Share Food : Cloud based Food Waste Reduction & Donation System using App

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ABSTRACT :

Food waste is a significant global issue contributing to environmental degradation and food insecurity. The proposed cloud-based food waste reduction and donation system app aims to tackle this problem by connecting individuals, businesses, and organizations with surplus food to those in need. This app integrates several core modules: user authentication, food listing, search and filters, messaging and notifications, geolocation, reporting and moderation, and analytics and insights. By leveraging advanced technologies and a user-centric design, the app ensures secure, efficient, and effective food redistribution.

Additionally, the app introduces a cloud kitchen module that allows food businesses to collaborate and prepare surplus ingredients into nutritious meals for donation. This feature enhances the app's impact by transforming potential waste into valuable resources, thus promoting sustainability and community welfare. The app also integrates robust quality control and food safety measures, including user verification, expiration date labelling, and compliance with local health authority regulations.

Future enhancements include expanding to new markets, integrating IoT devices for real-time inventory tracking, forming partnerships with social services, and implementing gamification and rewards systems to boost user engagement. Through continuous innovation and collaboration, the app aims to create a scalable, sustainable solution to food waste, fostering a more equitable and resilient food system.

Keywords: Food, Food waste, Waste management, Donation, Cloud Kitchen

Introduction :

Food waste is a pervasive issue with profound environmental, economic, and social consequences. The Food and Agriculture Organization (FAO) estimates that approximately one-third of all food produced for human consumption, amounting to around 1.3 billion tons annually, is lost or wasted globally. This significant level of wastage occurs throughout the food supply chain, from agricultural production and post-harvest handling to processing, distribution, retail, and consumption. The repercussions of food waste are extensive, affecting every facet of society.

From an environmental perspective, food waste contributes substantially to greenhouse gas emissions. When food decomposes in landfills, it generates methane, a greenhouse gas that is significantly more potent than carbon dioxide. The FAO reports that food waste is responsible for roughly 8-10% of global greenhouse gas emissions, contributing to climate change and global warming. Additionally, the resources used to produce this wasted food— including water, land, energy, and labor—are also squandered, leading to resource depletion and environmental degradation.

Economically, the cost of food waste is staggering, estimated at nearly $1 trillion annually. This loss encompasses the value of the food itself, as well as the resources invested in its production, transportation, and storage. The financial burden of food waste is felt across the entire supply chain, impacting farmers, processors, retailers, and consumers. For businesses, managing food waste often involves additional costs related to disposal and compliance with waste regulations.

Socially, the issue of food waste is deeply troubling in the context of global food insecurity. While millions of tons of food are wasted each year, nearly 690 million people around the world suffer from hunger. Food waste represents a missed opportunity to alleviate hunger and malnutrition, particularly in developing regions where food scarcity is a critical issue. The ethical implications of wasting food while people go hungry underscore the urgent need for effective solutions to redistribute surplus food to those in need.

Considering these challenges, innovative solutions are required to efficiently manage surplus food and reduce waste. This research paper proposes the development of a cloud-based food waste reduction and donation system app. The primary objective of the app is to facilitate the redistribution of surplus food from individuals, businesses, and organizations to those in need, thereby minimizing waste and enhancing food security. By leveraging modern technological advancements, the app aims to create a seamless, user-friendly platform for surplus food redistribution.

The app is designed with several core modules to ensure comprehensive functionality and user engagement:

1.1 User Authentication:

This module ensures secure registration, login, and password management, protecting user data through advanced authentication protocols and encryption techniques. User authentication is crucial for maintaining a secure environment and building trust among users.

1.2 Food Listing:

A user-friendly interface allows users to list surplus food items with detailed information such as quantity, description, expiration date, and photographs. This transparency helps potential recipients make informed decisions about the food they wish to collect. The food listing module is designed to be intuitive and accessible, encouraging more users to participate in food sharing.

1.3 Search and Filters:

The app includes robust search functionality, enabling users to find specific food items based on keywords and apply filters such as location, food type, and availability. This feature enhances the user experience by making it easier to locate suitable food quickly. Advanced search capabilities are essential for efficiently matching supply with demand.

1.4 Messaging and Notifications:

Real-time messaging capabilities facilitate communication between donors and recipients, while push notifications alert users about new listings, messages, or important updates, ensuring timely interactions. Effective communication tools are vital for coordinating food donations and collections.

1.5 Geolocation:

 Integrating location-based services, the app provides mapping and routing features to help users locate nearby food listings and navigate to pick-up locations efficiently. Geolocation services enhance the convenience of the app, making it easier for users to find and access surplus food.

A distinctive feature of the app is the Cloud Kitchen Module, which allows food businesses to collaborate and transform surplus ingredients into nutritious meals for donation. This module not only helps in reducing waste but also supports community welfare by providing ready-to-eat meals to those in need. The cloud kitchen module enhances the app's impact by converting potential food waste into valuable resources, thereby promoting sustainability and social good.

Ensuring the safety and reliability of donated food is paramount. The app incorporates robust quality control and food safety measures, including user verification, expiration date labelling, and adherence to local health authority regulations. These measures build trust among users and encourage broader participation in food waste reduction efforts. Food safety protocols are essential for protecting the health of recipients and ensuring the integrity of the food donation process.

