

CARTLOCK™

INFRARED RETROFIT CHECKOUT CART SYSTEM

Whitepaper v1.1

*Scan as you shop. Pay once. Walk out.
Secure bags released on payment.*

1. ABSTRACT

CARTLOCK™ is a retrofittable intelligent checkout system that transforms standard shopping carts into semi-autonomous checkout devices using a rectangular infrared scan frame mounted to the cart, 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 via the segmented reflective liner, which maintains consistent optical performance and reduces false triggers from internal movement. Customers complete purchases at a secure bagging and payment gate (GateLock™), which verifies contents, processes payment, releases the BagLock, and unlocks exit upon successful payment.

This system bridges traditional checkout and fully autonomous retail without requiring full infrastructure replacement, while adding robust anti-shrink and customer convenience layers.

2. PROBLEM STATEMENT

Retail checkout systems face four major constraints:

- **1. Labor Cost** — Cashiers and supervision remain expensive.
- **2. Friction** — Lines and scanning delays reduce throughput.
- **3. Shrink** — Self-checkout increases theft and error rates; internal cart movement and unsecured bags exacerbate issues.
- **4. Infrastructure Lock-In** — Smart stores require complete rebuilds.

There is no scalable retrofit solution for existing stores that combines reliable cart-level detection, optical robustness, and secure bag handling with payment-gated exit.

3. SOLUTION OVERVIEW

CARTLOCK™ introduces cart-level tracking combined with a controlled payment gate, enhanced detection via segmented reflective liner, and secure BagLock release on payment.

Flow:

1. Customer takes cart (BagLock engaged)
2. Items added → detected with high reliability (segmented reflective liner prevents folding/creasing and reduces double-scanning false positives)
3. Items removed → detected
4. Cart builds accurate inventory
5. Customer goes to GateLock payment station

6. System verifies inventory + processes payment
7. BagLock releases securely; Gate unlocks
8. Customer exits with secured bags now released

4. SYSTEM ARCHITECTURE

4.1 CartScan Frame

Rectangular infrared detection frame mounted at basket opening, augmented by segmented reflective optical boundary liner.

Functions:

- Detects item entry/exit with directional analysis
- Logs events with reduced false positives from internal movement
- Builds reliable inventory

Segmented Reflective Optical Boundary Liner (New in v1.1)

- Durable, tarp-like reflective mirror layer lining the interior walls and base of the cart basket.
- Divided into 4–6 rigid or semi-rigid reflective panels connected by flexible living hinges or reinforced flexible joints.
- Prevents folding, creasing, or bunching during normal cart use and folding/storage — each segment remains flat and optically consistent.
- Maintains a stable reflective environment that improves IR beam behavior at the top detection plane, significantly reducing "double scanning" and ambiguous internal movement triggers.
- Easy to clean, replaceable in segments, and designed for harsh retail environments (impact, moisture, frequent sanitation).
- Low-cost retrofit addition that hardens the core IR detection layer without requiring changes to existing cart structures.

Features: Slim rectangular housing • Multi-point IR beam grid • Directional analysis • Low power operation • Segmented reflective liner for optical robustness and anti-false-positive performance

4.2 Cart Intelligence Module

Components: Microcontroller (ESP32 class) • Rechargeable battery • Wireless communication (WiFi/BLE) • Cart ID chip • BagLock actuator interface (new)

Functions: Event logging • Session tracking • Backend sync • Anti-tamper monitoring • BagLock engagement/release signaling

4.3 Multi-Sensor Validation Layer

Infrared = primary directional detection (hardened by segmented reflective liner)

Validation = accuracy

Options: Barcode assist • RFID tagging • Weight tracking • Camera verification

4.4 GateLock™ Payment Station

Functions: Pull cart inventory • Display items • Final verification • Accept payment (tap/card/mobile) • Signal BagLock release • Unlock exit gate

4.5 BagLock™ Secure Bag System (New in v1.1)

Integrated secure bag handling mechanism that works in concert with the payment-gated exit.

Functions:

- Lockable bag attachment points or secondary locking compartment on the cart.
- Bags remain secured and tamper-evident throughout the shopping session (prevents bag swapping, spillage, or pre-payment removal).
- Upon successful payment verification at GateLock station, the Cart Intelligence Module receives release signal and electronically disengages BagLock.
- Customer can then remove bags cleanly and exit.
- Adds strong anti-shrink layer and improves customer experience (bags stay organized and secure until payment is complete).

Integration: Electronically linked to GateLock verification and payment confirmation. Manual override available for staff with proper authentication. Contributes to overall "no payment = no exit and no bag release" security model.

4.6 Exit Control

Gate locked until payment + BagLock release confirmed • Cart flagged as cleared • Optional exit verification • Alert system for anomalies

5. OPERATIONAL FLOW

- 1. Cart Activation & BagLock Engagement** — Session begins when cart is taken; BagLock secures bags.
- 2. Shopping Phase** — Items added/removed → tracked with enhanced reliability via segmented reflective liner (reduced double-scanning).
- 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; session closes.
- 7. Exit** — Customer departs with secured bags now released.

6. RETROFIT DESIGN

CARTLOCK™ upgrades existing carts without replacement. Compatible with metal carts, plastic carts, grocery and retail chains.

Installation: Clip-on or bolt-on frame • Segmented reflective liner (segmented panels install easily into existing basket) • BagLock attachment points (minimal modification) • Charging docks • POS integration

7. SECURITY MODEL

Multi-layer system (hardened in v1.1):

- Event tracking with optical robustness (segmented reflective liner)
- Directional detection
- Gate enforcement
- Cart identity tracking
- Anomaly detection
- BagLock secure bag control (releases only on verified payment)
- No payment = no exit and no bag release

8. COMPETITIVE POSITION

CARTLOCK™ v1.1: Low-medium cost • Low infrastructure requirement • High accuracy (with hybrid validation + hardened IR via segmented reflective liner) • High scalability • Added BagLock security and customer convenience layer

9. MARKET IMPACT

Retail: Reduced labor • Faster throughput • Lower shrink (improved detection + BagLock) • Modern UX with secure bag handling

Customer: No scanning fatigue • Faster checkout • Transparent cart tracking • Bags stay secure until payment complete, then release cleanly

10. EXPANSION

Warehouse carts • Airport retail • Hardware stores • Medical logistics • Industrial inventory • Enhanced with BagLock for high-shrink categories

11. IP POSITIONING

Novel Elements (expanded in v1.1):

- Retrofittable cart scan frame with segmented reflective optical boundary liner
- Directional detection at cart level hardened against internal movement false positives
- Cart-to-gate validation loop
- Payment-gated exit tied to cart
- BagLock secure bag system with electronic release on verified payment
- Segmented liner design that prevents folding/creasing while maintaining optical performance

Defensibility: Hardware + system integration (IR frame + segmented liner + BagLock + gate) • Retrofit-first model • Controlled exit + bag release architecture • Specific segmented reflective liner geometry and hinge design for optical consistency

12. FUTURE DEVELOPMENT

AI vision integration (layered on hardened IR base) • Fully autonomous checkout • Mobile app integration • Dynamic pricing systems • AZ Interface integration • Advanced BagLock variants (multi-compartment, smart tagging)

13. 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.

END OF DOCUMENT

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Refinements: Segmented reflective liner + BagLock integration for improved accuracy, security, and usability.