IoT Assisted Food Donation and Waste Management System

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Abstract—**Food waste is still a problem in the world today, having negative effects on the environment, the economy, and society. This research article presents a unique way to use the Internet of Things (IoT) within a web application to alleviate this problem. The suggested solution integrates real-time food quality evaluation with food donation and trash management. The programme makes sure that donated food is safe to eat by keeping an eye on its temperature, humidity, and freshness using IoT-enabled sensors. The platform facilitates the effective matching and distribution of food donations by offering an intuitive interface for donors, recipients, and volunteers. Furthermore, it optimizes and predicts food waste reduction tactics through the application data analytics. This research provides a holistic solution that minimizes food waste and guarantees the safety and quality of donated food, by addressing the crucial element of food quality evaluation with IoT technology. This, in turn, contributes to a more sustainable and humane society.**

Keywords- Data Analytics, Food Quality Monitoring, Food Redistribution,, IoT (Internet of Things), Real-time Monitoring, Supply Chain Management, Web Application Development

I. Introduction

Waste management, environmental sustainability, and charity giving are becoming worldwide concerns that call for creative solutions utilizing state-of-the-art technologies.In urban settings, waste management is becoming more and more of a difficulty, and traditional techniques frequently fail to identify and classify garbage effectively. By installing these sensors at garbage collection locations, accurate waste classification and real-time odor monitoring are made possible. Advanced machine learning algorithms are utilised to process the obtained data in order to decrease environmental impact, improve garbage collection routes, and save operating expenses. The use of sensors and cutting-edge technologies in trash management offers several advantages beyond cutting operating costs and improving waste collection routes. The aforementioned factors encompass improved recycling initiatives, data-driven decision-making for waste management companies and municipalities, public engagement via smartphone apps and online platforms, decreased environmental impact due to fewer vehicles on the road, enhanced safety and health aspects in waste collection areas, employment opportunities in data analysis and sensor maintenance, and the possibility of international collaboration to tackle waste management challenges on a global scale. In summary, utilizing state-of-the-art technologies for waste management not only solves the pressing issues of waste collection and disposal, but it also supports the more general objectives of environmental sustainability and charitable giving, improving the efficiency, cleanliness, and greenness of our urban environments.

II. Literature review

Using the creation of a mobile application, Hajjdiab, Anzer, Tabaza, and Ahmed's research paper "A Food Wastage Reduction Mobile Application" addresses the urgent problem of food waste and was presented at the 2018 6th International Conference on Future Internet of Things and Cloud Workshops (FiCloudW) in Barcelona, Spain. The writers of this study acknowledge that cutting down on food waste is an important part of managing resources sustainably. A smartphone application is presented with the goal of encouraging users to reduce food waste. The characteristics and capabilities of this smartphone software, as well as its possible influence on increasing awareness and lowering food waste—a serious worldwide issue—will probably be covered in the article. Given the larger context of the Internet of Things (IoT) and cloud computing, the research probably examines the application's design, usability, and integration with cloud technology. Readers may learn more about the

possibilities of technologically driven solutions to reduce food waste, a major worldwide issue with substantial economic and environmental ramifications, by critically analyzing the study's findings.[1]

At the 2020 3rd International Conference on Computer and Informatics Engineering (IC2IE), held in Yogyakarta, Indonesia, Oktaviana, Febriani, Yoshana, and Payanta present their work titled "FoodX, a System to Reduce Food Waste". The "FoodX" system is emphasized in this study report as a creative approach to the issue of food waste. The main goal of the system is probably to create a platform that helps reduce food waste by giving users a useful way to handle extra food in different situations. The design, functionality, and possible applications of the system will be explained to readers, providing light on how technology might be used to address the problem of food waste.[2]

Patil, Nikam, Nair, Raut, and Lobo's study, "Sustainable Food Waste Management and Tracking System Using Blockchain," delves into the field of food waste management. This paper examines the integration of blockchain technology for food waste management and was presented at the 2023 International Conference on Advancement in Computation & Computer Technologies (InCACCT) in Gharuan, India. The decentralized and transparent characteristics of blockchain provide distinctive opportunities for the monitoring and control of food waste along the whole supply chain. This research presumably looks at the viability and possible benefits of applying blockchain technology to sustainable food waste management. It is anticipated that readers will acquire knowledge about how this new technology might support efforts to reduce food waste in a more effective and long-lasting way.[3]