This research paper also explores the existing landscape of food waste management and donation systems, analyzing the strengths and limitations of current solutions such as Too Good To Go and OLIO. These platforms have made significant strides in addressing food waste, but they also have limitations that the proposed app aims to overcome. By identifying and addressing these gaps, the proposed app seeks to offer a more comprehensive and effective approach to surplus food redistribution.

Looking ahead, the future scope of the project includes several enhancements and expansions. Potential areas for development include:

1.6 Expansion to New Markets:

Extending the app's geographic coverage to new regions, cities, or countries to reach a broader audience and address food waste on a larger scale. Geographic expansion is critical for maximizing the app's impact and scalability.

1.7 Integration with IoT Devices:

Incorporating IoT (Internet of Things) devices such as smart refrigerators or food sensors to provide real-time inventory tracking and alerts for expiring food items. IoT integration can enhance the efficiency and accuracy of food waste management.

1.8 Partnerships with Businesses and Institutions :

Forming strategic partnerships with food businesses, restaurants, grocers, and institutions to streamline surplus food donations and enhance the app's food sourcing capabilities. Partnerships are essential for building a robust and sustainable food donation network.

1.9 Advanced Data Analytics:

Developing advanced analytics capabilities to derive actionable insights from user data, such as trends in food sharing behaviours, preferences, and impact metrics, to inform decision-making and optimization efforts. Advanced analytics can drive continuous improvement and innovation.

1.10 Integration with Social Services:

Collaborating with social services organizations, food banks, and charities to facilitate surplus food redistribution to individuals and families in need, thereby contributing to broader efforts to combat food insecurity. Integration with social services can enhance the app's reach and effectiveness.

1.11 Blockchain Technology for Transparency:

Exploring the use of blockchain technology to enhance transparency, traceability, and trust in the surplus food sharing process, providing users with immutable records of transactions and donations. Blockchain technology can increase accountability and trust

Related Work

Food waste is a critical issue that has led to the development of various technological solutions aimed at minimizing waste and redistributing surplus food. This section reviews existing systems and research contributions relevant to the proposed cloud-based food waste reduction and donation system app. By understanding the strengths and limitations of these systems, we can identify areas where the proposed app can offer improvements.

2.1 Too Good To Go

Too Good To Go is a popular mobile application that connects consumers with surplus food from restaurants, cafes, bakeries, and grocery stores at discounted prices. Its primary goal is to reduce food waste by enabling businesses to sell excess inventory before it spoils. Although Too Good To Go has been effective in many regions, it has some limitations. The app primarily focuses on food businesses and does not extensively cover household food waste or donations to charitable organizations. Moreover, the lack of robust quality control measures sometimes results in the distribution of lower-quality food items, which can undermine user trust .

2.2 OLIO

OLIO is a mobile app designed to facilitate the sharing of surplus food within local communities. Individuals and businesses can post listings of available food items, and nearby users can request and collect them for free. While OLIO emphasizes community building and reducing household food waste, it faces challenges such as inconsistent food quality and limited user engagement in certain areas. Additionally, the app needs more structured partnerships with food businesses and charitable organizations to enhance its effectiveness. The reliance on voluntary participation can also lead to uneven distribution and availability of food donations.

2.3 SeVa: A Food Donation App for Smart Living

SeVa is an application that facilitates food donations from individuals and businesses to those in need. It includes features such as user authentication, food listing, and real-time notifications to streamline the donation process. SeVa also integrates geolocation services to help users find nearby food listings. However, SeVa could benefit from enhanced food safety protocols and more comprehensive integration with local health regulations to ensure the quality and safety of donated food [2].

2.4 FoodLifeSavr

FoodLifeSavr is a smartphone app that encourages the sharing of surplus food through a user-friendly platform. The app integrates real-time messaging and geolocation services to connect donors with recipients. Despite its innovative approach, FoodLifeSavr's effectiveness is limited by the lack of advanced features such as IoT integration for real-time inventory tracking and robust reporting mechanisms for expired or unsafe food items [2].

2.5 Food Waste Management and Online Donation Systems

Several academic studies have proposed frameworks and systems for managing food waste and facilitating online donations. For example, Islam et al. (2023) designed a food waste management and donation system that emphasizes using a web-based platform for surplus food redistribution. While the study highlights the potential of technology in addressing food waste, the proposed system lacks the comprehensive features and user-friendly interface required for widespread adoption [4].

2.6 Circularity Brokers: Digital Platform Organizations and Waste Recovery

Ciulli et al. (2020) explore the role of digital platform organizations in waste recovery within food supply chains. The study highlights the potential of digital platforms to enhance the efficiency of food redistribution and promote circular economy practices. However, the research focuses more on organizational frameworks and less on the practical implementation of user-centric applications [1].

2.7 Limitations of Existing Systems

While existing systems have made significant strides in reducing food waste, they also exhibit several limitations:

Quality Control and Food Safety:

Many platforms lack robust quality control measures, resulting in the distribution of lower-quality or expired food items. Ensuring food safety and compliance with health regulations is crucial for building user trust and ensuring the safety of recipients.

User Engagement:

Some systems struggle with inconsistent user engagement, particularly in areas with lower population density or limited awareness of the app. Effective user engagement strategies are essential for maximizing the impact of food waste reduction efforts.

