PATENT SPECIFICATION

A HYBRID, REAL-TIME SURPLUS REDISTRIBUTION SYSTEM WITH DYNAMIC LOGISTICS PRIORITIZATION AND FRAUD-PROOF CHAIN-OF-CUSTODY

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TITLE OF THE INVENTION

A HYBRID, REAL-TIME SURPLUS REDISTRIBUTION SYSTEM WITH DYNAMIC LOGISTICS PRIORITIZATION AND FRAUD-PROOF CHAIN-OF-CUSTODY

FIELD OF THE INVENTION

The present invention relates generally to the field of logistics optimization and distributed resource allocation systems. More particularly, the invention relates to a technology-enabled platform for the real-time redistribution of surplus resources, employing a hybrid logistics selection engine, a multi-factor priority scoring algorithm, a route coincidence optimization metric, an escrow-based fraud detection layer, and an identity-masked chain-of-custody protocol to improve computational efficiency, resource allocation, and systemic trust in a distributed network.

BACKGROUND OF THE INVENTION

There is a significant global challenge at the intersection of resource waste and scarcity. Inefficiencies in supply chains and the absence of real-time redistribution mechanisms result in the disposal of millions of tons of usable food and clothing annually, while a substantial portion of the population faces food insecurity and a lack of basic necessities.

Existing systems for resource redistribution are largely fragmented and technologically deficient. They can be categorized as follows:

1. **Volunteer-Only Coordination Platforms:** These systems (e.g., basic food rescue apps) rely on a pool of volunteers for pickup and delivery. The primary technical gap is a lack of reliability; the system has no resumption when volunteers are unavailable, leading to failed missions and resource destruction. They lack an integrated, multi-source logistics engine.

2. **Basic Driver-Matching Systems:** Prior art describes systems that match available drivers to delivery tasks. However, these are optimized for commercial efficiency (cost/time) and do not incorporate a hybrid logic that prioritizes non-commercial, moral-based deliveries (e.g., route-coincidence riders) before engaging paid logistics. They lack a sequential, cost-minimizing dispatch ordering.

3. **Donation Tracking and Listing Services:** Many existing platforms function as digital bulletin boards, simply listing available surplus. These systems lack the core technical components of a dynamic redistribution engine, including intelligent matching based on perishability, real-time logistics orchestration, and automated liability tracking.

Furthermore, all existing systems share common technical deficiencies. They lack a robust, automated mechanism for establishing trust and preventing fraud in a donation-funded model. There is no provision for identity masking to protect parties from defamation or collusion. They fail to define a clear, phase-based liability transition model, creating legal ambiguity. Critically, no prior art teaches a system that integrates a hybrid logistics selection engine with a donation-funded escrow payment system, a route-coincidence optimization metric, and a multi-factor verification protocol to create a technically secure, operationally efficient, and legally defensible redistribution platform. The present invention addresses these technological gaps.

SUMMARY OF THE INVENTION

The present invention provides a system and method for the real-time redistribution of surplus resources. The system comprises a plurality of user interfaces (donor, NGO, delivery partner) coupled to a backend server implementing a hybrid logistics selection engine. Upon receiving a surplus listing, the system executes a sequential, cost-minimizing dispatch logic. It first queries a registered NGO for self-pickup. If unavailable, it invokes a route-coincidence optimization engine to match the task with pre-existing travel routes of registered individuals. Failing this, it escalates to a volunteer pool and, as a final measure, to a professional logistics partner API integration.

A core component is an intelligent matching engine that computes a multi-factor priority score (P) to allocate resources fairly and efficiently, considering perishability, distance, NGO capacity, urgency, and a fairness weight to prevent monopolization. A novel route coincidence score (RC) quantifies the suitability of a rider for a delivery task.

The invention further includes a secure escrow and fraud detection layer. Delivery payments, funded by a platform donation pool, are held in escrow and released only upon multi-factor confirmation: QR code scans at pickup and drop, geo-tagged timestamps, and GPS route validation. A dynamic risk scoring engine analyzes behavioral patterns to detect and prevent collusion and fraud. An identity masking protocol ensures stakeholder privacy while maintaining backend traceability for dispute resolution. A chain-of-custody logging module timestamps each phase of the transaction, establishing a clear, phase-based liability framework.

