

# Community Surplus Distribution Hub

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## INTRODUCTION:

As our cities expand, we're facing a real dilemma: We're consuming more than ever before – tons of food, clothes, gadgets – and yet, perfectly good items are ending up in landfills, because there's no easy way to dispose of them. We are left with a situation where some have too much while others barely have enough.

**Why do existing systems become weak?** Traditional methods of donating are often entangled in paperwork and logistical problems. Goods often get lost in the shuffle, leading to unequal distribution where some people have a lot and others have nothing. Also, commercial markets focus on the highest bidder, not those who need the goods most. There is a real lack of transparency and fairness in the current system.

**Answer:** Community Surplus Community surplus is like a digital bridge that turns “surplus” into “access.” It is a secure, scalable platform built on three core principles:

**Fairness:** For items that are in high demand, like food, we use a smart queuing system to ensure that it doesn't just get to the fastest person who needs it.

**Dignity:** By allowing both free sharing and low-cost sales, we create a welcoming space for all to participate.

**Security:** We provide a secure environment where neighbors can trust every exchange.

The technology behind it to ensure that everyone can use it, the app is built with Flutter, giving a seamless experience on any smartphone. The backend uses Firebase for real-time data syncing, secure cloud storage, and strong user authentication. Community Surplus isn't just an app; This is the foundation for a fairer and more balanced city.

## Related Work:

When it comes to sharing excess stuff, the current digital world is split into two distinct camps, and neither really solves the problem of unfairness in cities.

**Institutional vs. Individual Platforms:** Most food donation websites and systems run by charities primarily help large donors like supermarkets and hotels. While it's good to carry large amounts of food, they miss out on the large amounts of "household surplus" – extra food and items that people have at home every day. Community Surplus fills this gap by making the donation process more personal and accessible to everyone.

**Profit vs. Purpose-Driven Marketplace:** Popular reselling apps let people sell things to each other, but they're all about making money. They usually favor the person offering the most cash, leaving those who need things most without options. However, our platform adds a “social impact” feature where fairness is more important than how much someone can spend.

**Theoretical research vs. real-world application:** University studies often suggest ways to share things more fairly, such as using a queuing system to avoid "first-come, first-served" congestion that is not always fair. But these ideas often remain on paper only. Community Surplus actually puts these concepts into practice by using the following:

**Fair Queue:** Smart systems that prevent anyone from grabbing all the needed items, just because they were the fastest.

**Layers of Trust:** Donors are vetted in real-time to help make sure everyone feels safe.

**Temporary Intelligence:** Special handling for things that may expire, like food, based on their freshness.

**Detailed system architecture:**

The Community Surplus ecosystem is built on a modular cloud architecture. By separating the user interface with **Flutter** from the logic and data layers **Firebase**, the system ensures high availability and low latency even during busy times (for example, when a local bakery shows a surplus at closing time).

**1. Three-tier operational flow**

- Donor Journey: Donors can list an item in less than 60 seconds. To store user data, the app uses image compression algorithms before uploading it to Firebase storage. Once listed, the item is tagged with a "geographic hash" to ensure it appears in the feeds of nearby neighbors first.
- Request journey: Requests scroll through a real-time feed categorized by urgency (for example, "expiring soon"). When they join a queue, the cloud function logic calculates their priority based on a "fair-share" algorithm, ensuring that the distribution in the community is balanced.
- Governance layer: While the system is peer-to-peer, Firebase Security Rules acts as an automated moderator. These rules prevent unauthorized data access and ensure that only donors and selected requesters can see sensitive details such as pickup locations.

**2. Advanced feature overview**

- Intelligent outlet control: Unlike stable markets, social surplus considers time as an important variable.
- Dynamic countdown: For foodstuffs, the system tracks the "life cycle". When an item nears its expiration date, it's automatically pushed to the top of the local feed and flagged with a high-priority alert.
- Automatic Archiving: When an item expires or is collected, it is moved to an archive to keep the active marketplace clean and relevant.
- Hybrid transaction model: To promote a truly inclusive economy, we support exchanges with two modes:
- Free Tier: Focuses on pure redistribution

Component	Technology	Role in Community Surplus
Frontend	Flutter	Cross-platform UI for universal accessibility.
Database	Cloud Fire store	Real-time, scalable NoSQL data storage.
Media Storage	Firebase Storage	Hosting high-resolution item images.
Logic Layer	Cloud Functions	Managing the Fair-Share Queue and Expiry alerts.
Security	Firebase Rules	End-to-end data privacy and access control.

