BILKENT UNIVERSITY

ON THE SHELF

PROJECT SPECIFICATION DOCUMENT

CS491 SENIOR DESIGN PROJECT

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1. Introduction

In today's busy world, efficiently managing household tasks like grocery shopping has become increasingly important. As a fundamental part of daily life, grocery shopping often presents challenges related to planning, organization, and time management. Families as well as individuals often face difficulties in managing kitchen inventory, planning meals, and preparing accurate shopping lists according to what their needs are. While the digital era has introduced a variety of applications to address similar challenges, a complete, user-friendly solution that combines these features into a smooth experience is still needed.

Recognizing this need, our project offers a new grocery management app designed to change the way users keep track of their kitchen supplies. Using a mix of receipt scanning and manual input, our app will learn what products users have and remind them when items are running low. It will also suggest recipes based on what's available in their kitchen, helping users make the most of their ingredients and reduce food waste. Additionally, it will create smart shopping lists, automating the process to save users time and make their grocery shopping more efficient.

This project addresses a current need: the need for efficiency and personalization in household management. Apart from just tracking inventory, the app introduces a social aspect by allowing collaborative management within families. Additional users can make requests or add notes to the shopping list, making it easier for families to plan groceries together transparently and collaboratively.

Our project aims to make grocery shopping easier and more efficient by using smart, automated tools. It helps users make better choices, reduce food waste, and create a better balance between what they need and what they have in their kitchen.

1.1 Description

Our grocery management app is created to offer a complete solution for keeping track, organizing, and planning household groceries. The app mainly uses two ways to identify products:

1. **Receipt Scanning:** Users can take a photo of their shopping receipts, and the app will extract product information to update the inventory automatically.
2. **Manual Input:** Users can add products manually, ensuring flexibility and adaptability for unique or custom items.

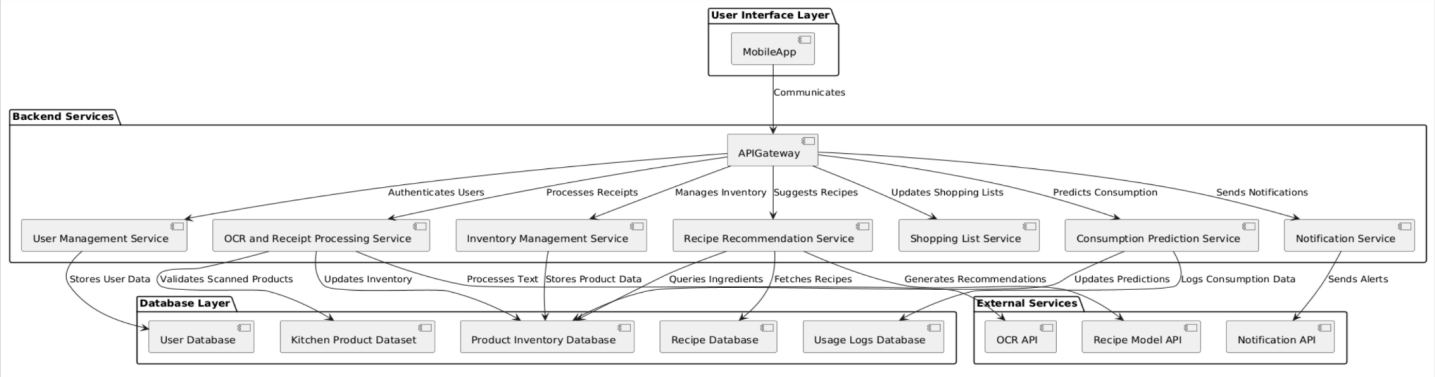
Key features of the app include:

- **Kitchen Inventory Management:** Users can view a complete list of items in their kitchen, with details about quantities and expiration dates.
- **Meal Suggestions:** The app analyzes available ingredients and suggests recipes or meals that users can prepare. Users can also input their allergies to ensure that meal suggestions align with their dietary needs, adding a personalized touch to meal planning.
- **Smart Shopping Lists:** When products are marked as finished, the app automatically adds them to a shopping list, minimizing the risk of forgotten items.
- **Collaborative Requests:** Additional users, such as family members, can make requests that appear on the main user's shopping list. Each request will display the name of the person who made it, ensuring clear and effective communication within the household.

This app is particularly useful for families and multi-person households, where collaborative grocery management is essential. It also aims to minimize food waste by helping users track what they have and plan meals effectively.

By combining useful features with an easy-to-use design, our app connects technology with everyday life. It offers a smarter and more personalized way to manage groceries, making it a valuable tool for today’s households.