The paper "IoT Based Smart Waste Management System" is presented by Gayathri, Divagaran, Akhilesh, Aswiin, and Charan at the 7th International Conference on Advanced Computing and Communication Systems (ICACCS) in Coimbatore, India in 2021. This research paper probably talks about creating an Internet of Things-based smart trash management system. The system's capabilities, architecture, and potential to increase the effectiveness of trash collecting and disposal may all be covered by the writers[4]

The research project "Developing Food Charity Operations Management System" is presented by Alblihed, Almutairi, Almahmoud, Aladhadh, and Alabdulatif at the 2nd International Conference on Computing and Information Technology (ICCIT) in Tabuk, Saudi Arabia in 2022. The method intended to optimize and streamline food charity operations is probably the main emphasis of the article. It could investigate how technology might help with food waste reduction and resource allocation by helping to manage the logistics and delivery of food to those in need.[5]

Authors S.P. Kale, Meet Patel, Mehtab Ansari, Aditi Dhumal, and Ruchika Arote, who are connected to the Department of Computer Science & Engineering at Sandip Polytechnic in Nashik, India, have developed a novel web-based application called "FOOD WASTE MANAGEMENT SYSTEM" to address the problem of food waste in dining establishments, parties, and mess areas. The goal of the authors' research is to enhance the present food waste management system, which

mainly provides information on food waste but is devoid of tools for data analysis and donation. The suggested approach offers a platform for giving extra food and uses data analysis to visualize the effects of food waste. By informing volunteers, orphanages, and NGOs in the area, this approach makes it possible for them to gather the extra food. Given that figures show a sizable amount of food is wasted annually, the report emphasizes how urgent it is to reduce food waste.[6]

The development of an intelligent food logistics system using an Android-based mobile application is the topic of the paper "FOOD WASTE MANAGEMENT USING ANDROID" by Aashish Khandkar, Palomi Gawali, Ajay Aswar, Yashaswi, and Yash Satpute, who are affiliated with the Sinhgad Academy of Engineering in Pune, Maharashtra, India. The authors stress the significance of effective technologies and procedures in the context of intelligent transportation systems since these systems directly affect the enhancement of food firms' competitiveness as well as the improvement of food quality, safety, and waste reduction. The study tackles the urgent problem of food waste and the necessity of making use of locally accessible food sources, such as leftover food from eateries, shops, and distribution centers. Crises like the COVID-19 outbreak have made this problem even more urgent. In order to alleviate hunger and food waste at the same time, the study primarily focuses on developing a mobile application that provides a ubiquitous platform for users to visualize and access nearby food resources.[7]

The possibilities of the Internet of Things (IoT) in relation to food waste management are examined by Tbk, Bharath, and Prashar in their work "Review on Efficient Food Waste Management System Using Internet of Things." In 2021, the International Journal of Current Research and Review released a research that was conducted. This research article probably explores how to use IoT to optimize food waste management. IoT has drawn a lot of interest as a viable solution for tackling a variety of environmental and socioeconomic concerns. An overview of Internet of Things (IoT)-based solutions and their uses in managing and monitoring food waste may be given by the writers. The benefits, difficulties, and possible solutions related to integrating IoT technology into the process of reducing food waste could be discussed.[8]

The "SeVa" app, created for food donation and encouraging smart living, is introduced in the article "SeVa: A Food Donation App for Smart Living" by Christina Varghese, Drashti Pathak, and Aparna Varde, which was published in 2021. The software seems to be centered around making it easier for people to donate extra food to those in need, which promotes a more humanitarian and environmentally friendly way of living. The writers most likely go over the features, capabilities, and general effects of the SeVa app on smart living and food giving.[9]

A smart electronic nose (eNose) system for managing food waste is presented in the paper "Smart eNose Food Waste Management System" by Shazmina Gull, Imran Sarwar Bajwa, Waheed Anwar, and Rubina Rashid, which was published in the Journal of Sensors in 2021. The authors acknowledge the increasing problem of food waste and provide a creative remedy that makes use of eNose

technology. The eNose system is intended to identify and evaluate food scents, enabling in-the-moment food freshness and quality monitoring. The authors want to minimize food waste by enabling timely actions, such recognizing food products approaching their expiration date and supporting their efficient distribution or donation, by integrating data acquired from the eNose into a smart food waste management system.[10]

Furthermore In the restaurant business, intuition and historical data analysis serve as the main foundations for sales forecasting. This method might not be able to make precise forecasts, which could result in issues like excessive food production or inadequate preparation—both of which increase food waste.

All things considered, the existing system is deficient in the real-time data insights, sophisticated analytical tools, and efficient communication channels needed for food waste management and donation. To reduce food waste, a more effective technology-driven system is required, one that can maximize food supplies, link donors and NGOs, and produce precise sales projections.

