

# Intelligent Valet Retrieval System for Multi-Gate Mall

## 1. System Overview

### Key Components

#### Mobile App/Web App:

Interface used by the customer to request car pickup. Collects device location, motion data, and proximity signals.

#### Backend Engine:

Core logic for exit gate prediction, valet dispatching, ETA estimation, and dynamic updates.

#### Valet Terminal:

Used by valet staff to receive car delivery requests and instructions for delivery gate.

#### BLE Beacons / Wi-Fi APs (optional but recommended):

Strategically placed at/near gates and inside the mall to aid with accurate positioning.

#### Geofencing Module:

Monitors user movement toward specific exit zones in real time.

## 2. Exit Gate Detection Logic

### Multi-Signal Gate Prediction Engine

Upon car request, the system uses a multi-layered approach to determine the likely exit gate.

#### A. Location and Motion Analysis

- GPS: Checks coarse location, trajectory vector, and walking speed to estimate path.
- Motion Sensors: Accelerometer and gyroscope detect walking direction even if GPS drifts.
- Dead Reckoning: Uses last known accurate location + step counting and orientation for indoor tracking.

#### B. Proximity Detection

- Bluetooth Beacons (BLE): Placed near exits; detect when a user is within 10-15m range of a gate.
- Wi-Fi Triangulation: Leverages existing mall access points to improve indoor positioning accuracy.

### C. Heuristics & Behavior Prediction

- Last Visit History: Gate most frequently used by the user in the past.
- Foot Traffic Trends: Prefer less congested exits if user is equidistant from two gates.
- Time of Day: Certain exits may be more popular at different times.

## 3. Dynamic Flow Logic

Retrieval Trigger Flow:

1. User clicks retrieval link (app/SMS) triggers:
  - Location & motion updates
  - Proximity signal scanning
  - Entry gate & timestamp logging
2. Gate Prediction Engine activates:
  - Computes confidence score for each gate
  - Selects likely gate based on weighted signals
3. Dispatch Decision:
  - Sends car to predicted gate
  - Valet app receives gate + ETA
  - Monitors for user path changes via real-time updates
4. Fallback:
  - If user deviates from predicted gate:
    - Update gate
    - Reassign valet or notify user of new gate via app/SMS

## 4. Assumptions

- BLE beacons are deployed at all exit gates (low-cost and feasible).
- Users have background location permissions enabled during the retrieval session.
- Mall has reliable Wi-Fi and GPS coverage at periphery zones.
- Car retrieval takes ~5-10 mins; system optimizes to predict gate with at least 80% confidence

within first 1-2 minutes after request.

## **5. Summary**

- Combines sensor data, location, historical behavior, and real-time signals to accurately infer user's intended exit.
- Uses BLE beacons + geofencing + motion tracking to overcome GPS drift indoors.
- Supports dynamic reassignment in case the user changes direction or lingers.