1.2 High-Level System Architecture & Components of Proposed Solution



1.3 Constraints

1.3.1. Implementation Constraints

- The OCR processing time must not exceed 5 seconds per receipt to ensure a smooth user experience.
- UI interactions, such as adding products or updating the shopping list, must respond within 100 milliseconds to maintain a seamless user experience.
- The recipe recommendation engine should provide results within 3 seconds after querying available ingredients.
- Notifications for product expiration or low-stock alerts must be sent in real-time or within 1 minute of the trigger event.
- Only kitchen-related products should be stored in the inventory by cross-checking the Kitchen Product Dataset.
- Receipt images must be compressed before storage, with a maximum size of 2 MB per image to minimize storage costs.
- The product inventory database should support indexing to enable fast searches for specific products.
- The Kitchen Product Dataset must be updated monthly to reflect new product additions or removals.

1.3.2. Economic Constraints

- Open-source libraries and frameworks will be used to minimize development costs.
- Cloud services, if required, will be selected based on affordability. Platforms like *Firebase* [1] or *AWS* [2] have free options or educational credits that we can use during development.
- For advanced features like receipt scanning using OCR, we will review the costs and benefits of paid tools or APIs. Wherever possible, we will use free or open-source options instead.
- *GitHub*'s [3] free tools will help us manage our code and work together without adding extra costs.

1.3.3. Ethical Constraints

- **Data Privacy:** User data must remain confidential, stored securely, and not shared without explicit consent.
- **Transparency:** Clearly inform users about data collection and use through a privacy policy.
- **Intellectual Property:** Avoid using copyrighted materials without permission; respect user-contributed content.
- **Fairness:** Ensure algorithms are unbiased and inclusive of diverse dietary preferences.
- **Accuracy:** Provide reliable predictions and suggestions to avoid misleading users.
- **User Control:** Allow users to delete their data and accounts permanently.
- **Sustainability:** Promote waste reduction without encouraging over-purchasing or unsustainable practices.
- **Safety:** Warn users about allergens.
- **Ethical Marketing:** Avoid misleading advertising.
- **Partnership Accountability:** Ensure ethical standards in collaborations with external stakeholders.

1.4 Professional and Ethical Issues

Professional and ethical issues in developing *On the Shelf* include ensuring data privacy and security, maintaining transparency about data usage, and respecting user consent. Intellectual property rights must be upheld, to avoid unauthorized use of copyrighted content. Algorithms must be fair, unbiased, and inclusive, while suggestions and predictions must be accurate and reliable. The app should promote sustainable practices, avoid misleading marketing, and prioritize user safety. Developers must ensure accountability in partnerships and provide users with control over their data, fostering trust and upholding ethical standards in all aspects of the project.

1.5 Standards

- UML 2.5.1 for modeling
- IEEE 830 for requirements documentation
- IEEE for referencing style

2. Design Requirements

2.1. Functional Requirements

2.1.1. Product Tracking

- The system shall allow users to add/edit/delete products from their inventory manually.
- The system shall allow users to scan or upload receipt images.
- The system shall use OCR to extract products from receipts.
- The system shall verify extracted data for accuracy and allow users to correct errors before adding to the inventory.
- The system shall notify users of products when their expiration dates get close.
- The system shall filter the products in the inventory.

2.1.2. Consumption Prediction

- The system shall record product consumption history, such as quantity and frequency.
- The system shall predict when a product will likely run out based on consumption history.
- The system shall log and report waste due to expired or unused products.

2.1.3. Shopping List Creation

- The system shall automatically generate a shopping list for products predicted to run out soon.
- The system shall allow users to add, remove, or edit items in the shopping list.
- The system shall update the shopping list dynamically as products are added, used, or edited in the inventory.

2.1.4. Recipe Recommendations

- The system shall suggest recipes based on the products available in the user's inventory.
- The system shall allow users to input their allergies and diet preferences.
- The system shall recommend meals according to their allergies and diet preferences.

2.1.5. Family Member Accounts

- The system shall allow the primary user to create sub-accounts with restricted permissions.
- The system shall allow the primary user to assign permissions such as viewing inventory, adding suggestions, or editing shopping lists.

2.1.6. User Interface and Usability

- The system shall allow users to access features like inventory, shopping lists, and recipes.
- The system shall support multiple languages for a diverse user base.

2.1.7. Additional Features

- The system shall send notifications for upcoming expiration dates, low-stock alerts, and suggested shopping list updates.
- The system shall synchronize data for the same user account across multiple devices.