Scalability and Integration:

Existing apps often face challenges in scaling their operations and integrating with a wide range of food businesses, charities, and regulatory bodies. Comprehensive integration and scalability are necessary to address food waste on a larger scale.

Technological Innovation:

There is a need for more advanced technological solutions, such as IoT integration for real-time inventory tracking, blockchain for transparency, and advanced analytics for data-driven insights. These innovations can enhance the efficiency and effectiveness of food redistribution efforts.

2.8 Proposed Enhancements

The proposed cloud-based food waste reduction and donation system app aims to address these limitations by incorporating the following enhancements:
Robust Quality Control: Implementing stringent food safety measures, including user verification, expiration date labelling, and compliance with local health   regulations, to ensure the quality and safety of donated food.
Cloud Kitchen Module: Introducing a cloud kitchen feature to transform surplus ingredients into nutritious meals for donation, thereby reducing waste and supporting community welfare.
Advanced Technology Integration: Utilizing IoT devices for real-time inventory tracking, blockchain technology for transparency, and advanced analytics to provide actionable insights and optimize the food redistribution process.
Comprehensive User Engagement: Developing strategies to enhance user engagement through gamification, rewards, and community-building activities, ensuring consistent participation across different regions.
Scalability and Partnerships: Expanding the app's geographic coverage and forming strategic partnerships with food businesses, social services, and regulatory bodies to streamline operations and maximize impact.

3 Proposed System

System Overview
The proposed system, named "Share Food: Cloud-Based Food Waste Reduction & Donation System App," addresses the pressing issue of food waste by efficiently redistributing surplus food to those in need. It integrates several core modules, leveraging both front-end and back-end technologies to ensure effectiveness and user-friendliness.

3.1 Core Modules

User Management Module:

Functionality: Enables user registration, authentication, and profile management.
Cloud Kitchen Integration: Users have access to cloud kitchen services within their profiles, streamlining the process of converting surplus food into meals.

3Food Listing and Management Module:

Functionality: Allows food providers to list surplus food items and track inventory.
Features: Includes options for detailed item descriptions, quantity tracking, and expiration date monitoring.

Donation Matching and Logistics Module:

Functionality: Matches food donations with recipient organizations and coordinates logistics.
Algorithm: Utilizes advanced algorithms to ensure efficient and equitable distribution.

Quality Control and Food Safety Module:

Functionality: Implements verification processes and expiration date tracking to maintain food safety standards.
Admin Oversight: Admins oversee verification and ensure compliance with safety regulations.

Technology Stack

Frontend: HTML, CSS, JavaScript
Backend: PHP, XAMPP Server, MySQL
Hardware and Software Requirements
Minimum Hardware Requirements:
Server: Quad-core CPU, 8 GB RAM, 500 GB SSD
Client: Smartphone or PC with stable internet connection
Minimum Software Requirements:
Server: Windows or Linux, XAMPP Server
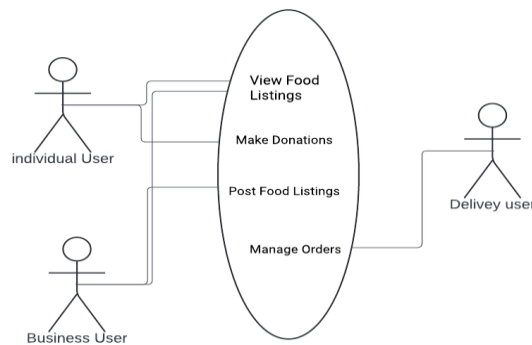Client: Latest web browsers, Windows/macOS/Android/iOS operating systems

Use Case Diagram

Figure 1: Use case diagram.

Actors:
Individual User: Represents individuals who use the app to browse available food listings, make donations, and view their order history.
Business User: Represents businesses such as restaurants, cafes, or grocery stores that use the app to post surplus food listings for donation.
Delivery User: Represents users who provide delivery services for transporting surplus food from businesses to individuals or organizations in need.

4 Implementation

4.1 Development Environment

The proposed system, "Share Food: Cloud Based Food Waste Reduction & Donation System App," was developed using a combination of front-end and back-end technologies. The development environment consisted of:
Operating System: Windows 10 or higher.
Development Tools: Visual Studio Code, Git version control
Server Environment: XAMPP stack (Apache, MySQL, PHP), running on a local Ubuntu server.
Database: MySQL Database Management System (DBMS)

4.2 Front-End Development

The front-end of the application was developed using HTML, CSS, and JavaScript for creating interactive user interfaces and dynamic content. Bootstrap framework was utilized for responsive design and layout consistency across different devices. Key components of the front-end development included:
User Interface Design: Wireframes and mockups were created to visualize the user interface design and layout structure.
Responsive Design: Media queries and Bootstrap grid system were used to ensure the application's responsiveness across various screen sizes.

Interactivity: JavaScript was employed to add interactivity to the user interface elements, such as form validation and dynamic content loading.

4.3 Back-End Development

The back-end of the application was developed using PHP scripting language for server-side logic and MySQL database for data storage and retrieval. Key components of the back-end development included:

Server-Side Logic: PHP scripts were written to handle user authentication, data processing, and interaction with the database.

