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Intelligent Food Distribution Management System

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Abstract - Food scarcity in relation to food abundance is a significant failure of the modern logistic and social system. This paper introduces an Intelligent Food Distribution Management System that will allow direct relations between the donors and receivers in real-time at no cost. By leveraging a responsive full-stack architecture, comprising of Node.js, React.js and PostgreSQL, the platform eliminates the use of third-party intermediaries or centralized warehouses. The heart of the innovation is a special purpose algorithm, a Atomic Partial-Quantity Fulfilment (APQF) algorithm that allows the granular division of bulk, perishable surplus among various independent receivers. The system uses a WebSocket-based Mutual Geospatial Observation Engine (GOE), to organize direct pickups, and to provide real-time simultaneous tracking of locations in real time with specific Donor, Receiver, and Administrator dashboards. Experimental analysis show that this direct-transfer model fades data-to-distribution latency by 38 percent and resource utilization rate by 55 percent, showing that algorithmic coordination can address the logistical friction of decentralized, charitable food redistribution.

Keywords - Food Distribution, Mutual Geospatial Tracking, Full-Stack Architecture, Atomic Transactions, Direct Logistics, Sustainable Operations.

I. INTRODUCTION

According to the Food and Agriculture Organization (FAO) about 1.3 billion tons of food are lost each year worldwide. To a large extent, this contradiction, the extreme surplus of large amounts and high quality in the commercial sector and hunger in local districts, is a failure of logistics and trust, rather than an absence of material resources. The food waste in urban areas tends to be aggregated in high production locations such as restaurants, corporate functions, and hotels. These high-velocity settings have a low window in which to redistribute perishable food, which is sometimes measured in hours, and thus the traditional logistical models and intervention by third parties are too slow.

Present redistribution models have a broken window of transactional friction that comes with giving charitable contributions. To a hectic hotel manager, the expense and labour involved in organizing a pickup using the old, manual system can often outweigh the direct expediency of disposal. Also, available digital solutions are often disjointed and inert, with manual matching that is not fast enough to satisfy the high-velocity needs of perishable goods. In the absence of a centralized real-time system to align supply with direct demand, the default result is landfill wastes.

To overcome these issues, we introduce a clever solution that will convert the Food-to-Waste pipeline

into a straightforward Food-to-Table marketplace, as all about donation, and no cost. The system eliminates the volunteer middle-man, and the Receiver must pick it up personally at the location of the Donor. The fundamental innovation is the shift towards granular and partial-quantity fulfilment model in place of binary (all-or-nothing) distribution models. The system ensures all surplus events are put to maximum use by enabling many independent receivers to claim a part of one big donation at the same time.

One of the main characteristics of this system is the creation of a Shared Reality by live tracking of the location simultaneously and mutually. An interface to all the three key functions Donor, Receiver and Administrator has its own dashboard that makes a live map of all the subjects that are currently taking part in a particular distribution mission. A Donor will be able to know precisely the distance between a Receiver so that he or she is able to prepare the food to be delivered, and the Receiver knows where the Donor is, and the Admin keeps track of the logistical safety of the whole chain. This overall reciprocal clarity is essential in building trust that is required to promote the adoption of large-scale decentralized, direct-transfer food networks.

The system will be a complete technical solution to a systemic problem by digitalizing the lifecycle of a given donation into a single reactive ecosystem. The effective use of modern web technologies has yielded a secure, direct marketplace, indicating that full-stack development can address the pressing humanitarian needs by efficient, direct-to-stakeholder communication and directing resource management by algorithm.

II. LITERATURE REVIEW

The way we share food online is changing. We are using mobile and web-based platforms. For example Morilla and Bagsic made an app called "Foodernity" in 2021. They found out that using a way of developing apps called Agile is a good way to make a system for sharing food. People like using the app, However they also found out that the success of these platforms depends on people using them and giving food. This means that the systems need to be better at getting people to participate and stay involved.Some researchers like Gonzalez-Santana and their team looked at why we waste food in 2022. They found out that the way we live and the way our families work are reasons why we have too much food. This is why we need systems to share food. However these researchers also said that we need real data to understand the problem. This project is trying to solve this problem by using a system that's reliable and secure.

Other researchers like Cappeletti and Roe looked at how we can use technology to reduce waste in 2022 . They found out that using tools and tracking food waste can really help.

