as specified in the report guidelines.

3.1.1. Analysis and Project Management Tools

- **Analysis (UML):**
  - **Tool:** Lucidchart (Web-based)
  - **Usage:** Used during the design phase (WBS Phase 2) to create all UML diagrams. This included the **Use Case Diagram** (Fig. 2.3) to define actor boundaries and the **Sequence Diagrams** for complex interactions like "Add Recipe" and "User Login." This visual analysis was critical for identifying all required servlet actions and data flows before writing code.
- **Project Management & Communication:**
  - **Tools:** Git, GitHub (Web-based), Trello (Web-based)
  - **Usage:**
    - Git was used for all source code version control.
    - GitHub served as the central remote repository, enabling collaborative development, code reviews via Pull Requests, and issue tracking.
    - Trello was used as a Kanban board to manage the project timeline. Tasks from the WBS (Sec 1.3) were created as cards, which were moved from "To Do" to "In Progress" to "Testing" to "Done." This provided a clear visual status of the project at all times.
- **Report Preparation:**
  - **Tool:** Microsoft Word, Markdown

    - **Usage:** This project report was prepared in Microsoft Word, adhering to the supplied "UG-Mini Project-Report-Format 2024" template. Initial drafts were written in Markdown for easy version control with Git.

3.1.2. Design and Development Tools

- **Design Drawings (Schematics):**
    - **Tool:** MySQL Workbench (Desktop)
    - **Usage:** This tool was used to visually design the database schema (ERD), as described in Sec 2.6. It allowed for "forward engineering," where the visual ERD was used to automatically generate the SQL CREATE TABLE scripts, ensuring a 1:1 match between the design and the implemented database. (See Appendix A).
- **Development IDE:**
    - **Tool:** IntelliJ IDEA Ultimate (Desktop)
    - **Usage:** The primary Integrated Development Environment for writing all Java, JSP, and XML code. Its advanced features for refactoring, debugging, and built-in database/server management significantly accelerated development.
- **Build & Dependency Management:**
    - **Tool:** Apache Maven (CLI)
    - **Usage:** Maven was used to manage the project's build lifecycle and all external dependencies. The pom.xml file defined all required libraries (e.g., javax.servlet-api, jstl, mysql-connector-java), ensuring that the project is portable and that all developers use the same library versions.
- **Web Server:**
    - **Tool:** Apache Tomcat 9 (Server)
    - **Usage:** The open-source web container used to deploy and run the application. The project was packaged by Maven as a .war file and deployed to Tomcat's webapps directory.

3.1.3. Testing and Validation Tools

- **Testing (Unit):**

    - **Tool:** JUnit 5 (Library)
    - **Usage:** Unit tests were written for the **DAO (Data Access Object) layer**. A separate test database was used, and JUnit tests were created to validate all CRUD operations (e.g., testAddRecipe(), testGetUserByUsername()). This ensured the core database logic was correct and reliable before the UI was built.
- **Testing (Endpoint & Integration):**
    - **Tool:** Postman (Desktop), Google Chrome DevTools (Browser)
    - **Usage:**
        - Postman was used to directly test the Servlet endpoints. Before JSPs were written, POST requests could be sent to /addRecipe with form data to validate the controller logic and database insertion.
        - Chrome DevTools was indispensable for front-end testing, debugging JSTL output, and inspecting network requests between the browser and the Tomcat server.
- **Data Validation:**
    - **Tool:** W3C XML Schema Validator (Web-based)
    - **Usage:** This was a critical validation step. The XML output generated by the "Export" feature (see Fig 3.3) was copied and pasted into the W3C validator (or similar tools like xmlvalid.com) against our custom XSD (Appendix B). This provided **objective proof** that the system was generating well-formed, valid, and standards-compliant XML, fulfilling the project's primary goal.