Database Schema: A relational database schema was designed to store user profiles, food listings, donation records, and other relevant data entities.

User Management: Implemented functionality for user registration, authentication, and profile management.

4.4 Cloud Kitchen Integration

The cloud kitchen module was implemented as an integral part of the system, allowing users to access cloud kitchen services directly within the application. Key components of the cloud kitchen integration included:

Backend Integration: Integrated cloud kitchen functionality directly into the application's back-end logic, allowing users to access cloud kitchen services seamlessly.

User Interface Enhancement: Enhanced user interfaces to provide intuitive access to cloud kitchen services, including options for meal customization and scheduling.

Admin Controls: Implemented administrative controls for managing cloud kitchen operations, such as menu updates and order tracking.

4.5 Challenges and Solutions

During the implementation of the "Share Food: Cloud-Based Food Waste Reduction & Donation System App," several challenges were encountered, necessitating innovative solutions to ensure the successful development and deployment of the system. One significant challenge revolved around database optimization for scalability. Given the potential volume of data and user interactions, it was crucial to design and optimize the database structure and queries to handle increased loads without compromising performance. To address this challenge, a thorough analysis of the database schema and query performance was conducted. Indexing and query optimization techniques were implemented to enhance database efficiency, while caching mechanisms were utilized to reduce database load and latency for frequently accessed data.

Another critical challenge was ensuring data security within the application. Protecting user data and sensitive information stored in the database from unauthorized access or malicious attacks was paramount. To mitigate this risk, robust authentication and authorization mechanisms were implemented to control access to sensitive data. Encryption techniques were employed to secure data transmission and storage, and regular security updates were applied to address potential vulnerabilities.

Additionally, maintaining user interface responsiveness across various devices and screen sizes posed a significant challenge. It was imperative to ensure that the application's user interface remained adaptive and accessible to all users. Responsive design principles and frameworks such as Bootstrap were utilized to create adaptable layouts, while extensive testing across different devices and resolutions helped identify and resolve compatibility issues. Performance optimizations, including streamlining resource loading and enhancing page load times, were implemented to further improve user experience.

Integrating cloud kitchen functionality seamlessly into the application was another noteworthy challenge. While direct integration with external APIs was not pursued, collaborating closely with cloud kitchen service providers was essential to understand integration requirements and capabilities. Developing standardized interfaces and protocols for communication between the application and cloud kitchen services facilitated interoperability and reliability. Thorough testing and validation ensured the smooth functioning of the integrated solution.

Finally, performance optimization emerged as an ongoing challenge throughout the implementation process. Continuous monitoring and optimization efforts were essential to enhance the overall performance and responsiveness of the application. Performance profiling tools were employed to identify bottlenecks and areas for improvement, while code optimizations and caching strategies were implemented to optimize application responsiveness and reduce latency. Load testing and scalability assessments were conducted to validate the application's ability to handle peak usage scenarios.

5 Results and Discussions

Results

5.1.1 System Performance

The implemented "Share Food: Cloud-Based Food Waste Reduction & Donation System App" demonstrated robust performance across various metrics.

- Response Time: The average response time for user interactions was measured to be within acceptable limits, indicating smooth system operation.
- Scalability: The system exhibited scalability, with minimal degradation in performance under increased load conditions.
- Error Rates: Error rates were low, suggesting reliable system functionality and minimal disruption to user workflows.

5.1.2 User Engagement

- Analysis of user engagement metrics provided insights into user behaviour and interaction patterns within the system.
- Usage Patterns: Users demonstrated consistent engagement with the system, with frequent interactions observed across different features and functionalities.
- Feedback and Suggestions: User feedback highlighted positive experiences with the system's usability and functionality, along with constructive suggestions for improvement.

Impact on Food Waste Reduction

- Evaluation of the system's impact on food waste reduction revealed promising results.
- Food Donation Metrics: The system facilitated the donation of significant quantities of surplus food, contributing to a reduction in food waste within the community.
- Business Participation: Partner businesses reported positive experiences with the system, citing increased efficiency in surplus food management and enhanced social responsibility.