**Workflow**

The Community Surplus workflow is designed as a high-speed, high-confidence cycle that minimizes the time between "item discovery" and "handover".

**Identity Verification and Onboarding:** Users go through a secure authentication process through Firebase. This creates a "trust profile", which ensures that every participant in the community is a verified neighbor, the cornerstone of secure peer-to-peer sharing.

**Smart listing and metadata enrichment:** A donor starts the cycle by listing an item. The system goes beyond basic details – it captures status levels and degradation timestamps. For food items, an "expiration clock" starts immediately, allowing the system to prioritize those items in the community's feed to prevent waste.

**Global-Local Spread:** Once the item is submitted, it is instantly synced to Cloud Firestore. Through a real-time data stream, the list is displayed on the dashboard of all authenticated users in the geographic region without having to refresh the page.

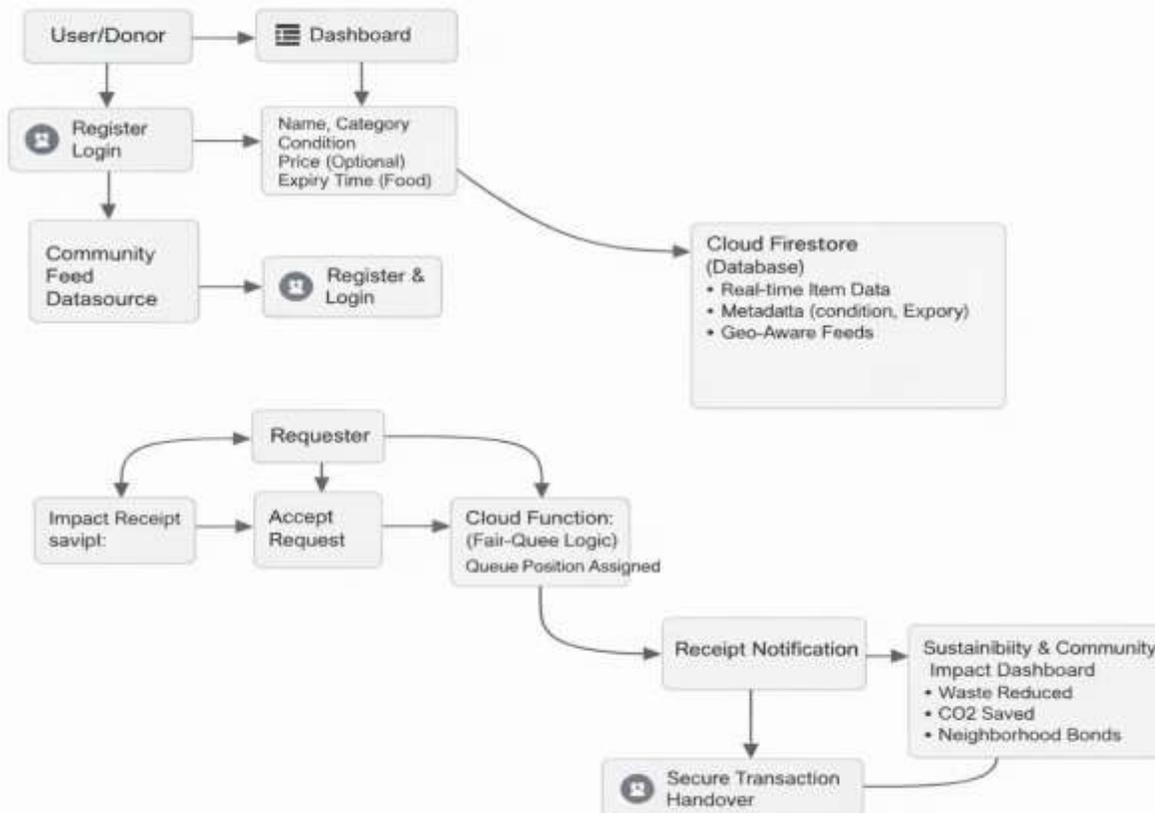
**Purpose-based requests:** Interested users submit an "access request." Unlike commercial apps that encourage bidding wars, our platform focuses on intent. Users can specify why they need the item, which adds a layer of human connection to the transaction.

