Intelligent Valet System Design

Title: Intelligent Valet System for Multi-Gate Mall

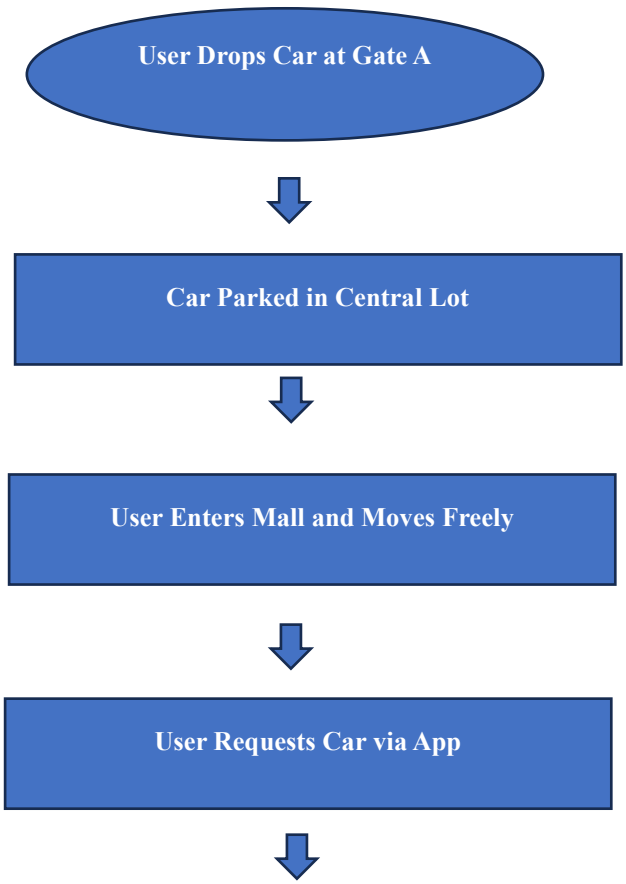
Objective: To proactively determine a user's intended exit gate upon a car retrieval request and dispatch their vehicle to that gate with perfect timing, without requiring any explicit input from the user.

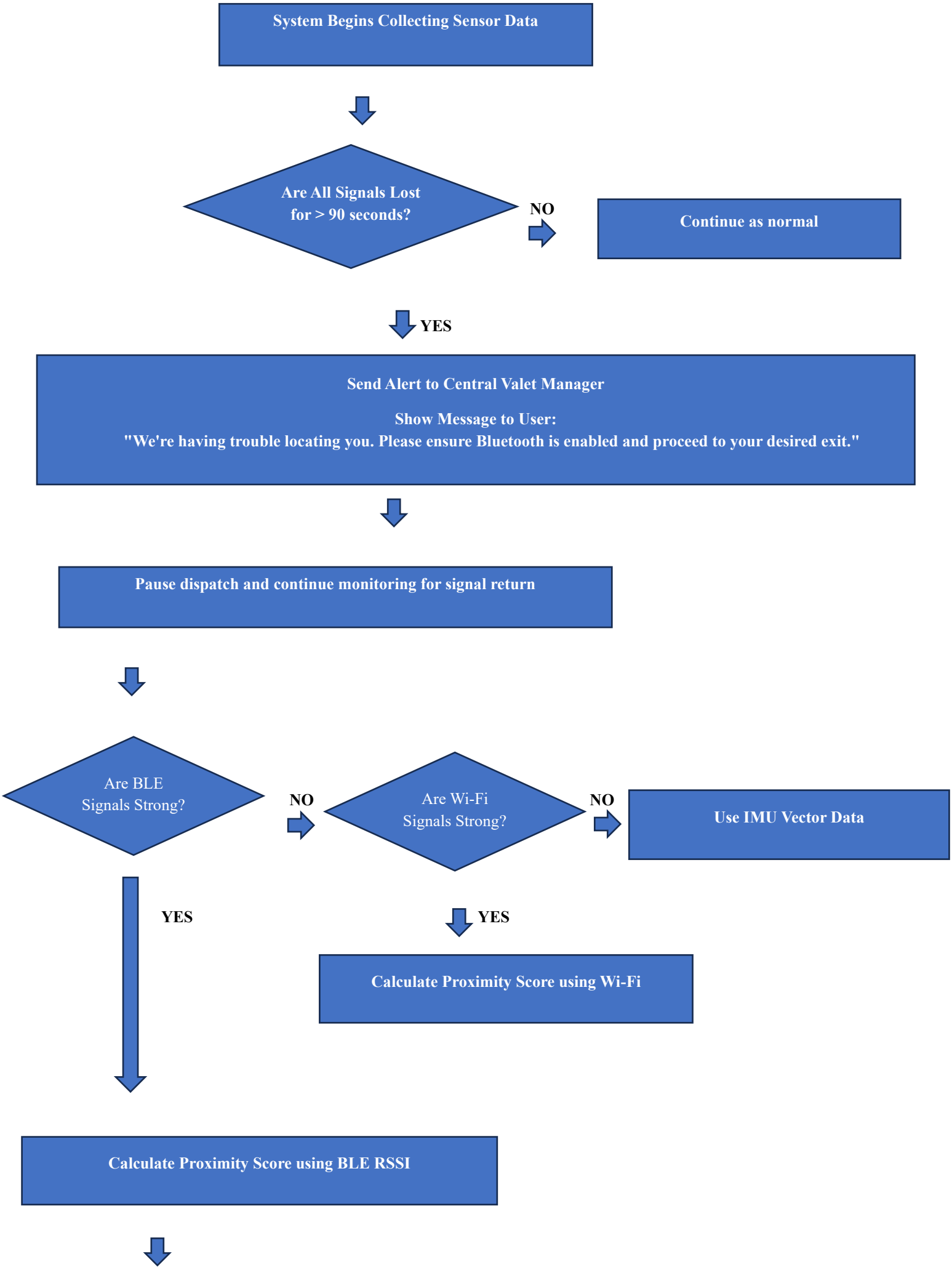
The system is built on a principle of multi-sensor fusion and probabilistic modeling. It combines data from various sources within the mall to build a high-confidence prediction of the user's path.