In the age of the Internet of Things, a substantial number of research on food have surfaced for different states. Studies on waste management, quality control, and production monitoring have been conducted with RFID, temperature, humidity, cameras, and many other sensors and modules. There isn't a single study that suggests utilizing inexpensive sensors to identify food items and detect them while also measuring the amount of food lost. The research in issue is unique in this specific context because of its structure and methodology.

PROBLEM STATEMENT

The need for creative solutions that make use of cutting-edge technologies is driven by the growing worldwide concern for waste management, environmental sustainability, and philanthropic giving. an app for donation using IOT technology. With serious consequences for the environment, society, and economy, food waste is a major worldwide problem. Nonetheless, millions of people experience hunger and food insecurity globally. In order to close this gap and solve this issue, food donation and trash management require creative IoT (Internet of Things) solutions. The way trash is managed and food is donated now is frequently ineffective, opaque, and underutilizes contemporary technologies.

The purpose of this project is to create a cutting-edge Internet of Things system that can monitor, control, and improve food donation and waste management procedures..

MEHTODOLOGIES

A. Communication: Customer and developer contact is the first step in the software development process. We used the following communication phase concepts when we interacted with the user during this phase.We planned ahead of time, that is, we decided on the meeting's agenda with the goal of focusing on the features and services offered by other comparable programs.Our team's leader guides the group and gathers all user requirements, including what the user truly needs, what is input, and the format of the system's output.

B. Planning: Comprehensive scheduling, estimating, and risk analysis are all included.We scheduled the software delivery date, estimated project costs, and addressed project risk pertaining to the messenger program and file transfers throughout this phase.Lastly, at this phase, we calculated the project's total cost, accounting for all software expenses and software releases in accordance with user deadlines.

C. Modelling: It comprises project design and a detailed study of the requirements. An algorithm solves a problem step-by-step, whereas a flowchart depicts the entire program's visual flow.We examine the user's requirements and create the system's block diagrams based on that analysis. That is only the UML-based behavioral structure of the system, represented by various diagrams such as the class, use case, components, etc.

D. Construction

1) Coding**:** The proper programming language is used to implement design details.To communicate with the database on the server side, we have opted to use the Javascript programming language.
- Front-end developers may build an interactive and responsive user experience by utilizing HTML5, CSS, and JavaScript.
- For dynamic content administration, server-side scripting using MongoDB integration was used.
- included HTML5 Geolocation API to determine the user's location automatically and determine the distance to the closest
- NGOs using Euclidean distance formula.

2. Implemented food Demand Forecasting:
- Integrated forecasting algorithms for food demand that make use of external APIs and historical data.
- Implemented features that allow users to import data from external sources or submit information about food demand.

3. Implemented Global Food Waste Analysis:
- Statistics on food waste worldwide was gathered from the Food and Agriculture Organization (FAO). produced data visualizations, including graphs and charts, to give consumers insight into worldwide trends in food waste.
- Carried out exploratory data analysis (EDA) to find patterns and connections in the information on food waste.

4. Sensor Deployment:

- Sensors: IoT devices are equipped with various sensors (temperature, humidity, expiry date) strategically placed within the food supply chain (storage facilities, transport, donation centers).

- Purpose: These sensors make sure that food quality is constantly monitored and evaluated by gathering data in real time on critical food parameters.

5. Data Transmission and Connectivity:

- Communication Protocols: IoT devices utilize communication protocols (e.g., MQTT, HTTP) to transmit collected data securely to the central system.
- Connectivity: Devices are connected via wireless networks (Wi-Fi, cellular, or LPWAN) to ensure seamless data transmission.

6. Real-time Monitoring and Data Collection:

- Continuous Data Collection: IoT devices collect and transmit data in real-time, providing immediate updates on food conditions.
- Automation: Automated data collection allows for proactive response to changes in food quality, minimizing risks of spoilage or waste.

7. Data Processing and Analysis:

- Data Preprocessing: Raw data collected from IoT sensors undergoes preprocessing to clean, standardize, and prepare it for analysis.
- Analytical Insights: Data analytics and machine learning algorithms analyze the collected data, providing insights into food quality trends, anomalies, and predictions.

8.Alert Systems and Decision Support:

- Alert Mechanisms: Based on analyzed data, the system triggers alerts or notifications for stakeholders in case of deviations from predefined thresholds or potential risks to food quality.
- Decision Support: With the use of actionable insights gleaned from IoT-generated data, the solution helps stakeholders make wise decisions..