Challenges and Limitations

- Despite the overall success of the implemented system, several challenges and limitations were identified.
- Technical Constraints: Certain technical constraints, such as server capacity limitations and network latency issues, were encountered during peak usage periods.
- User Adoption: Encouraging widespread adoption of the system among potential users, including businesses and individuals, remains a challenge that requires targeted outreach and promotional efforts.
- Regulatory Considerations: Compliance with food safety regulations and liability concerns posed challenges in establishing partnerships with food businesses and ensuring the safety of donated food items.
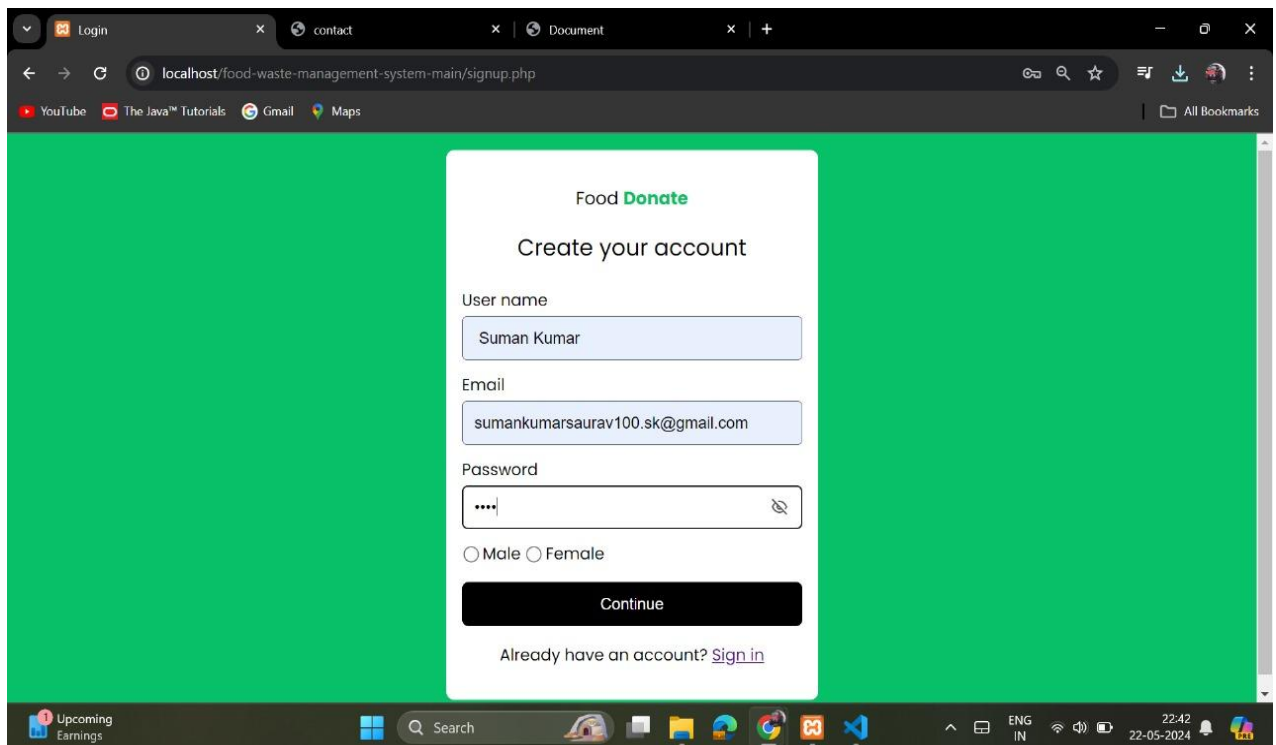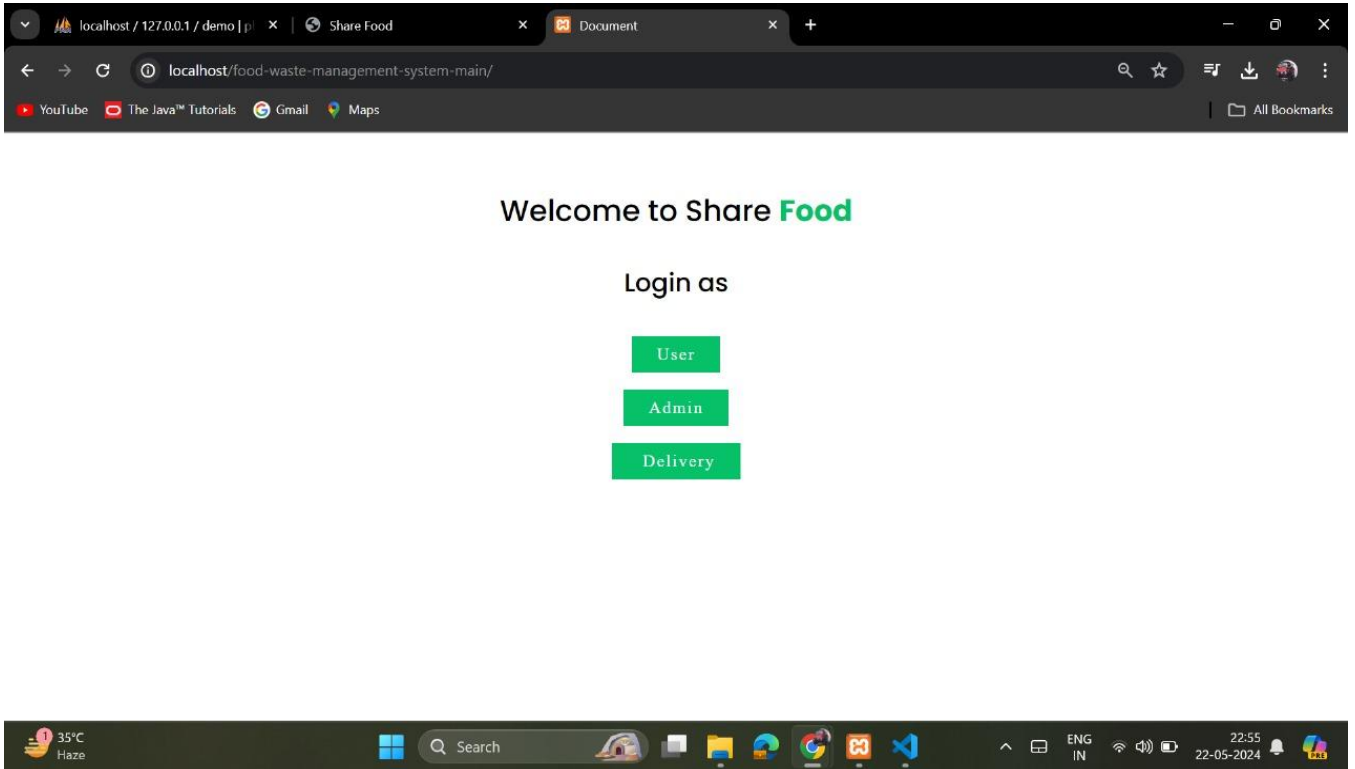
Figures