DETAILED DESCRIPTION OF THE INVENTION

A. System Architecture

Referring to **Figure 1**, the system (100) comprises several interconnected modules operating on a cloud-based server infrastructure.

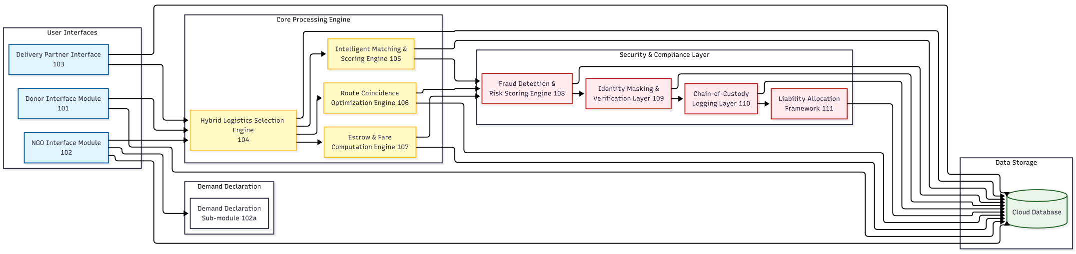

Figure 1: High-level block diagram illustrating the system architecture of the real-time surplus redistribution platform according to an embodiment of the invention.

1. **Donor Interface Module (101):** An application (web/mobile) allowing donors to register, submit surplus details (type, quantity, preparation time, photos, location), and declare a safe consumption window. It includes a multi-tier verification sub-module for identity validation (e.g., Aadhaar, DigiLocker, or commercial licenses).

2. **NGO Interface Module (102):** An interface for registered NGOs to manage their profile, including a **Demand Declaration Sub-module (102a)** for declaring daily capacity, current need status (High/Moderate/Low), and food-type compatibility (e.g., Veg/Non-Veg). This sub-module also tracks incoming allocations to prevent exceeding capacity.

3. **Delivery Partner Interface Module (103):** A unified interface for different classes of delivery agents, including registered volunteers, professional logistics partners (integrated via API), and individual riders for route-coincidence matching.

4. **Hybrid Logistics Selection Engine (104):** The core control logic implementing the sequential prioritization sequence, as detailed in **Section C**.

5. **Intelligent Matching & Scoring Engine (105):** This engine computes a dynamic matching score to select the most suitable NGO for a given surplus listing. The score is calculated using a multi-factor algorithm:

$$P = \alpha \cdot (S_p) + \beta \cdot (1/D) + \gamma \cdot (C_{match}) + \delta \cdot (U_{level}) + \varepsilon \cdot (N_{need}) - \zeta \cdot (A_{freq})$$

   Where:

   - S_p is the perishability score based on the remaining safe window.
   - D is the distance between donor and NGO.
   - C_{match} is the compatibility between donor and NGO declared types.
   - U_{level} is the urgency level flagged by the donor or system.
   - N_{need} is the declared need weight from the NGO.
   - A_{freq} is the allocation frequency to that NGO over a recent rolling window, acting as a fairness weight to prevent monopolization.

- $\alpha, \beta, \gamma, \delta, \varepsilon$, and ζ are configurable weighting coefficients.

6. **Route Coincidence Optimization Engine (106):** A specialized engine for matching delivery tasks with pre-existing travel plans. It computes a Route Coincidence Score (RC):

$$RC = w_1 \cdot R_{overlap} + w_2 \cdot T_{slack} - w_3 \cdot R_{delay}$$

   Where:

   - $R_{overlap}$ is the ratio of the delivery route overlapping with the rider's planned route.
   - T_{slack} is the time flexibility the rider has to perform the pickup/drop-off.
   - R_{delay} is a risk factor based on the rider's historical on-time performance.
   - w_1, w_2, and w_3 are configurable weights.

   Tasks are offered to riders with the highest RC score, with a user-interface flag for optionally waiving payment as a moral contribution.

7. **Escrow & Fare Computation Engine (107):** Calculates delivery fares using a proprietary model or via partner APIs. The proprietary model computes fare as a function of distance, estimated time, container size, and a platform-determined subsidy factor. The calculated fare is placed in an escrow account upon task assignment.