9. User Interface Integration:

- Web Application Interface: A user-friendly online interface is used to display and convey the data provided by the Internet of Things, allowing stakeholders to manage inventories, keep an eye on food quality parameters, and take appropriate action.

10. Security Measures:

- Encryption and Authentication: Implementing security protocols to secure data transmission and access control mechanisms to safeguard IoT devices and the central system from cyber threats.

E. Testing: Application analysis is the first stage in the testing process. We build the application's module and then work step by step to identify input and output defects, including initialization, performance, interface, and data structure issues.

F. Deployment: Delivery of software, client feedback, and support are all included. Changes are necessary for any fixes or upgrades that users want, whether they are for errors or extra capabilities. User evaluation is followed by spiral implementation, "enhancement plan" and "user's suggestions." Consequently, every round around the spiral results in a software version that is more polished.

The system comprises of three major modules:
1. Admin
2. Donor
3. Agent

A. Admin :
1. View the request raised by Donor, NGO and logistics.
2. Accept or deny the request from the users after verify true information or not.
3. Mapping the Logistics with NGO and Donor.
4. View the complaints and suggestions about the requests and can reply it.

B. Donor :
1. Register with name, username, password and some personal information.
2. Login with registered Username and password.
3. Raise the request with details like date, number of packets that can be sent and location.
4. View the raised requests and can view the status regarding whether the request is accepted or denied by the Admin.
5. Can give complaints or suggestions about the website capabilities.

C. Agent

1. Agents will receive notifications from admins to collect food from donor's homes.
2. Agents can mark their collection upon collection of food from donor's home.
3. Agents can also view all those food donations which have been collected by them previously.
4. Agents can update their profile.

EXECUTION

In the home page, the users have to be registered in various roles such as Donor, NGO or Logistics. After registration, they can raise the requests with the availability for donors, requirements for NGOs and vehicle details in their respective logins. Then the admin can login to his environment and can either accept or deny the requests of the donor and the NGO. And also he will map the Donor with NGO along with the logistics, using the mapping feature available in the website.
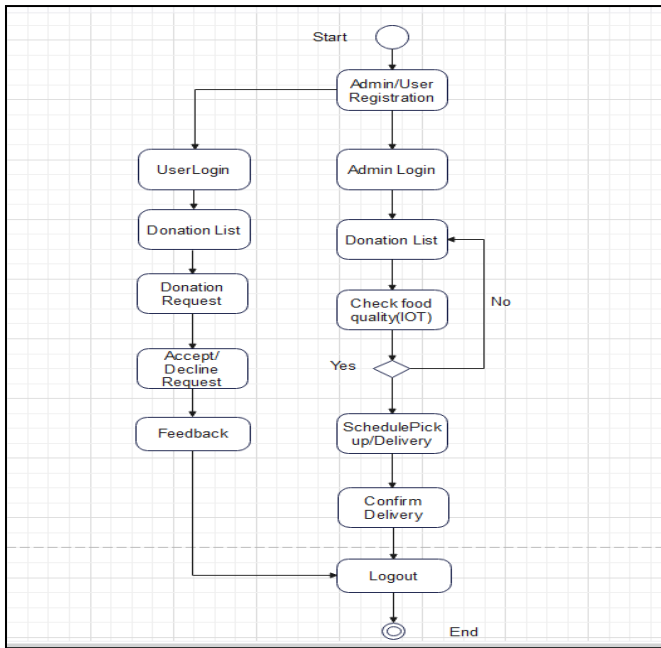
SYSTEM ARCHITECTURE

Fig. 1

Let's examine in more detail each element of the architecture for a web service that donates food and using IoT to verify the quality of the food:

1. IoT Sensors:

In the food storage or donation centers, a variety of sensors, including temperature, humidity, and freshness indicators, are positioned thoughtfully.
These sensors keep an eye on the surroundings and gather information on the food donations' freshness on a constant basis.

2. Sensor Data Collection and Processing Layer:

In this layer, a gateway or middleware serves as an interface between the backend system and the Internet of Things sensors.
In order to guarantee data integrity and accuracy, the gateway gathers data from the sensors and preprocesses it.It guarantees a smooth flow of data from sensors to the cloud or edge infrastructure, controls data transfer, and handles errors.

3. Cloud or Edge Computing Infrastructure:

The sensor data that has been gathered is sent to an edge computing or cloud computing infrastructure.
Cloud-based solutions provide processing power, scalability, and flexibility; edge computing, on the other hand, processes data closer to the source, lowering latency.
Incoming sensor data is stored, processed, and analyzed via this infrastructure.