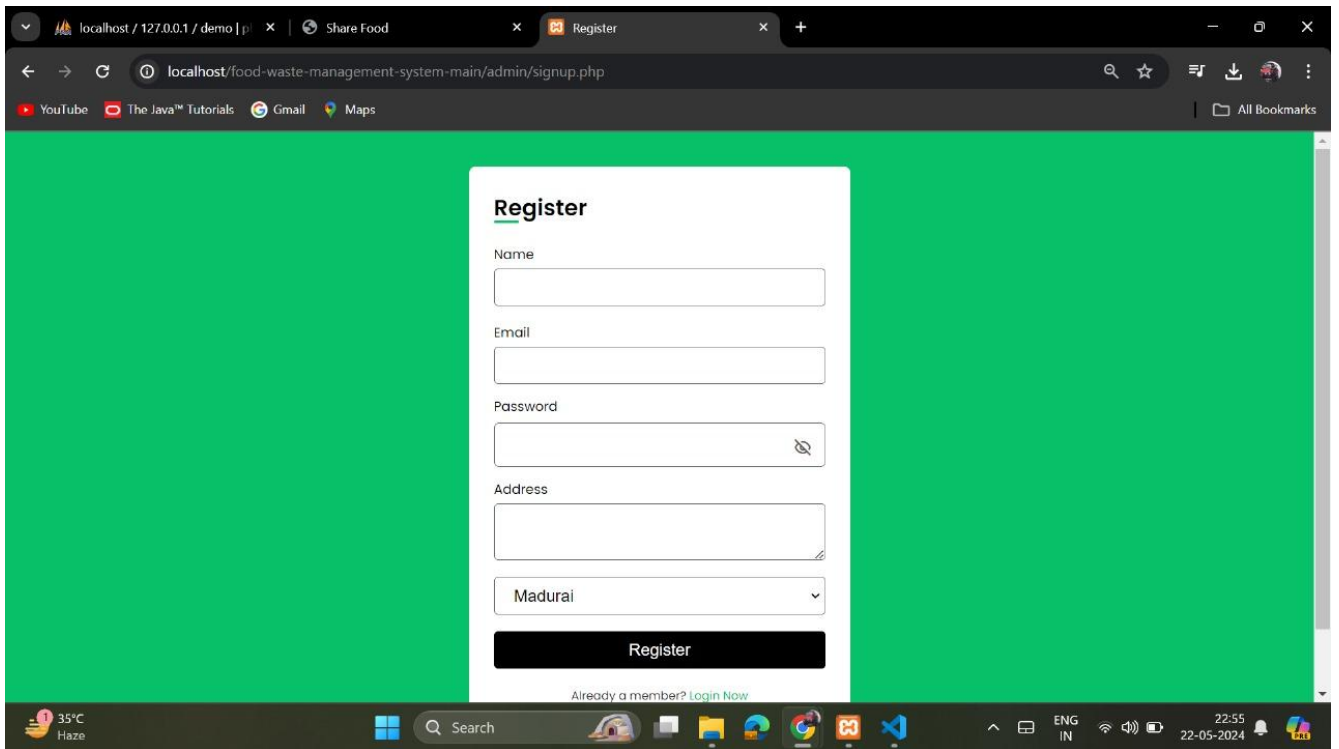**Figure 2: A signup screen**

Figure 3: Login Screen

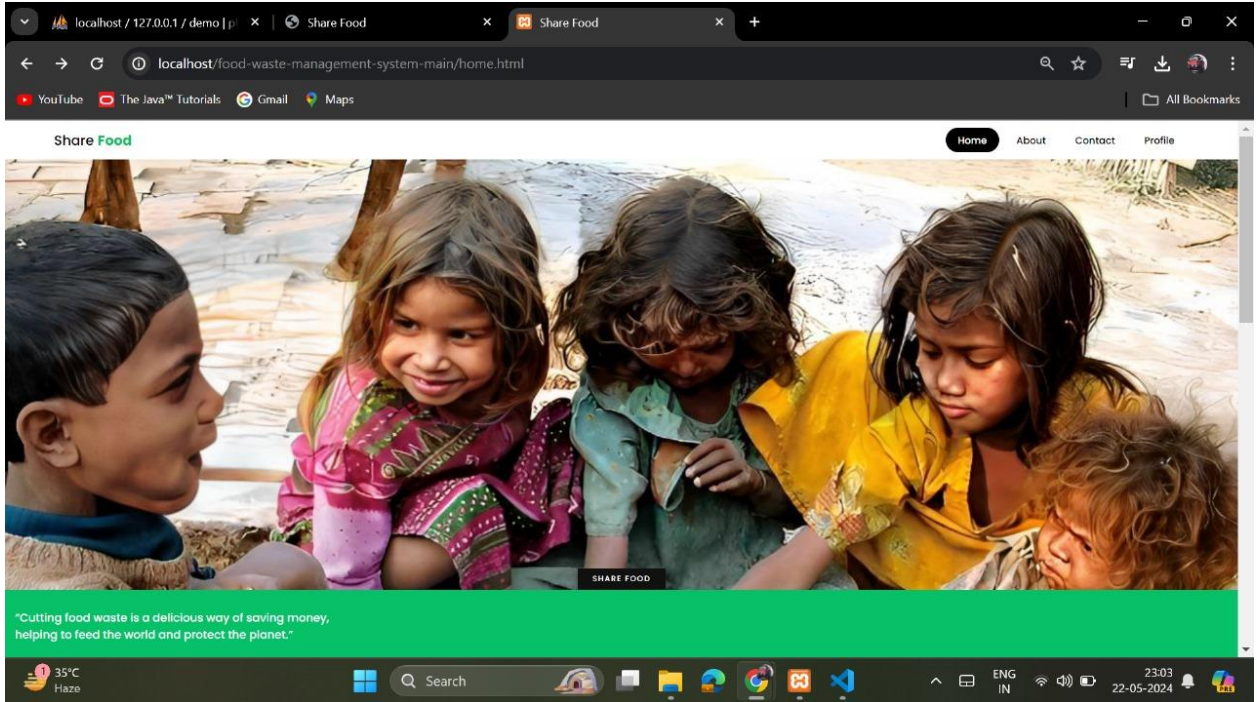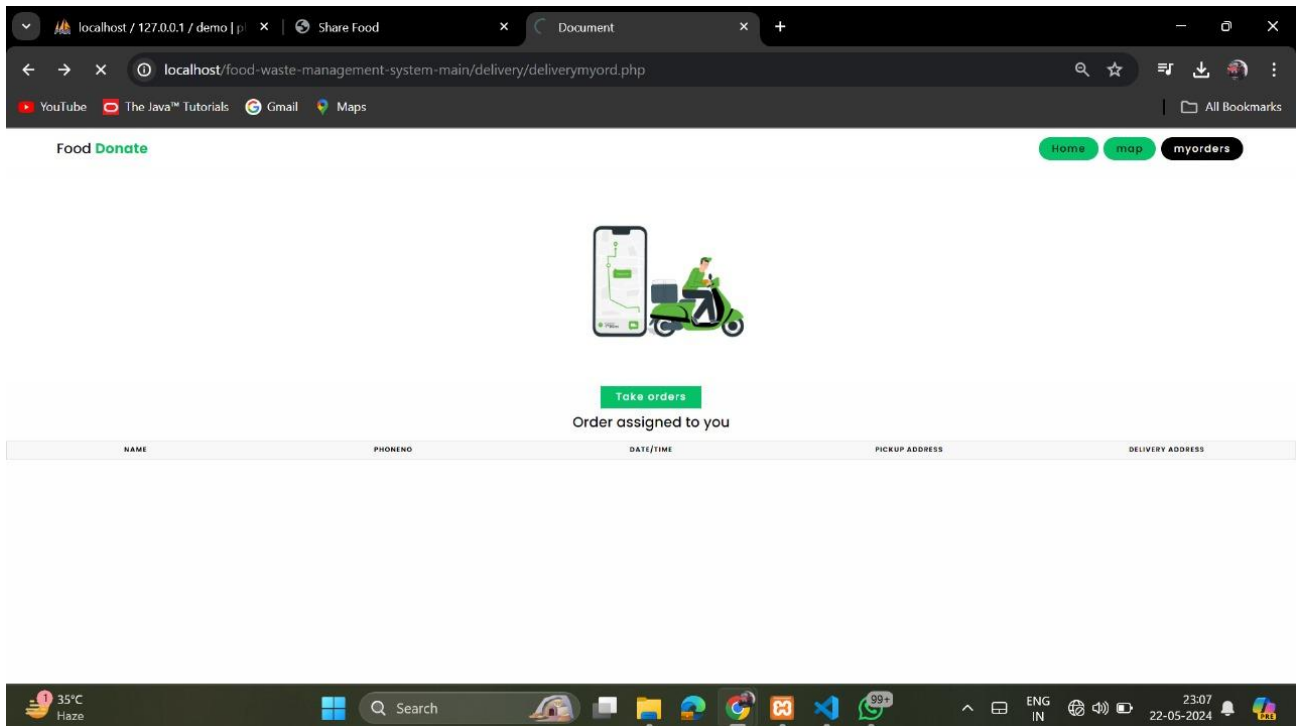**Figure 4: Registration Screen**

Figure 5: Home Page

Figure 6: order assigned screen.

5.3 Discussions

The findings regarding system performance provide valuable insights into the effectiveness of the "Share Food: Cloud-Based Food Waste Reduction & Donation System App." The observed response time, which remained within acceptable limits for user interactions, indicates that the system operates smoothly and efficiently. This is crucial for ensuring a positive user experience and encouraging continued engagement with the platform.