8. **Fraud Detection & Risk Scoring Engine (108):** Continuously monitors transactions and assigns a dynamic risk score to each actor (donor, NGO, delivery partner). The score is a function of historical disputes, frequency of transactions, anomalous route patterns, and unusual pairing patterns. It flags potential collusion (e.g., repeated donor-NGO-delivery partner triads) for manual audit or automatic freezing of payouts.

9. **Identity Masking & Verification Layer (109):** This critical security layer anonymizes the identity of donors and NGOs from each other and from delivery partners during the transaction lifecycle. Communication and task details are associated with a unique, system-generated Transaction ID. Full identity details are stored in an encrypted back-end database and are only revealed to involved parties under a formal dispute resolution protocol.

10. **Chain-of-Custody Logging Layer (110):** An immutable logging module that timestamps and records every critical event in a transaction: donor declaration, pickup confirmation, delivery acceptance, drop confirmation, and NGO final acceptance. This creates a verifiable audit trail.

11. **Liability Allocation Framework (111):** A logic module that, in conjunction with the chain-of-custody logs, automatically assigns prima facie responsibility based on the phase in which an issue is reported, as detailed in **Section F**.

B. Hybrid Logistics Selection Logic

Referring to **Figure 2**, upon receiving a validated surplus listing, the Hybrid Logistics Selection Engine (104) executes the following sequential, cost-minimizing logic (the ”51234” model):