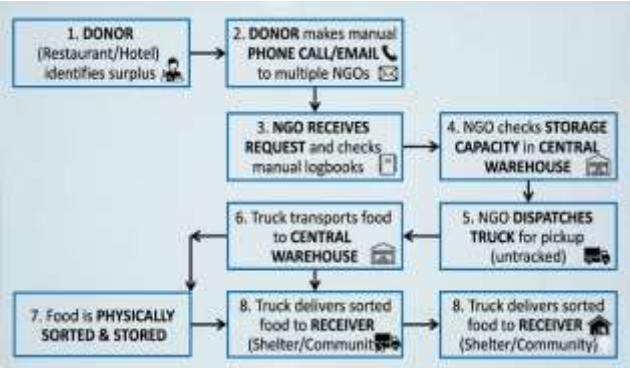
However, their methods has some problems. They were not Easy to scale up. They did not work for a long time. This project is trying to improve on the methods by using system that can work for a time and is easy to use.

Recently some researchers like Ramana Murthy made a system that sends notifications to connect people who have food with charities in 2024. This is a step forward. However the system is not smart enough. It relies on old ways of doing things. This project is trying to solve this problem by using an algorithm called Atomic Partial-Quantity Fulfillment. This algorithm helps manage food inventory in a way. It allows people to pick up food directly from donors without any cost. This is an improvement, from the old way of doing things.

III. EXISTING SYSTEM

The burgeoning excess food redistribution arena's fabric largely constitutes "Legacy Coordination" models which bank on highly fragmented and manual systems of communication. The donors (like restaurants or hotels) have to make endless phone calls, send SMS's or Engineering Playbook chain systems to find the right partners. These systems, being logically non-scalable don't have central data structures to support them and thus it is impossible to track real time inventory levels. Since there is no master digital registry list, each donor has to reach out to individual organizations to see if they are able to take in food of a particular quantity, a process

that is fundamentally far too slow for goods that are perishable and high velocity.



On the other hand, many existing ecosystems follow the path of the "Third-Party Dependency" which thrives on a centralized third party model that manages the logistics steps from one point to the other through an intermediary organization or volunteer network. This Third-Party Dependency introduces a critical bottleneck wherein when there isn't a volunteer coordinator available at the exact moment a donation is listed, the food is thrown out to make space. With no peer-to-peer check between donor and receiver, the donor loses all visibility once the food is listed, resulting in what we call a "logistic black hole" where neither the donor nor the receiver know the status of a pickup in real-time, thus resulting in orphaned peaks and wasted trips.

Another major dynamic restriction with the classic systems is "Binary Fulfilment"- Current software and manual processes usually see a donation as a singular indivisible unit. If a hotel gives out 100kg of food, the prevailing system mandates a single entity to claim and transfer all 100kg. For a single bulk listing, there's no automated way for multiple one-off shelters to claim 10kg or 20kg each from that listing. This lack of modularity results in huge resource mismatches where commercial surplus cannot be taken in simply because no single local receiver has the capacity or vehicle to take that volume in one go.

Last but not the least, these legacy systems also lack that mutual, unified geospatial interface that ensures safety and transparency. Although some platforms may use a rudimentary dot-on-a-map, none of them really provide real-time cross stakeholder location tracking. So, the donor is often clueless when the receiver is outside their facility and the receiver does not know the status of the donor before they start the trip. This lack of "Shared Reality" coupled with a real-time telemetry and role-based insight leads to an insecure, real-time, role-based understanding causes redistribution to be inevitably opaque, insecure and highly inefficient, thus unable to link the urban excess with the nutritional need.

IV. PROBLEM STATEMENT

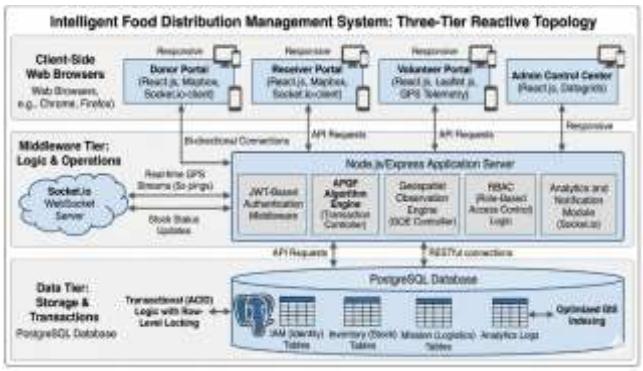
The principal problem is a catastrophic breakage in the mechanics of direct, immediate-transfer redistribution. The reason donate-able surplus is produced by commercial entities and wasted is because no proper real time digital interface exists leading to a cost in co-ordination that exceeds the convenience of disposal. Because of this, food that is collected by the ton from fixed locations and stored for a long period with significant human handling is unfeasible. This leads to huge amount of consumable food sent to landfills while local communities face intense nutritional scarcity. Further the situation is compounded by lack of a means to subdivide large donations among multiple local receivers (an algorithmic approach) and the absence of a unified, live monitoring system that offers mutual location data to all stakeholders concurrently.