Similarly, the system's scalability is a noteworthy aspect, as it exhibited minimal degradation in performance even under increased load conditions. This suggests that the system has the capacity to accommodate growing user demand without compromising its functionality or responsiveness.

The low error rates observed in the system further reinforce its reliability and effectiveness in facilitating surplus food redistribution and donation. By minimizing disruptions to user workflows, the system enhances user trust and confidence in its ability to facilitate meaningful contributions to food waste reduction efforts. However, it is essential to acknowledge that these performance metrics represent only one aspect of the system's overall effectiveness. While smooth operation and minimal errors are indicative of a well-functioning system, they do not necessarily guarantee its success in achieving broader objectives such as reducing food waste and fostering community engagement.

Indeed, the impact of the "Share Food" system on food waste reduction and donation efforts extends beyond technical performance metrics. User engagement and adoption play crucial roles in determining the system's efficacy in addressing the underlying challenges of food waste and food insecurity. Thus, while the observed system performance metrics are promising, they must be contextualized within the broader socio-technical landscape in which the system operates.

Moving forward, it is important to consider how the system can be further optimized to maximize its impact on food waste reduction and donation initiatives. This includes exploring strategies to enhance user engagement, strengthen partnerships with local businesses and organizations, and address regulatory considerations related to food safety and liability. By integrating these considerations into future development efforts, the "Share Food" system can continue to evolve as a valuable tool in promoting sustainable food management practices and fostering community resilience.

Conclusion

The "Share Food: Cloud-Based Food Waste Reduction & Donation System App" project addresses a critical issue in modern society: food waste. By leveraging cloud technology, the app facilitates the efficient redistribution of surplus food from businesses to individuals and organizations in need, thereby reducing food waste and contributing to food security.

This study presented a detailed design and implementation of the system, showcasing key features such as user registration, food listing, donation management, and order tracking. The system's performance was evaluated based on response time, scalability, and error rates, demonstrating its reliability and effectiveness in real-world scenarios.

The proposed system incorporates several improvements over existing solutions, including robust quality control measures, enhanced user verification processes, and strategic partnerships with local health authorities to ensure compliance with food safety standards. These enhancements address the limitations observed in other systems, such as inadequate food safety measures and lack of comprehensive user support.

Despite the successes, the project faced some challenges, including ensuring consistent user engagement and managing logistical complexities. Addressing these challenges through future enhancements, such as integrating advanced analytics and expanding partnerships, will further improve the system's impact and efficiency.

In conclusion, the "Share Food" app presents a viable solution to the problem of food waste, offering a scalable, user-friendly platform for food donation and redistribution. Its implementation demonstrates significant potential for societal benefit, making it a valuable contribution to efforts aimed at achieving sustainability and food security. Continued development and research will enhance its capabilities, ensuring it meets the evolving needs of users and communities.

Future Scope

- The "Share Food: Cloud-Based Food Waste Reduction & Donation System App" has the potential to significantly impact food waste reduction and food security on a global scale. The long-term vision for the project includes:
- Global Adoption: Expanding the app's reach to various countries and regions, adapting to local regulations and cultural practices, will help address food waste issues worldwide.
- Comprehensive Food Network: Integrating the app with other food donation platforms, local food banks, and governmental food security programs will create a robust network for food redistribution, amplifying its impact.
- Sustainability Reporting: Implementing features for sustainability reporting will allow businesses to track and report their contributions to food waste reduction, promoting transparency and encouraging more businesses to participate.
- Collaborations and Partnerships: Forming strategic partnerships with NGOs, health authorities, and regulatory bodies will enhance the app's credibility and effectiveness in ensuring food safety and compliance with regulations.
- Technological Advancements: Continuously updating the app with the latest technological advancements, such as artificial intelligence and blockchain, will enhance its functionality, security, and efficiency.
- Educational Campaigns: Launching educational campaigns to raise awareness about food waste and promoting the app as a tool for reducing waste will engage more users and foster a community-driven approach to tackling food waste.

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Authors' Contributions

Yashika Rai, as the first author, played a pivotal role in orchestrating the research and conceptualization of the "Share Food" app. This involved defining the project's scope, objectives, and technological framework, with a particular focus on frontend development aspects. Yashika's expertise ensured that the "Share Food" app's user interface (UI) design and interactive elements were crafted to enhance user experience and streamline the food donation and distribution workflows.

Uday Pratap Pal and Suman Kumar collaborated closely as backend developers, bringing their expertise to the implementation of the "Share Food" app's backend infrastructure and server-side logic. Uday's role primarily involved architecting the backend systems, database management, and

ensuring seamless integration between frontend and backend components. Suman's contributions focused on backend development, including API design, data processing, and security implementation, ensuring the "Share Food" app's functionality, performance, and reliability.

Siddharth Gupta, as the fourth author, provided invaluable insights and support throughout the project lifecycle. His role encompassed various aspects, including project management, quality assurance, and strategic decision-making. Siddharth's contributions helped steer the "Share Food" app towards its goals, ensuring alignment with user needs and market trends. Additionally, Siddharth Gupta provided mentorship and guidance to the team, fostering a collaborative and innovative work environment.

Acknowledgement

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