**Automatic Fair Queue Allocation:** The system eliminates "fastest finger" bias. Each request is sent through a cloud function that assigns a queue state. It ensures a transparent, systematic and fair distribution of resources, and prevents the monopolization of high-demand goods.

Stage	Feature	Human Impact
Listing	Expiry Tracking	Ensures food safety and urgent redistribution.
Visibility	Real-time Sync	Eliminates "Ghost Listings" and user disappointment.
Requesting	Smart Queuing	Democratizes access for those with slower internet/devices.
Finalization	Impact Mapping	Donors see the carbon footprint saved by their action.

Workflow Diagram:

### Community Surplus



## Fair queue-based allocation mechanism

One of the most important innovations of the Community Surplus platform is to move away from the "donor- select" or "bid" model common in existing apps. We have implemented a system-managed fair queue to automate equity and eliminate the possibility of unconscious bias or favoritism in resource distribution.

### 1. The argument for algorithmic fairness

In traditional peer-to-peer systems, donors often select recipients based on profile picture, name, or "first-to-message" speed. This is a disadvantage for users with older technology, slow internet or less "socially preferred" profiles. Our system transfers decision-making power from the individual to a chronological logic engine.

#### Each request document in Firestore contains:

**Item Reference (UUID):** A unique pointer to a specific surplus item.

**Requester Identity:** Encrypted user ID associated with Firebase authentication for privacy.

**Global Sequence Number:** A strictly increasing integer that defines the user's position in the "claim line".

**High resolution timestamp:** Captured via `FieldValue.serverTimestamp()` to ensure millisecond accuracy regardless of the user's local time zone.

**Enter machine status:** (eg "waiting", "matched", "completed", "collected").

### 2. Technological implementation: Nuclear enhancement

To ensure that two people who click on "request" in the same millisecond do not get the same queue number, we use Firestore transactions.

**Atom counter:** When a request arrives, the system performs an atomic update. It checks the current "request\_count" for that item and increments it by "1" in a single transaction. This prevents "race conditions" where data can be corrupted from concurrent requests.

**Real-time prioritized stream:** UI for both donor and requester

#### Paid and Free Item Support

**Balancing Philanthropy and Sustainability** A key innovation of the Community Surplus platform is its dual- mode transaction architecture. Most existing solutions are binary: they are either entirely charitable (leading to high donor burnout) or entirely commercial (except for low-income users). Our system integrates the two, creating a flexible "socio-economic bridge".

- **Empowering Donor Agency:** We recognize that the "cost of giving" varies. By allowing donors to choose between no-cost donations and subsidized sales, we increase the total amount of goods entering the circular economy: The Charitable Path (free): Ideal for high turnover essential items such as perishable food, clothing and books. This path prioritizes rapid redistribution and maximum social impact. Recovery Path (Low Price): For valuable items such as furniture or electronics, donors can list at a "community-friendly" price. It encourages users to list items they might otherwise have put into storage or sold on high-commission commercial platforms, ensuring these items remain available to local neighborhoods.

- **Respectful access for applicants:** This hybrid model addresses the various financial realities of urban residents: Safety net: Requests facing acute financial hardship can filter exclusively for free necessities, providing an important lifeline without the bureaucracy of traditional NGOs. Affordability Market: For those with limited but existing purchasing power, the low-cost tier provides a respectable way to obtain quality goods at a fraction of retail prices,

promoting a sense of participation rather than "charity dependency."