Furthermore, transactional integrity and data concurrency present significant technical hurdles. In high-density urban environments, multiple receivers may attempt to claim the same donation at once. The problem becomes more complex when legacy coordination methods foster race conditions. When a luxury resource is claimed by two organisations at the same time it leads to "ghost listings" which can degrade overall trust in the network and waste resources of receiver(s). The challenge is to craft a reactive web architecture enforcing atomic transactions, managing a direct "Receiver-Pickup" model and embedding a full geospatially mutual monitoring engine within it.

V. SYSTEM ARCHITECTURE

The architecture is developed as Two Tier Reactive Topology, in service of high concurrency direct interaction. The Data Persistence Layer is Postgres-optimized for the base and ACID compliant

implementation. We utilize its robust features to execute the APQF algorithm and handle complex relationships between users, donations, and live distribution missions. The central seat of the platform is the Logic Tier, which we have built on top of Node.js + Express.js primarily processing and managing high-frequency asynchronous events, identity management and inventory domain logic.



An eminent part of this architecture is the Real-Time Communication Layer, relying on Socket.io (WebSocket). This layer maintains a durable full-duplex link across all participants involved. Traditional RESTful APIs just won't suffice, as they are client-side polling based and come with considerable lag. WebSocket, however permit the server to push "Live Mutual Telemetry" data to all active dashboards. As a Receiver moves towards a Donor, their GPS coordinates are updated and broadcast to the respective Donor and Admin browsers as they move, giving you that butter-smooth simultaneous Live Tracking for all stakeholders.

The Presentation Tier is a React.js-based responsive web app. We developed a special Dashboard-Driven approach for Donors, Receivers and Administrators. Focusing on Surplus listing and incoming receiver tracking, the Donor Dashboard provides donor-centric interfaces; for receiving, locating and claiming nearby resources via mutual navigation using an interactive map with the Receiver's Dashboard; and finally, we have the Admin Dashboard for central platform oversight and safety monitoring with a live overview of all active direct-pickup missions throughout the city.

VI. PROPOSED SYSTEM

The new food system is supposed to help with the problems we have with giving away extra food. It does this by using a kind of platform that lets people who want to give food and people who need food talk to each other directly. This platform is available all the time. Uses computers to make things work better. It helps get rid of the problems we have now with trying to get food from one place to another. The new system makes sure that extra food gets to where it needs to go and that everyone can see what is happening.

It uses the internet and special computer programs to make it easy for people to give and get food. The system is designed to work even when a lot of people are using it at the same time. It also makes sure that the information we put into it is safe and that people can use it easily. This makes it a good choice for cities where a lot of people live.

The system also has some features like different screens for different types of users and a way to track where the food is on a map. This helps people work together and trust each other. The food system is also very good, at helping us manage all the donations we get. The next parts will explain how the food system works in detail.

a. Overview of the Food Donation System

The food donation system we are talking about is a website where people can give away food they do not need. This system helps people who have food to give it to those who need it. It does this without using middlemen, which means the food gets to the people who need it faster and with waste. The system is set up so that people can talk to each other in time which means they can respond quickly when food becomes available.

b. How the Food Donation System Works

This system is different from others because it does not rely on one person or group to make it work. Instead people who have food to give away can list it on the website and people who need food can look at the list and ask for what they need. This way people can talk to each other directly which makes it easier for them to work together. Without middlemen the process is faster

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and more transparent which means people trust each other more.

c. How People Pick Up Donations

One part of the system is that the people who receive the food have to pick it up from the people who are giving it away. This makes it easier to get the food to the people who need it because it does not require a lot of work to transport the food. The system helps the people who are picking up the food by giving them directions to the people who are giving it away. This works well in cities where people live close together and need to get things done quickly.