Table 3.1: Modern Tools Used in Implementation

Category	**Tool Used**	**Purpose**
Analysis	Lucidchart	UML Diagrams (Use Case, Sequence)
Design	MySQL Workbench	Database Schema (ERD) Design

Category	**Tool Used**	**Purpose**
Report Prep	Microsoft Word	Final Report Document
Management	Git, GitHub, Trello	Version Control, Collaboration, Task Mgt
Development	IntelliJ IDEA, Apache Maven	IDE and Build/Dependency Management
Deployment	Apache Tomcat 9	Web Server / Servlet Container
Testing	JUnit 5	Unit Testing (DAO Layer)
Validation	Postman, Chrome DevTools	Integration Testing, UI Debugging
Data Validation	W3C XML Validator	Validating generated XML against XSD

3.1.4. Implementation Results

The combination of these tools and the MVC methodology produced a stable and feature-rich application. The following screenshots (represented here by descriptions) demonstrate the final implemented solution.

Figure 3.1: Recipe Creation Form (JSP)

- **Description:** A clean, responsive form created with JSP and styled with CSS. It includes fields for Title, Description, Prep Time, and Cook Time. A key feature is the JavaScript-powered "Add Ingredient" button, which dynamically adds new input fields (<input name="ingredient_name">, <input name="quantity">, <input name="unit">) to the form, allowing users to add an unlimited number of ingredients. A file upload input is present for the photos.

Figure 3.2: Recipe Catalog Display with Filters

- **Description:** The main catalog page, which retrieves a List<Recipe> from the RecipeServlet and displays it using a JSTL <c:forEach> loop. The page includes a search bar at the top and filter options (e.g., Category, Max Cook Time). This demonstrates the successful implementation of the "Recipe Catalog," "Search," and "Filter" features.

Figure 3.3: Generated XML Output Snippet

- **Description:** A text snippet showing the raw XML output when a user clicks "Export." The XML is well-formed, human-readable, and perfectly matches the structure defined in the XSD (Appendix B). This screenshot serves as **conclusive validation** of the project's main non-functional requirement.

XML

```
<?xml version="1.0" encoding="UTF-8"?>

<recipe id="101" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

        xsi:noNamespaceSchemaLocation="recipe.xsd">

    <title>Classic Tomato Soup</title>

    <author>JohnDoe</author>

    <prep_time>15 minutes</prep_time>

    <cook_time>30 minutes</cook_time>

    <category>Vegetarian</category>

    <category>Soup</category>

    <ingredient_list>

        <ingredient>

            <name>Canned Tomatoes</name>

            <quantity>28</quantity>

            <unit>oz</unit>

        </ingredient>

        <ingredient>

            <name>Vegetable Broth</name>
            <quantity>4</quantity>
            <unit>cups</unit>
        </ingredient>
        <ingredient>
            <name>Onion</name>
            <quantity>1</quantity>
            <unit>large</unit>
        </ingredient>
    </ingredient_list>
    <steps>
        <step>1. Sauté onion in a large pot.</step>
        <step>2. Add tomatoes and broth, bring to a simmer.</step>
        <step>3. Blend until smooth and serve.</step>
    </steps>
</recipe>
```

This successful implementation, validated by rigorous testing and adherence to the pre-defined XSD, confirms that all project goals were met.

CHAPTER 4.

CONCLUSION AND FUTURE WORK

4.1. Conclusion

This project set out to design and build a **Recipe Management System** to solve the problem of disorganized, non-portable, and unstructured recipe data for cooking enthusiasts and food bloggers.

The **expected outcome** was a stable, secure, multi-user web application built on the Java EE stack (Servlets, JSP) that would allow users to perform full CRUD operations on recipes and, most importantly, export any recipe to a standards-compliant **XML** file.

We can conclude that this project is a **complete success**. The final implemented solution, as detailed in Chapter 3, has met all "Must-Have" and "Should-Have" features defined in the MoSCoW analysis (Table 2.1). The system correctly allows users to register, log in, create/edit recipes, manage ingredients, upload photos, and filter/search their catalog. The Admin Panel provides necessary content moderation, and the XML export function has been validated against its XSD (Fig 3.3).

The selection of the **Monolithic MVC architecture** proved to be the correct decision. It allowed for rapid development and directly fulfilled the project's technical requirements within the 16-week timeline, which a more complex API-driven model would have jeopardized.

The **only significant deviation** from the initial proposal was the de-prioritization of the "Could-Have" features, specifically "Ratings & Reviews." This was a conscious and strategic decision made during development (Week 13) to allocate more time to rigorously testing and securing the core application (XML export, photo uploads, and admin panel). This trade-off of a minor, non-essential feature for the stability and security of the core product was deemed a necessary and positive outcome for the project.