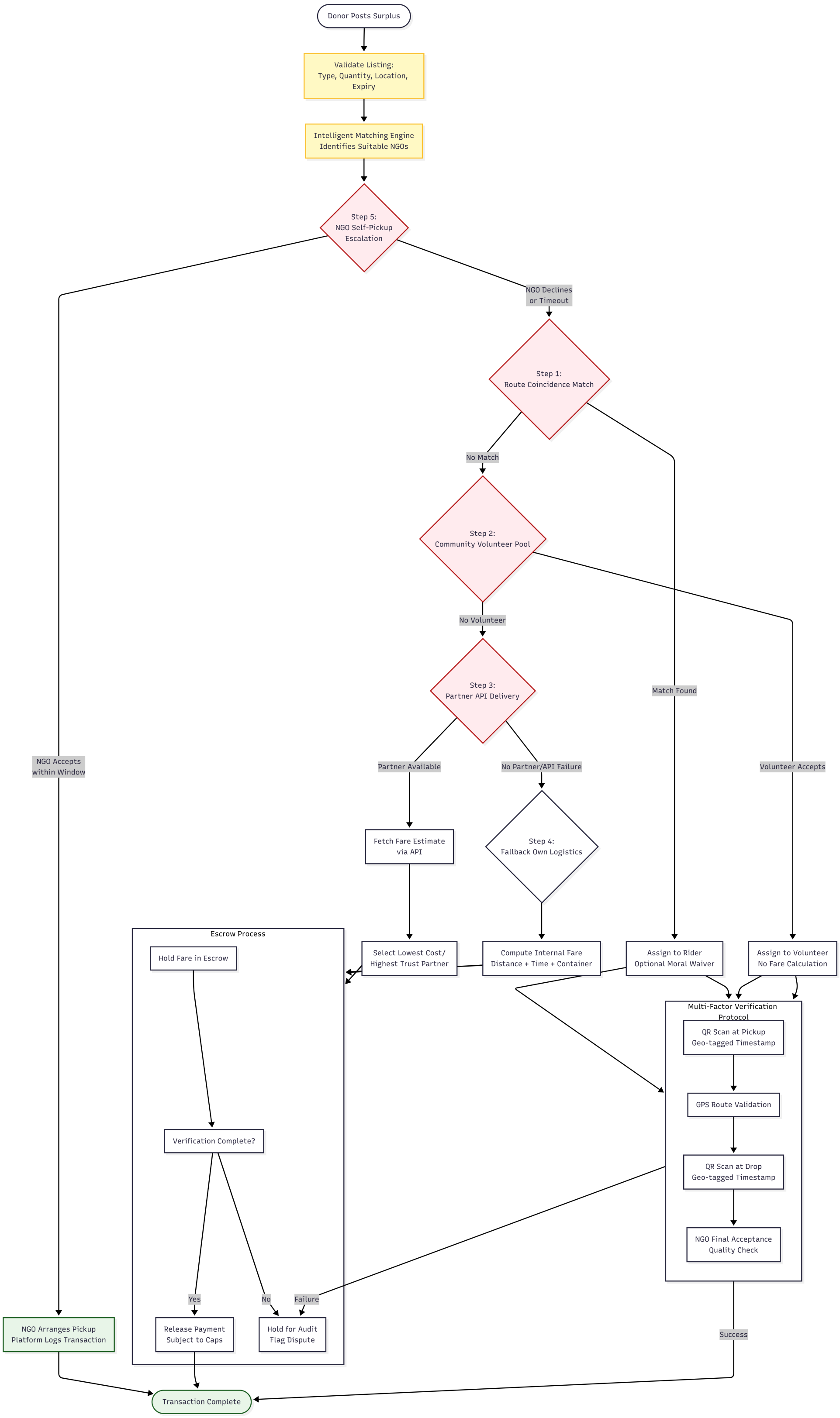

Figure 2: Flowchart depicting the hybrid logistics selection and prioritization sequence executed by the system.

- **Step 1: NGO Self-Pickup Escalation:** The system first notifies the matched NGO (from the Intelligent Matching Engine) of the listing and provides a predefined time window (e.g., 15-30 minutes) to confirm self-pickup. If confirmed, the transaction is logged, and no further system intervention is required. This step minimizes system-side logistics costs and complexity.

- **Step 2: Route Coincidence Match:** If the NGO does not confirm self-pickup, the system invokes the Route Coincidence Optimization Engine (106) to identify suitable riders from the pool of registered individuals. The task is offered to riders with the highest RC score. This step prioritizes low-cost, socially-motivated logistics.

- **Step 3: Community Volunteer Match:** If no route-coincidence rider accepts within a defined time, the system broadcasts the task to the general volunteer pool. Assignment is based on proximity, availability, and volunteer reliability score.

- **Step 4: Partner API Delivery Match:** If the volunteer pool fails, the system seamlessly transitions to a commercial logistics model. It interfaces with APIs of third-party logistics providers (e.g., Porter, Dunzo) to fetch real-time fare estimates and availability. The system selects a partner based on a weighted score of cost and reliability, and the task is dispatched.

- **Step 5: Fallback Own Logistics Engine:** In the event of partner API failure, extreme urgency (e.g., very short remaining safe window), or remote location, the system falls back to its own internal dispatch logic, using the proprietary fare model to engage a pre-vetted logistics provider.

C. Escrow, Fraud Prevention, and Verification Protocol

Referring to **Figure 3**, the system ensures transactional integrity through a robust, multi-layered protocol:

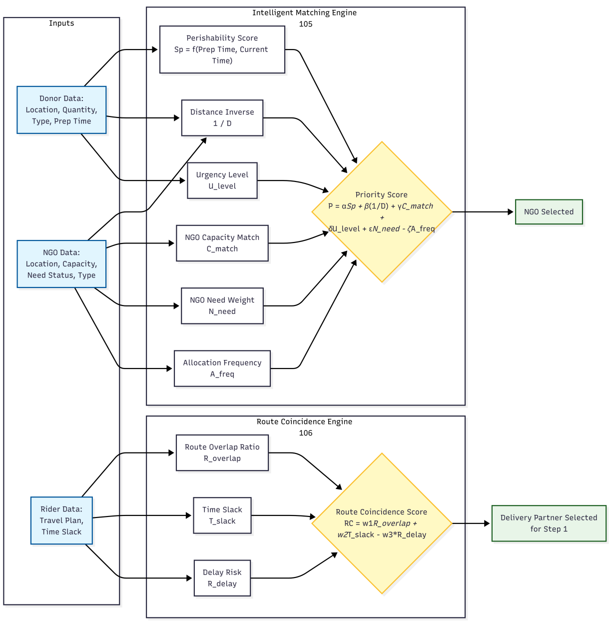

Figure 3: Illustration of the data flow and computation within the intelligent matching and route coincidence optimization engine.