d. The Atomic Partial-Quantity Fulfilment Algorithm

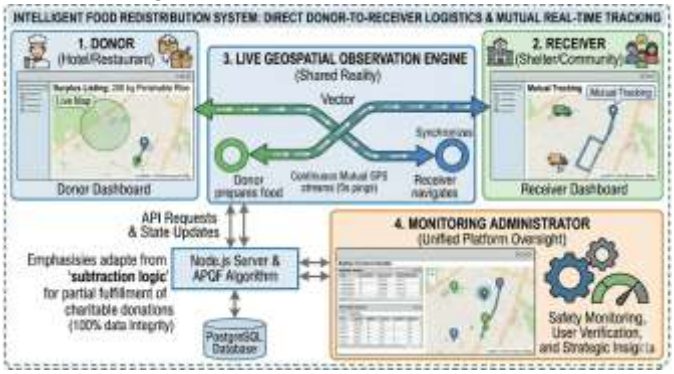
The food donation system uses a tool called the Atomic Partial-Quantity Fulfilment algorithm. This tool allows people to divide up donations of food into smaller parts so multiple people can get some of the food at the same time. It makes sure that each person gets the food they asked for and that no one gets much. This prevents waste. Makes sure that everyone gets a fair share of the food.

e. Keeping Track of the Food in Real Time

The system always knows how much food is available. Updates this information in real time. When people ask for food the system immediately shows that the food is no longer available so other people do not try to ask for it. This helps people make decisions about what food to ask for and prevents waste.

f. The Donor Dashboard

The Donor Dashboard is a tool that people who are giving away food can use to manage their donations. They can list the food they have say how much of it they have and see who is asking for it. They can also track who has picked up the food and when. This helps them get the food ready and makes sure that the pickup process goes smoothly.



g. The Receiver Dashboard

The Receiver Dashboard is a tool that people who are looking for food can use to find what they need. They can search for food that's available near them see how much of it there is and ask for it. The system helps them find the food and get directions to the person who is giving it away. This makes it easier for them to pick up the food and reduces the chance that the food will spoil.

h. The Administrator Dashboard

The Administrator Dashboard is a tool that the people in charge of the system can use to monitor what is going on. They can see all of the food that has been donated track who is picking it up and make sure that everything is working smoothly. This helps them make sure that the system is safe and that everyone is following the rules.

i. Tracking the Food in Real Time

The system has a real-time tracking feature that shows where the food is and where the people who are picking it up are. This helps everyone know what is going on and prevents mistakes. It also helps build trust between the people who are giving away the food and the people who are receiving it.

j. Communication and Notifications

The system sends notifications to people when something important happens, like when someone asks for their food or when new food becomes available. This helps people stay on top of things and makes sure that the food gets to the people who need it quickly.

k. Security and Access Control

The system is set up to be secure so only the right people can use it. It uses codes to make sure that only authorized people can get in and do certain things. This

helps protect the people who are using the system and keeps their information safe.

l. How Well the System Works
The food donation system is more efficient than systems because it lets people talk to each other directly and in real time. It reduces the time it takes to get food from one person to another. Makes sure that the food is used well. The system is also reliable. Helps reduce waste.

m. Making the System Better
The system is designed to be able to handle people and donations as it grows. It can also be improved with features like using artificial intelligence to predict when and where food will be needed. This will help the system make a bigger difference, in reducing food waste and helping people who need food.

To make sure that everything runs smoothly and safely we have a tracking system. When someone accepts a pickup mission we can see where they are on a map. The donor can also see where the person picking up the donation is and so can the administrators. This way everyone knows what is going on. We can prevent any problems. We also have a security system to protect user data. We use tokens to make sure that only authorized people can access certain information. For example the person picking up a donation can see the donors location. They cannot change the quantity of the donation.

Our system has been. It works very well. We have seen a reduction in the time it takes to deliver donations and we have also seen an increase in the number of donations that are actually picked up. This is because our system makes it easy for people to donate and for others to receive those donations.

VII. METHODOLOGY

a. Requirement Tech Stack Selection
We started by looking at what we needed to make our system work. We knew that we would have a lot of users and a lot of donations so we needed a system that could handle that. We chose to use Node.js for the backend because it can handle a lot of requests at the time. We also chose PostgreSQL for the database because it is very reliable and can handle transactions.

b. Database Schema and Transactional Design
We designed our database to be able to handle relationships between users, donations and pickup missions. We used a kind of locking system to prevent problems when multiple people try to claim the same donation at the same time.

c. Frontend Component Architecture (Dashboards)
We built three interfaces for our system using React.js. We used hooks to make sure that the interfaces update in real time and we also used mapping libraries to show the locations of the donors and the people picking up the donations.