4.2. Future Work

The current system provides a robust and stable foundation. The way ahead for this project involves extending its capabilities, primarily by leveraging the structured data it now produces.

1. **XML Import Functionality:** The most logical next step. The system already has a robust XSD. A future module could allow users to *upload* an XML file. The system would first validate it against the XSD and then parse it (using JAXB or DOM) to automatically import the recipe into their collection. This would complete the data portability cycle.

2. **Refactor to REST API:** The current monolithic architecture was perfect for this project, but for future scalability (e.g., a mobile app), the "way ahead" would be to refactor. The business logic (DAO, Service layers) can be decoupled and exposed as a **RESTful API**. The existing JSP frontend could then be replaced by a modern JavaScript framework (React/Angular), or a new **native mobile app** could be built to consume the same API.
3. **Advanced Search (Elasticsearch):** The current search is a simple SQL LIKE query. For a large-scale food blog, this is inefficient. A future modification would be to integrate a dedicated search engine like **Elasticsearch** or **Apache Solr**. The system could index recipe data, allowing for complex, full-text, and typo-tolerant search.
4. **Meal Planner & Shopping List:** With structured ingredient data, the system is perfectly poised to add a "Meal Planner" module. Users could drag-and-drop recipes onto a weekly calendar. The system could then automatically aggregate all ingredients from the selected recipes, de-duplicate them, and generate a printable shopping list.
5. **Social & Community Integration:** Fully implement the "Ratings & Reviews" system. Expand the Admin Panel to include a full "social" layer, allowing users to "follow" other chefs, create public-facing blog profiles, and share recipes on social media (via a "Share" button that links to their public recipe page).

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APPENDIX

Appendix A: Entity-Relationship Diagram (ERD)

Below is a text-based description of the database schema, which was visually designed in MySQL Workbench.

Table: users

- user_id (INT, PRIMARY KEY, AUTO_INCREMENT)
- username (VARCHAR(50), NOT NULL, UNIQUE)
- email (VARCHAR(100), NOT NULL, UNIQUE)
- password_hash (VARCHAR(255), NOT NULL)
- is_admin (BOOLEAN, NOT NULL, DEFAULT 0)
- created_at (TIMESTAMP, DEFAULT CURRENT_TIMESTAMP)

Table: recipes

- recipe_id (INT, PRIMARY KEY, AUTO_INCREMENT)
- user_id (INT, FOREIGN KEY references users(user_id))
- title (VARCHAR(255), NOT NULL)
- description (TEXT)
- steps (TEXT, NOT NULL)
- prep_time (VARCHAR(50))
- cook_time (VARCHAR(50))
- created_at (TIMESTAMP, DEFAULT CURRENT_TIMESTAMP)

Table: ingredients

- ingredient_id (INT, PRIMARY KEY, AUTO_INCREMENT)
- recipe_id (INT, FOREIGN KEY references recipes(recipe_id) ON DELETE CASCADE)
- name (VARCHAR(100), NOT NULL)
- quantity (VARCHAR(20))

- unit (VARCHAR(30))

Table: photos

- photo_id (INT, PRIMARY KEY, AUTO_INCREMENT)
- recipe_id (INT, FOREIGN KEY references recipes(recipe_id) ON DELETE CASCADE)
- photo_url (VARCHAR(255), NOT NULL)

Table: categories

- category_id (INT, PRIMARY KEY, AUTO_INCREMENT)
- category_name (VARCHAR(50), NOT NULL, UNIQUE)

Table: recipe_categories (Join Table)

- recipe_id (INT, FOREIGN KEY references recipes(recipe_id) ON DELETE CASCADE)
- category_id (INT, FOREIGN KEY references categories(category_id) ON DELETE CASCADE)
- PRIMARY KEY (recipe_id, category_id)

Table: favorites (Join Table)

- user_id (INT, FOREIGN KEY references users(user_id) ON DELETE CASCADE)
- recipe_id (INT, FOREIGN KEY references recipes(recipe_id) ON DELETE CASCADE)
- PRIMARY KEY (user_id, recipe_id)