4. Data Storage:

The sensor data is safely stored in a database or storage system.Large data volumes should be supported via scalable storage and real-time data intake.
MongoDB and Blynk databases are examples of technologies that might be useful for effectively managing IoT sensor data.

5. Web Application Frontend:

a user-friendly interface that may be accessed through mobile apps or online browsers.It lets receivers request or claim food items, gives donors the option to provide data about their offerings, and shows information about available donations.Users may check timetables, notifications, and contribution status on the dashboard provided by the interface.

6. User Authentication and Authorization:

Only authorized users will be able to access the system thanks to a secure authentication mechanism. It has functions for managing several user roles (administrators, donors, recipients, and volunteers) as well as role-based access control and user registration.

7. Application Logic and APIs:

The application's business logic is managed by this layer. It consists of APIs that handle requests, process data, and initiate relevant actions in response to user inputs, hence facilitating communication between the frontend and backend systems.

8. Feedback and Reporting:

In addition to generating reports and data about food donations, quality evaluations, and waste reduction initiatives, users may offer comments on donations they have received through the system.

9. Integration with External Systems:

Integration with payment gateways for financial transactions associated with the donation process and logistical systems for handling the shipping of gifts.
To easily connect and communicate with these external systems, connectors or APIs are employed.
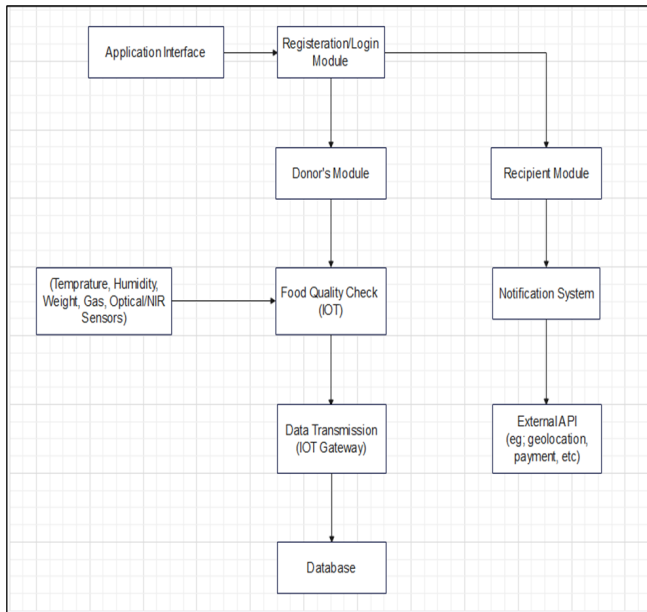
Block Diagram:

Fig. 2

Objectives:
1) To implement real time food odour monitoring.

2) To connect donors and beneficiaries.

3) To reach out to more people facing starvation.

System Components:
1) IoT System:
Collects data from the sensors and transmits it securely to the central server.

Hardware Requirement:
- NodeMCu- ESP8266
- Temperature Sensor - K Thermocouple Using MAX 6675
- Gas Sensor: MQ4
- Jumper Wires

2) Web Application:
  a) Allows users (residents, businesses, or institutions) to interact with the system. Provides features such as:
  b) Real-time monitoring of food waste levels in bins.
  c) Notifications/alerts for when bins are full or nearing capacity.
  d) Reporting and analytics on food waste trends.
  e) Recommendations for reducing food waste.

Software Requirement:
- Operating System (Windows 11)
- REACT Js
- Database
- Node JS
- Express
- MongoDB

System Workflow:
1) Food Monitoring:

Sensors will monitor food odour levels and types.

2) Data Transmission:
The IoT securely transmits data to the Web.

3) User Interaction:
Users access the system through a web application, providing them with real-time information and tools to manage their food waste.

4) Recommendations and Alerts:
The system provides users with recommendations on reducing food waste based on their usage patterns and trends.

Benefits:
1) Reduced Food Waste: By providing real-time feedback and recommendations, users can be more conscious about their waste generation.
2) Data-Driven Insights: The system can generate valuable data for waste management planning and policy-making.

3) Educational Tool: The system can educate users about the environmental impact of food waste and encourage sustainable practices.

4) Cost Savings: Efficient waste collection and reduced food waste can lead to cost savings for municipalities and businesses.

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[6] e-ISSN: 2582-5208 International Research Journal of Modernization in Engineering Technology and Science Volume:04/Issue:05/May-2022 Impact Factor- 6.752 FOOD WASTE MANAGEMENT SYSTEM
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