2.2. Non-Functional Requirements

2.2.1. Usability

- The system shall provide a clear and understandable interface suitable for all users.
- The system shall be optimized for mobile devices, ensuring seamless operation on both iOS and Android.

2.2.2. Reliability

- The system shall be available 99.5% of the time, minimizing the downtime.
- The system shall handle failures delicately, providing meaningful error messages and logging issues for debugging.
- The system shall ensure that no data is lost or corrupted during operations such as synchronization or updates.

2.2.3. Performance

- The system shall respond to simple user actions, such as adding products, generating shopping lists, etc., within 2 seconds under normal circumstances.

- The system shall display the user's inventory in under 3 seconds.

2.2.4. Maintainability

- The system shall be implemented using modular architecture to enable future updates and enhancements.
- All code shall be well-documented and clearly written to allow developers to understand and maintain the system efficiently.

2.2.5. Accessibility

- The system shall be accessible for both iOS and Android users.

2.2.6. Security

- The system shall store the sensitive information in an encrypted format.

2.2.7. Efficiency

- The system shall use device resources efficiently, consuming minimal battery, CPU, and memory on mobile devices.

3. Feasibility Discussions

3.1. Market & Competitive Analysis

In recent years, numerous applications have emerged to assist users in organizing their lives. However, many of these apps fall short in addressing the specific needs of efficient grocery management and food waste reduction. *On the Shelf* aims to fill this gap by offering a comprehensive solution that leverages technology to assist households with their kitchen management and help to minimize waste. To better understand the position of *On the Shelf* in the market, this section *examines four similar apps - Whisk* [4]*, KitchenPal* [5]*, Paprika* [6]*,* and *What's Left* [7] - analyzing their strengths, weaknesses, and how they compare to our proposed solution. This analysis

also emphasizes how *On the Shelf* bridges gaps in current offerings by integrating features that are mentioned in the above sections.

Another one is *Whisk.* It offers a recipe library with search and suggestion functionality. Users can even leverage AI to create custom recipes based on their preferences or specific ingredients. Additionally, *Whisk* facilitates collaboration through shared grocery lists and automatic ingredient detection from recipes. While these features are valuable for recipe discovery and meal planning, *Whisk* doesn't prioritize features that directly tackle food waste. It has more focus on meal planning needs rather than serving as a kitchen management app. It lacks some of the core features that *On the Shelf* provides, particularly in grocery inventory management. *Whisk* does not have robust features for tracking what ingredients are already in the pantry or keeping track of expiration dates, which is a key element in reducing food waste. Notably, *Whisk* does not offer receipt scanning, meaning users must manually input items into their inventory, which can be time-consuming. *On the Shelf* goes further by offering integrated grocery inventory management functionalities with meal planning features, making it a more holistic app.

The third one is *KitchenPal. KitchenPal* is a pantry management and meal planning app designed to help users organize their kitchen inventory, create grocery lists, and plan meals more efficiently. It offers help to manage pantry items, create shopping lists, and explore recipe ideas based on the ingredients available. Users can also compare products to make informed purchasing decisions and find the best deals while grocery shopping. While *KitchenPal* focuses heavily on meal planning and inventory management, *On the Shelf* goes a step further in encouraging sustainable practices and optimizing kitchen organization in a more integrated and comprehensive way. Also, *KitchenPal* lacks some features, it does not have a shared grocery list feature, which we predict to be beneficial for households or groups coordinating their shopping efforts. *KitchenPal* does not include receipt scanning, meaning users can only manually input items into their inventory, which can be time-consuming. This absence of automatic inventory updates makes it less efficient compared to *On the Shelf*.

The last one is *Paprika*. *Paprika* is designed as a recipe manager and meal planner, offering features like recipe organization, meal planning, and grocery list creation. Users can save recipes from websites, create meal plans, and generate shopping lists based on selected recipes. While *Paprika* excels as a recipe-focused tool, it lacks several key functionalities that our grocery management app provides. For instance, *Paprika* does not offer receipt scanning, which is a cornerstone of our app, allowing users to automatically update their inventory without manual effort. *Paprika's* pantry management is basic and does not include detailed tracking of quantities or expiration dates, unlike our app, which emphasizes these features to reduce food waste. Our app also stands out with its meal suggestion feature, which analyzes the current inventory to recommend recipes. In contrast, *Paprika* relies on users manually selecting recipes, making it less dynamic. Additionally, our app's collaborative request feature, which enables multiple users to contribute to the shopping list with notes and requests, adds a layer of household communication that *Paprika* does not address.