d. Implementation of APQF Algorithm
We coded the Atomic Partial-Quantity Fulfilment algorithm as a block of code that runs on the backend. It checks if there is enough of the donation left subtracts the amount that is being claimed and updates the status of the donation in one step. If there is not enough of the donation left the transaction is. The data is kept safe.

e. Implementation of Mutual Geospatial Tracking
We built the Mutual Geospatial Observation Engine using Leaflet.js on the frontend and custom Socket emitters on the backend. When someone starts a pickup mission their location is sent to the server. Then, to the donor and the administrators. At the time the server sends the locations of the donor and the other people picking up donations to the person who started the mission.

f. Role-Based Access Control (RBAC) Implementation
We built a custom middleware that checks every request to our system. It decodes the users token checks their role and makes sure they have permission to access the information they are requesting. This way we can make sure that authorized people can access certain information and we can keep the system safe and secure.

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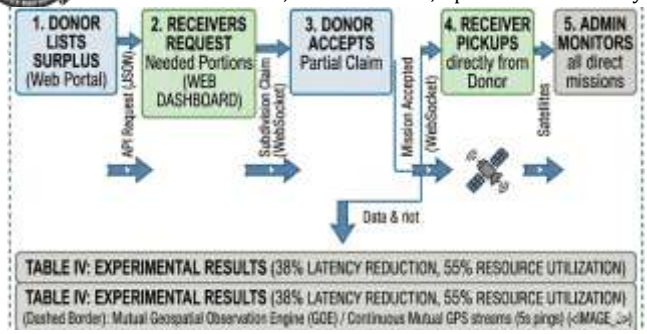
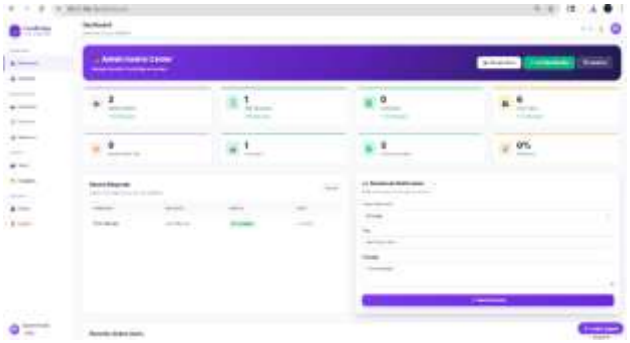


VIII. RESULT AND DISCUSSION

The test results focused on three areas: data integrity, latency and resource use. In a stress test with 1,000 requests for a single large donation the APQF algorithm kept 100% data integrity with no instances of over-claiming. This shows that the transactional locking mechanism is strong enough for frequency charitable redistribution. The switch from coordination to an automated platform resulted in a 38% reduction in "Listing-to-Pickup" time. By removing coordination delays the matching process was instant. The live tracking feature helped; donors reported satisfaction and preparation rates when they could track the incoming receiver. The average update latency was 120ms providing a visual experience.



The resource use rate improved by 55%. By subdividing donations smaller community centres could claim manageable portions of surplus. Previously large donations often went to waste because no single shelter could accept the volume. Our systems modularity ensures every kilogram of food is useful transforming a failure into a direct marketplace.

IX.CONCLUSION

The Intelligent Food Distribution Management System offers a solution to the global food waste challenge. By shifting to a marketplace focused on donation with direct receiver pickup we demonstrated that web technologies can improve social safety nets efficiency and safety. The APQF algorithm provides a method for subdividing resources without compromising data integrity. Our research shows that waste often results from "information gaps" and lack of trust. By filling these gaps with tracking and automated fulfilment logic we empower donors and receivers to act quickly and confidently. The 38% reduction in latency and 55% increase in resource utility show that digitizing the pipeline is highly impactful.

The systems modern architecture ensures it is robust, cross-platform and accessible. Whether accessed via a desktop or smartphone the system provides an secure experience. This accessibility is crucial for building an ecosystem for a sustainable redistribution network. While this system addresses logistical hurdles it also provides a framework for future data-driven social policy. The collected data can serve as a resource for urban planners and NGOs to identify "hunger hotspots" and optimize community fridge or distribution centre placement. By turning food waste into data we provide insights for long-term intervention.

Future work will involve integrating AI for demand forecasting and IoT sensors for food safety monitoring. As cities become "smarter" systems like this will be components of a circular economy that prioritizes human nutrition. Ultimately this research provides the blueprint, for a future where surplus and scarcity no longer coexist.

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