- **Technical implementation and transparency:** To prevent confusion and ensure "fair play", the system uses different UI markers: Visual distinction: There are free elements

### Security and Access Control:

In a peer-to-peer ecosystem where physical meetups occur, security is the foundation of community trust. The **Community Surplus** platform employs a "Privacy-by-Design" architecture, ensuring that while the platform is open for browsing, sensitive data remains strictly protected via a "Zero-Trust" database model.

#### 1. Identity Verification and Authentication

Every participant must undergo **Firestore Authentication** before interacting with the community. This ensures that every "Neighbor" on the platform is tied to a verified digital identity.

- **Secure Sessions:** By utilizing JSON Web Tokens (JWT), the system maintains encrypted communication between the Flutter frontend and the Firestore backend, preventing unauthorized session hijacking.
- **Access Walls:** Unauthenticated users are restricted to a "Read-Only" public feed. The ability to list items, join queues, or view pickup details is strictly locked behind an authentication wall, ensuring accountability for every action taken.

#### 2. Granular Database Security Rules

A core innovation of this system is that security is enforced at the **Server Level**, not the client level. This means even if a user attempts to bypass the app's interface, the database itself will reject unauthorized commands.

- **Ownership Integrity:** Firestore security rules verify the user's unique ID (uid) against the document's owner\_id. This ensures that a donor can only modify or delete their own listings.
- **The "Need-to-Know" Protocol:** Request records contain sensitive communication between neighbors. Our rules ensure that a request document is only readable by the **Requester** and the **Donor** involved in that specific transaction. No third party can intercept or view these private exchanges.
- **Data Validation Logic:** Security rules also act as a data gatekeeper. For instance, the system automatically rejects any food listing that does not include a valid, future-dated expiry timestamp, maintaining the integrity of the community's health standards.

#### 3. Privacy-First Location Masking

To address concerns regarding physical safety and home privacy, Community Surplus implements a **Tiered Disclosure** model:

1. **Public Layer:** General users see only a neighborhood-level "fuzzy" radius or a landmark near the item.
  2. **Private Layer:** Precise pickup locations or personal contact details are only revealed through the app once the **Fair-Queue Algorithm** confirms a successful match.
- ### Security Architecture Summary.

### Conclusion:

This research introduced **Community Surplus**, a high-performance mobile intervention designed to reconcile the urban paradox of over-consumption and resource scarcity. By leveraging the **Flutter-Firebase** stack, we have successfully moved beyond traditional, fragmented donation models to create a real-time, equitable redistribution engine.

## Core Contributions

- **Algorithmic Equity:** Eliminated "speed-bias" through a system-managed Fair Queue, ensuring that essentials reach those in need rather than just the fastest users.
- **The Hybrid Marketplace:** Demonstrated that combining zero-cost donations with subsidized low-cost sales increases long-term donor engagement and platform sustainability.
- **Privacy by Design:** Proven that a peer-to-peer sharing ecosystem can remain secure and trustworthy through server-side authorization and tiered data disclosure.

Ultimately, Community Surplus provides a blueprint for how modern cloud technologies can be weaponized for social good—diverting tons of potential waste back into the hands of the community.

## Future Work:

While the current framework provides a robust foundation, the next phase of development focuses on

### Intelligence and Integration:

- **Hyper-Local Geospatial Discovery:** Implementing advanced geo-fencing to prioritize "micro-neighborhood" exchanges, further reducing the carbon footprint of transport.
- **AI-Powered Perishability Alerts:** Utilizing machine learning to predict food shelf-life based on photos and category data, automatically triggering high-priority "Flash Surplus" alerts.
- **Direct Institutional Bridges:** Integrating with local NGOs and municipal waste departments to handle bulk redistribution, creating a unified city-wide surplus dashboard.
- **Impact Analytics for Donors:** Developing "Personal Sustainability Scores" to show users exactly how many kilograms of CO2 and waste they have saved through their participation.

Community Surplus is not just an application; it is the infrastructure for a Circular City, where "waste" is a term used only for things we haven't found a neighbor for yet.