The first app is *What's Left*. Its key features include receipt scanning for automatic inventory updates, keeping digital receipts for record-keeping, tracking the money spent on groceries, and account sharing for collaborative inventory management. These functionalities make it a practical tool for users seeking detailed grocery tracking and spending insights. However, while *What's Left* shares many features with *On the Shelf*, it lacks some of the advanced personalization and planning options our app offers. One key difference is that *On the Shelf* includes a section for managing dietary preferences and allergens for all household members. This feature allows users to select individuals when receiving AI-generated recipe suggestions, ensuring meal plans are tailored to specific needs. By addressing dietary requirements directly, our app offers a more inclusive and practical solution for families or groups with diverse dietary restrictions. This personalized functionality, combined with the robust grocery management features shared with *What's Left*, makes *On the Shelf* a more comprehensive and user-centric platform.

All these apps share some similarities with ours, such as recipe suggestions, meal planning, and basic grocery management. However, none of them integrates all

these features into a single, cohesive solution with the same focus as ours. Our app stands out as a collaborative, waste-free, and all-in-one platform, combining detailed kitchen inventory management, receipt scanning for automated updates, smart meal suggestions, and shared shopping list functionality. Our app offers a unique and innovative approach to modern grocery management by prioritizing sustainability and seamless household coordination, making it truly one of a kind.

3.2.Academic Analysis

This section explores key academic concepts and technologies relevant to the app's core features: inventory management, receipt scanning, meal suggestions, and collaborative functionalities.

3.2.1. OCR for Receipt Scanning

OCR technology is vital for automating the extraction of product details from receipts, enabling efficient and accurate inventory updates. Academic research underscores OCR's ability to interpret printed text with high accuracy when combined with advanced algorithms. Holley [8] mentions that OCR systems, when coupled with robust preprocessing and advanced algorithms, can achieve high levels of accuracy in recognizing printed text. The reported accuracy rates for printed text in controlled environments often exceed 95%, depending on factors such as text clarity, font variability, and image quality [8]. Incorporating a machine learning model for OCR can significantly improve the app's receipt scanning functionality. Models like Tesseract offer a cost-effective solution and can be enhanced with neural network-based approaches, such as convolutional neural networks (CNNs), to address the diverse font styles and layouts commonly found on receipts. Alternatively, pre-trained models like Google Vision API and AWS Textract provide robust performance and advanced capabilities, particularly for handling complex or non-standard receipt formats.

3.2.2. Inventory Management Systems

The concept of inventory management has been explored in academic literature, particularly in the context of optimizing supply chains. However, applying these principles to household settings is a novel approach. Studies on IoT-based smart refrigerators demonstrate the potential for technology to track and monitor household inventory in real time [9]. While *On the Shelf* does not rely on IoT devices, it adapts similar methodologies, such as real-time data updates and user notifications for low-stock or expired items.

3.2.3. Recipe Recommendation Systems

When it comes to recommendation systems collaborative filtering and content-based filtering are commonly used methodologies for personalizing recommendations. While developing our application one of these two approaches or a combined version of them might be applied. According to Gaikwad[10], the combined version yields more accurate results in food recommendation systems. Furthermore, incorporating dietary preferences and allergen information is crucial for considering user-specific health parameters in meal-planning applications. By integrating natural language processing (NLP) to analyze user inputs (e.g., dietary restrictions) and matching them with a recipe database, the app can generate highly relevant meal suggestions.

3.2.4. Collaborative Features and Usability

Research on collaborative tools shows the importance of user-friendly interfaces and seamless data sharing for effective teamwork. *On the Shelf* builds on these findings by allowing multiple users to interact with the same shopping list, with features such as tagging requests with contributor names and enabling sub-account permissions. Usability studies also underline the significance of designing interfaces accessible to diverse users, including non-technical users. Adhering to guidelines such as Nielsen’s

Usability Heuristics ensures the app is intuitive and user-friendly, reducing the learning curve for new users [11].

3.2.5. Sustainability and Food Waste Reduction

On the Shelf's goal of reducing food waste aligns with global sustainability initiatives, such as the United Nations' Sustainable Development Goal 12: Responsible Consumption and Production. Academic studies on food waste management suggest that awareness and tracking are critical for behavioral change [12]. By providing users with insights into their consumption patterns and waste history, our app applies these principles to encourage more sustainable practices.

4. Glossary

- OCR: Optical Character Recognition
- UI: User Interface
- MB: Megabyte
- AWS: Amazon Web Services
- API: Application Programming Interface
- AI: Artificial Intelligence
- IoT: Internet of Things
- UML: Unified Modelling Language
- IEEE: Institute of Electrical and Electronics Engineers

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