1. **Task Assignment & Escrow:** Upon task assignment to a paid delivery partner (Step 3 or 4), the computed fare is debited from the platform's donation fund and held in a temporary escrow account.

2. **Pickup Confirmation:** At the donor location, the delivery partner scans a dynamic, time-bound QR code presented by the donor. This action records a geo-tagged timestamp and confirms the start of transit.

3. **In-Transit Validation:** The delivery partner's mobile app continuously (or at intervals) transmits GPS location data, allowing the system to validate that the route from pickup to drop is being followed in a realistic timeframe. Anomalies (e.g., extended stops, route deviations) are flagged.

4. **Drop Confirmation:** Upon reaching the NGO, the delivery partner scans a QR code unique to the receiving NGO. This action records another geo-tagged timestamp, confirming delivery.

5. **NGO Final Acceptance & Quality Check:** An authorized NGO representative visually inspects the goods and confirms receipt and quality via a final checkbox in the app. This step triggers the release of funds from escrow.

6. **Risk Score Update & Payout:** The system updates the risk scores for all involved parties. Funds are released from escrow to the delivery partner, subject to daily payout caps enforced by the system. High-risk transactions may have their payouts delayed for manual audit.

D. Identity Masking and Liability Framework

The Identity Masking & Verification Layer (109) ensures that throughout the transaction lifecycle (assignment, pickup, transit), the donor and NGO are identified only by their Transaction ID. The delivery partner sees only the pickup and drop-off locations necessary for the task. This prevents direct contact, data harvesting, and potential defamation or harassment.

Concurrently, the Liability Allocation Framework (111) enforces a clear, phase-based responsibility model based on the chain-of-custody logs:

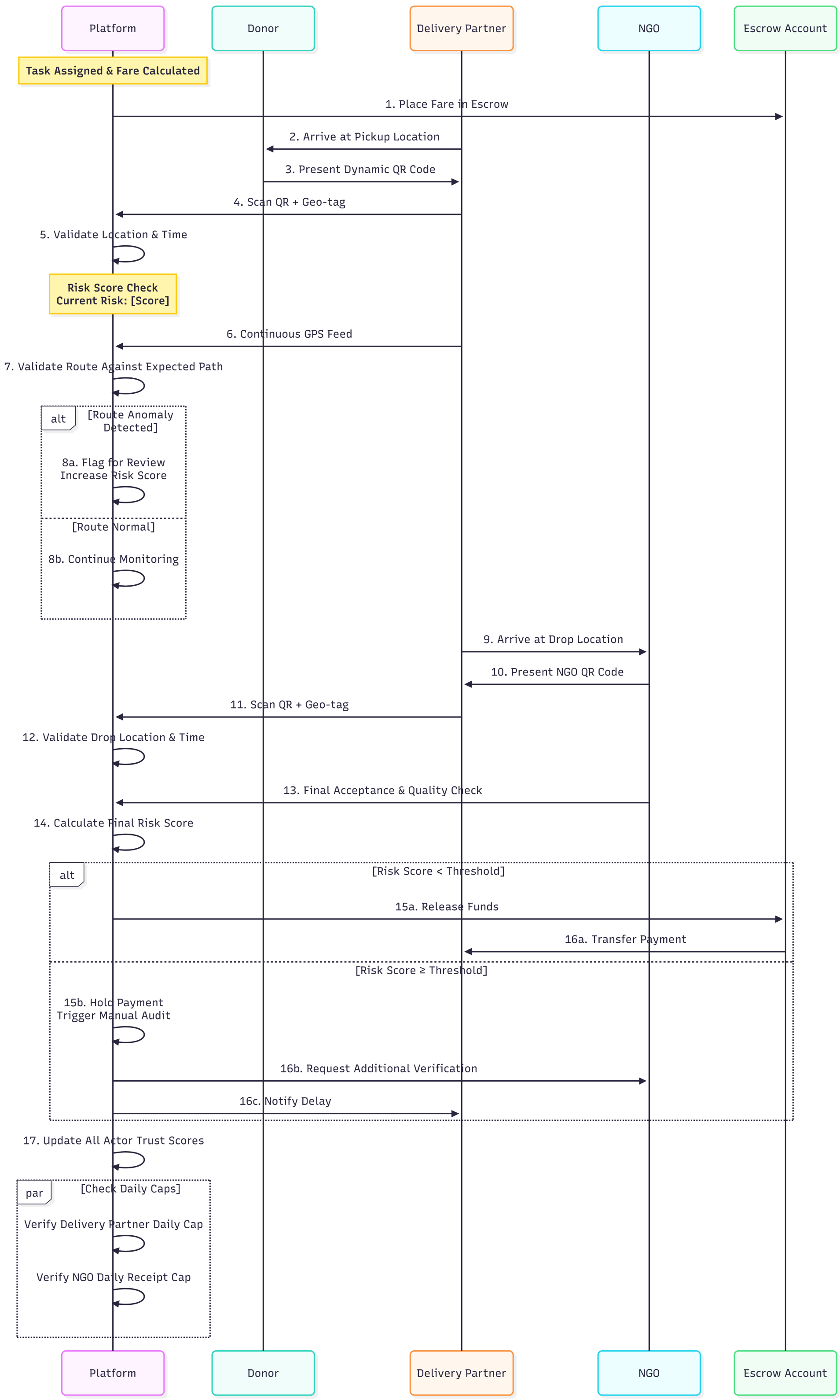

Figure 4: Swimlane diagram detailing the multi-factor fraud detection and escrow release protocol.

- **Phase 1 (Pre-Pickup):** The donor is responsible for the safety and accuracy of the surplus at the point of handover.

- **Phase 2 (In-Transit):** Responsibility transfers to the delivery partner upon successful QR scan at pickup. The delivery partner is responsible for maintaining the integrity of the goods during transit.
- **Phase 3 (Post-Acceptance):** Responsibility transfers to the NGO upon successful QR scan and final acceptance at drop-off. The NGO is responsible for subsequent storage and distribution.

The platform is explicitly defined as a technology facilitator and coordinator, disclaiming responsibility for the physical handling and safety of the goods, as the system does not prepare, store, or alter them.

E. Food vs. Clothing Logic

The system differentiates between resource types.

