

CARTLOCK™

Infrared Retrofit Checkout Cart System with Segmented Reflective Liner and Secure Bag Control

Whitepaper v1.1

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Abstract

CARTLOCK™ is a retrofittable intelligent checkout system that transforms standard shopping carts into semi-autonomous checkout devices. The system uses a rectangular infrared scan frame mounted at the cart basket opening, enhanced by a segmented reflective optical boundary liner and integrated BagLock secure bag system. Items are detected as they enter and exit the cart with improved accuracy. The segmented reflective liner maintains consistent optical performance, reduces false triggers from internal cart movement, and significantly decreases double-scanning errors. Customers complete purchases at a secure GateLock payment station, which verifies inventory, processes payment, releases the BagLock, and unlocks exit upon successful payment. This architecture bridges traditional checkout and fully autonomous retail without requiring full store infrastructure replacement, while adding strong anti-shrink protection and improved customer experience through secure bag handling.

1. Problem Statement

Retail checkout systems face persistent structural constraints: **Labor Cost** — Cashiers and supervision remain significant ongoing expenses. **Friction** — Lines, scanning delays, and repetitive actions reduce throughput and customer satisfaction. **Shrink** — Self-checkout systems increase theft, error rates, and loss. Internal cart movement and unsecured bags during shopping exacerbate these issues. **Infrastructure Lock-In** — Fully autonomous "smart store" solutions typically require complete store rebuilds or proprietary infrastructure, making them inaccessible to most existing retailers. There is currently no scalable, cost-effective retrofit solution that combines reliable cart-level detection, optical robustness against common failure modes, and secure bag handling with payment-gated exit control.

2. Solution Overview

CARTLOCK™ introduces cart-level tracking combined with a controlled payment gate, hardened detection via segmented reflective liner, and secure BagLock bag release on verified payment. **Core Flow:** 1. Customer takes cart (BagLock engaged) 2. Items added/removed → tracked with high reliability 3. Cart builds accurate live inventory 4. Customer proceeds to GateLock payment station 5. System verifies inventory and processes payment 6. BagLock releases securely; exit gate unlocks 7. Customer exits with secured bags now released

3. System Architecture

3.1 CartScan Frame with Segmented Reflective Liner (v1.1 Enhancement)

A rectangular infrared detection frame is mounted at the basket opening. This is augmented by a **segmented reflective optical boundary liner** — a durable, tarp-like reflective mirror layer divided into 4–6 rigid or semi-rigid panels connected by flexible living hinges or reinforced joints. **Key Benefits of the Segmented Liner:** - Prevents folding, creasing, or bunching during normal use and cart folding/storage - Maintains consistent reflective performance at the top detection plane - Significantly reduces "double scanning" false positives and ambiguous internal movement triggers - Easy to clean and replace in segments - Low-cost retrofit addition that hardens IR detection without structural cart changes

3.2 Cart Intelligence Module

Components: Microcontroller (ESP32 class), rechargeable battery, wireless communication (WiFi/BLE), Cart ID chip, BagLock actuator interface. Functions: Event logging, session tracking, backend synchronization, anti-tamper monitoring, and BagLock engagement/release signaling.

3.3 Multi-Sensor Validation Layer

Infrared serves as the primary directional detection layer (hardened by the segmented reflective liner). Additional validation options include barcode assist, RFID tagging, weight tracking, or camera verification for higher-security environments.

3.4 GateLock™ Payment Station

Functions: Pulls cart inventory, displays items for customer review, performs final verification, accepts payment (tap/card/mobile), signals BagLock release, and unlocks the exit gate upon successful payment.

3.5 BagLock™ Secure Bag System (v1.1 Enhancement)

Lockable bag attachment points or secondary locking compartment on the cart. Bags remain secured and tamper-evident throughout the shopping session, preventing bag swapping, spillage, or pre-payment removal. Upon successful payment verification at the GateLock station, the Cart Intelligence Module receives a release signal and electronically disengages BagLock. This adds a powerful anti-shrink layer while improving customer experience — bags stay organized and secure until payment is complete, then release cleanly.

4. Operational Flow

1. **Cart Activation & BagLock Engagement** — Session begins when cart is taken. 2. **Shopping Phase** — Items added/removed and tracked with enhanced reliability. 3. **Live Inventory** — Running total maintained with improved accuracy. 4. **Gate Entry** — Cart enters payment station. 5. **Verification + Payment** — Inventory confirmed; payment processed. 6. **BagLock Release + Gate Unlock** — On successful payment, BagLock disengages and gate opens. 7. **Exit** — Customer departs with secured bags now released.

5. Security Model

Multi-layer hardened system (v1.1): - Event tracking with optical robustness (segmented reflective liner) - Directional detection at cart level - Gate enforcement - Cart identity tracking - Anomaly detection - BagLock secure bag control (releases only on verified payment) - Core principle: **No payment = no exit and no bag release**

6. Competitive Position & Market Impact

CARTLOCK™ offers low-to-medium cost, low infrastructure requirement, high accuracy (with hybrid validation), high scalability, and added BagLock security/customer convenience. **Retail Impact:** Reduced labor, faster throughput, lower shrink, modern UX. **Customer Impact:** No scanning fatigue, faster checkout, transparent tracking, bags stay secure until payment is complete.

7. IP Positioning

Novel elements in v1.1 include the retrofittable cart scan frame with segmented reflective optical boundary liner, directional detection hardened against internal movement false positives, payment-gated exit tied to cart, and BagLock secure bag system with electronic release on verified payment. Defensibility rests on hardware + system integration, retrofit-first model, and controlled exit + bag release architecture.

8. Conclusion

CARTLOCK™ v1.1 upgrades existing retail systems into a semi-autonomous checkout model without requiring store rebuilds. The addition of the segmented reflective optical boundary liner hardens IR detection against common failure modes, while the BagLock system adds a powerful new layer of shrink prevention and customer convenience through payment-tied secure bag release. **Core Principle:** The cart becomes the checkout — with hardened detection and secure bag control.

Signed

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