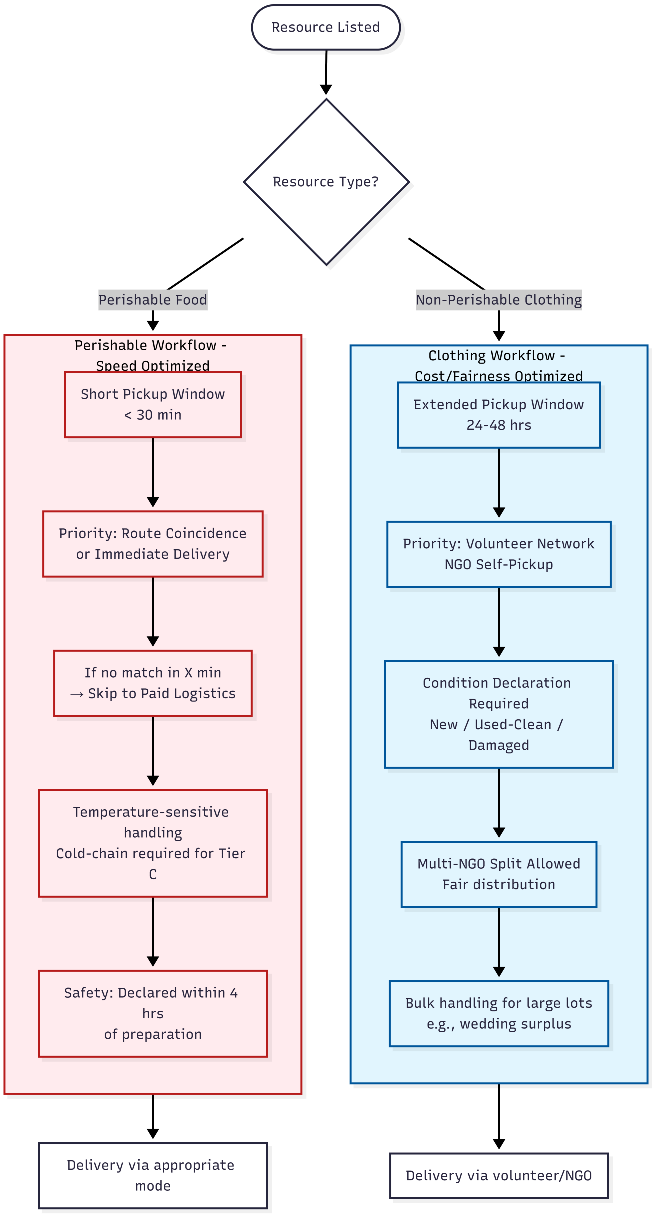

Figure 5: Timeline diagram defining the phase-based liability transition framework.

- **Perishable Food Workflow:** Prioritizes speed. It employs shorter time windows for each step in the hybrid logistics sequence and may bypass Steps 1 and 2 if the S_p (perishability score) falls below a critical threshold.
- **Non-Perishable Clothing Workflow:** Optimizes for cost and fairness rather than speed. It can utilize longer pickup windows, rely more heavily on volunteer networks, and incorporate a clothing-specific condition declaration (New/Used-Clean/Damaged) in the matching process.

CLAIMS

1. A real-time surplus redistribution system for coordinating the transfer of a resource from a donor to a recipient, the system comprising:
   (a) a donor interface module configured to receive a listing for the resource, the listing comprising a resource type, a pickup location, and a time constraint;
   (b) a recipient interface module configured to receive a demand declaration from a recipient, the demand declaration comprising a capacity and a need status;
   (c) a hybrid logistics selection engine configured to assign a delivery task associated with the listing to one of a plurality of logistics resource types based on a sequential, cost-minimizing logic;
   (d) an intelligent matching and scoring engine configured to compute a priority score for matching the listing with the recipient, the priority score being a function of a perishability metric, a geographic proximity metric, and a fairness weight based on an allocation frequency to the recipient;
   (e) an escrow and fare computation engine configured to calculate a fare for the delivery task and hold the fare in escrow pending verification;
   (f) a fraud detection and risk scoring engine configured to assign a dynamic risk score to each of a plurality of actors and to condition the release of the fare from escrow based on said risk score and a multi-factor verification protocol; and
   (g) an identity masking and verification layer configured to anonymize the identity of the donor and the recipient from each other and from a delivery partner assigned to the delivery task.

2. The system of claim 1, wherein the sequential, cost-minimizing logic of the hybrid logistics selection engine comprises a sequence of: (i) a recipient self-pickup escalation; (ii) a route-coincidence matching with a pre-existing travel route; (iii) an assignment to a volunteer pool; and (iv) an integration with a third-party logistics provider application programming interface (API).

3. The system of claim 2, further comprising a route coincidence optimization engine configured to compute a route coincidence score for a potential delivery partner, the score being a function of a route overlap ratio and a time slack, wherein the hybrid logistics selection engine assigns the delivery task to a delivery partner with a highest route coincidence score.

4. The system of claim 1, wherein the multi-factor verification protocol comprises: a first QR code scan at the pickup location generating a geo-tagged timestamp; a GPS trace validation of a route from the pickup location to a drop location; and a second QR code scan at the drop location generating a geo-tagged timestamp.

5. The system of claim 1, wherein the fraud detection and risk scoring engine is configured to detect a collusion pattern by analyzing a frequency of transactions involving a specific donor-recipient-delivery partner triad.

6. The system of claim 1, further comprising a chain-of-custody logging layer configured to record a plurality of timestamps corresponding to a donor declaration, a pickup confirmation, a drop confirmation, and a recipient final acceptance, thereby creating a verifiable audit trail.

7. The system of claim 6, further comprising a liability allocation framework configured to assign a liability for a reported issue based on a phase of the transaction in which the issue occurred, said phase being determined from the chain-of-custody logs.

8. The system of claim 1, wherein the priority score computed by the intelligent matching and scoring engine is further a function of a recipient need weight derived from the demand declaration.

9. The system of claim 1, wherein the escrow and fare computation engine is configured to enforce a daily payout cap for at least one of the delivery partner, the donor, or the recipient.

10. The system of claim 1, further comprising a logic for splitting the listing, wherein a quantity of the resource is allocated to a plurality of recipients based on their respective capacities and priority scores.

11. The system of claim 1, wherein the donor interface module includes a multi-tier verification sub-module requiring a different level of identity documentation based on a donor type.

12. The system of claim 1, wherein the time constraint comprises a declared safe consumption window, and the perishability metric is derived from a remaining time within said window.

13. A computer-implemented method for real-time surplus redistribution, the method comprising:

    (a) receiving, by a donor interface module, a listing for a resource;

    (b) receiving, by a recipient interface module, a demand declaration from a recipient;

    (c) computing, by an intelligent matching and scoring engine, a priority score to match the listing with the recipient;

    (d) selecting, by a hybrid logistics selection engine, a logistics resource type for a delivery task associated with the listing by executing a sequential logic comprising a recipient self-pickup check before querying an external logistics source;

    (e) calculating, by an escrow and fare computation engine, a fare and placing the fare in escrow;

    (f) verifying, by a fraud detection and risk scoring engine, a completion of the delivery task via a multi-factor verification protocol; and

    (g) masking, by an identity masking and verification layer, an identity of the donor and the recipient during the delivery task.

14. The method of claim 13, wherein selecting the logistics resource type further comprises computing, by a route coincidence optimization engine, a route coincidence score for a rider, and assigning the delivery task to the rider based on the score.

15. The method of claim 13, wherein the multi-factor verification protocol comprises: validating a QR code scan at a pickup location; validating a GPS trace of a delivery partner's route; and validating a QR code scan at a drop location.

16. The method of claim 13, further comprising detecting, by the fraud detection and risk scoring engine, a fraudulent pattern based on an analysis of transaction frequencies and actor pairings.

17. The method of claim 13, further comprising logging, by a chain-of-custody logging layer, a plurality of timestamps corresponding to key events in a transaction lifecycle to create an audit trail.

18. The method of claim 17, further comprising allocating, by a liability allocation framework, a legal responsibility for an issue based on a phase of the transaction determined from the audit trail.

19. A non-transitory computer-readable medium storing instructions that, when executed by a processor, cause the processor to perform a method for real-time surplus redistribution, the method comprising the steps of claim 13.

20. The computer-readable medium of claim 19, wherein the method further comprises the step of applying a fairness weight in the computation of the priority score, the fairness weight being inversely proportional to an allocation frequency of resources to the recipient.

ABSTRACT

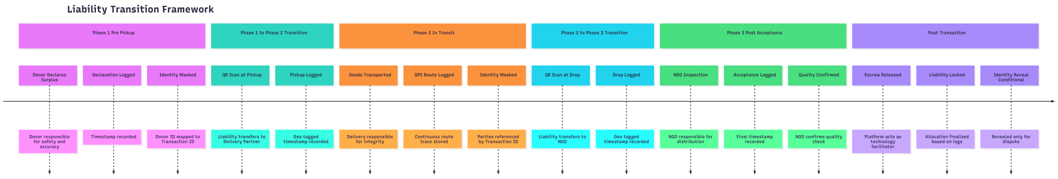

Figure 6: Timeline diagram defining the phase-based liability transition framework.

A hybrid, real-time surplus redistribution system and method are disclosed. The system comprises a donor interface, a recipient interface, and a delivery partner interface coupled to a backend server. A hybrid logistics selection engine (104) sequentially prioritizes resource allocation, first checking for recipient self-pickup, then employing a route-coincidence optimization engine (106) to match tasks with pre-existing travel routes, followed by volunteer and professional logistics partner assignments. An intelligent matching and scoring engine (105) uses a multi-factor priority score incorporating perishability and a fairness weight to allocate resources. An escrow and fare computation engine (107) manages donation-funded payments, which are released only upon a multi-factor verification protocol (QR scans, GPS validation) enforced by a fraud detection and risk scoring engine (108). An identity masking and verification layer (109) anonymizes stakeholders during transactions, while a chain-of-custody logging layer (110) timestamps events to support a clear, phase-based liability framework. The integrated system significantly improves operational efficiency, trust, and security in surplus redistribution networks.