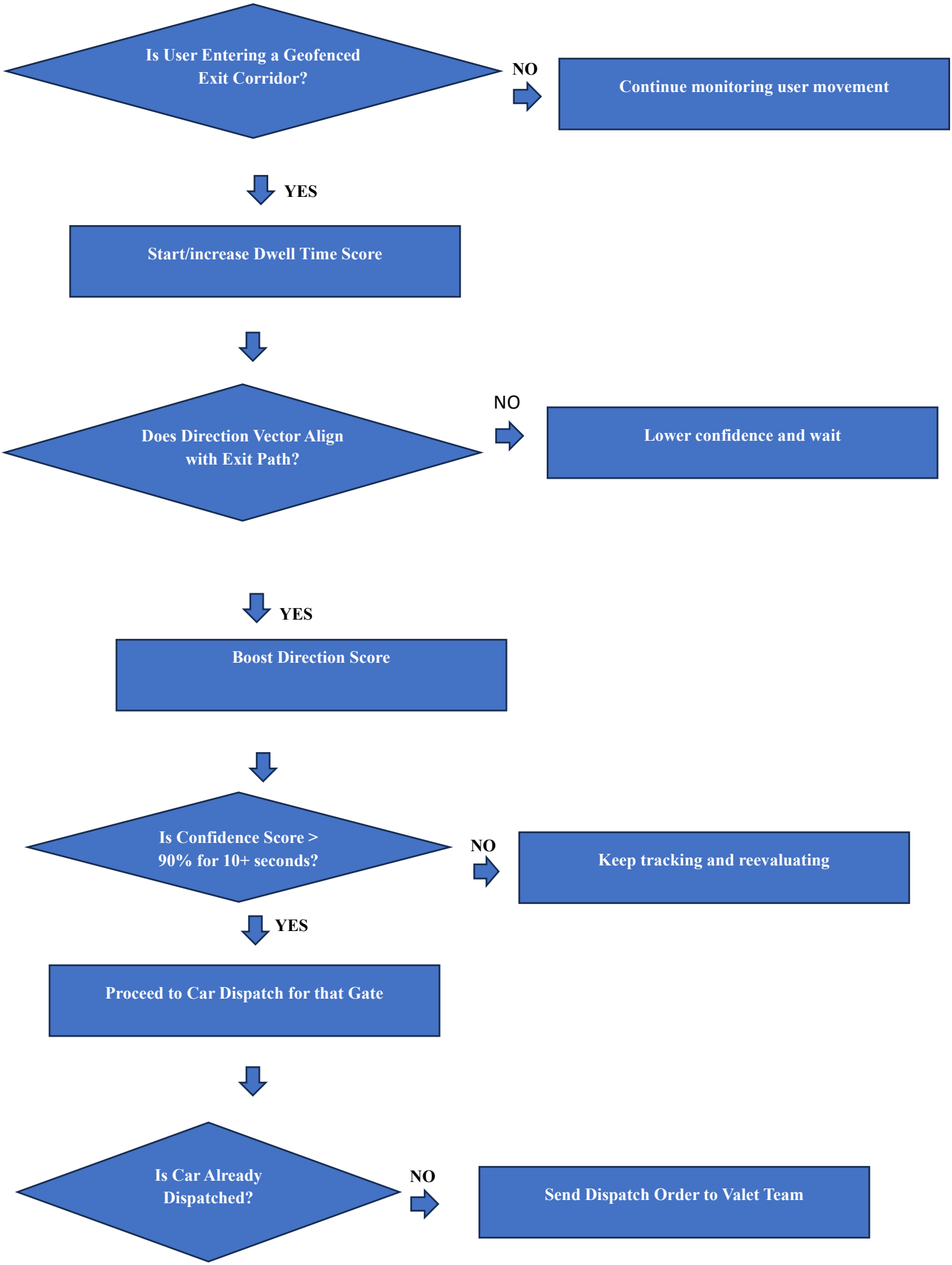
Key Components:

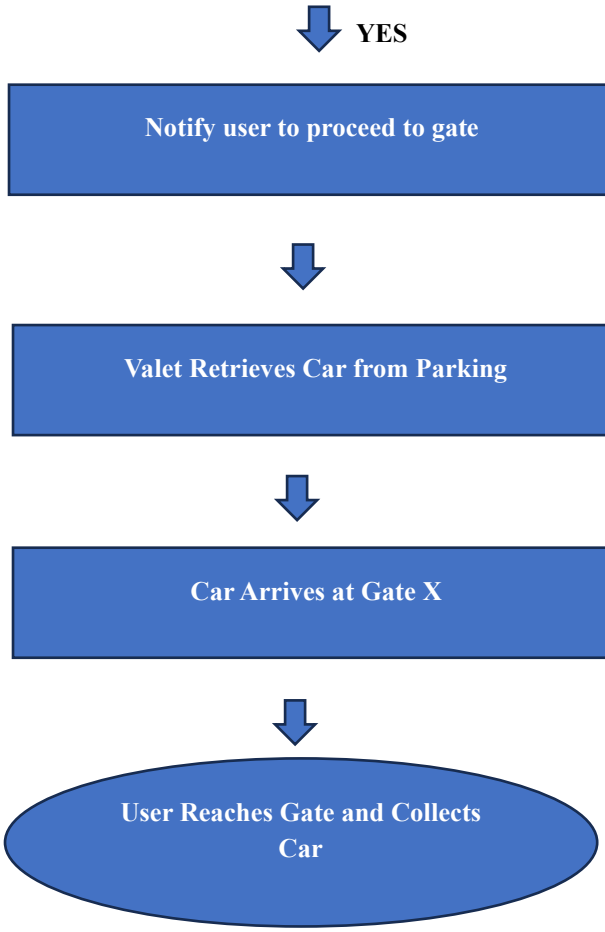
- **Mobile App**: Car request trigger + sensor data sender.
- **Backend Logic**: Location analysis, gate prediction, dispatch decision.
- **Sensors**: BLE beacons, Wi-Fi, IMU (accelerometer/gyroscope).
- **Valet Dashboard**: Receives car dispatch instructions in real-time.

Flow Diagram:




System Begins Collecting Sensor Data
Are All Signals Lost for > 90 seconds?
NO
Continue as normal
YES
Send Alert to Central Valet Manager
Show Message to User:
"We're having trouble locating you. Please ensure Bluetooth is enabled and proceed to your desired exit."
Pause dispatch and continue monitoring for signal return
Are BLE Signals Strong?
NO
Are Wi-Fi Signals Strong?
NO
Use IMU Vector Data
YES
YES
Calculate Proximity Score using Wi-Fi
Calculate Proximity Score using BLE RSSI


Is User Entering a Geofenced Exit Corridor?
NO
Continue monitoring user movement
YES
Start/increase Dwell Time Score
Does Direction Vector Align with Exit Path?
NO
Lower confidence and wait
YES
Boost Direction Score
Is Confidence Score > 90% for 10+ seconds?
NO
Keep tracking and reevaluating
YES
Proceed to Car Dispatch for that Gate
Is Car Already Dispatched?
NO
Send Dispatch Order to Valet Team



Exit Gate Detection Logic:

Probabilistic Scoring Model

Score = (w1 * Proximity) + (w2 * Direction) + (w3 * DwellTime)

- **Proximity (40%)**: Based on BLE signal strength to nearest beacon.
- **Direction (40%))**: IMU vector alignment to corridor/gate.
- **Dwell Time (20%)**: Time spent within geofenced corridor area.

Trigger: Score > 90 maintained for 10 seconds = Dispatch

Real-World Challenges:

Challenge	Solution
GPS Unreliable	Use BLE > Wi-Fi > IMU fallback hierarchy
User Changes Direction	Recalculate confidence; redirect valet if car not dispatched
Congestion at Gate	Adjust scoring to prioritize least-busy gate nearby

User Stands Still	Delay dispatch until movement is detected
Signal Loss	Notify user + central valet manager

Conclusion:

This intelligent valet system moves beyond simple requests to create a seamless, predictive, and user-centric experience. By leveraging a multi-layered sensor strategy and a probabilistic inference engine, it removes the burden of choice from the user and solves the complex logistical challenge of a multi-gate environment. The design is robust, accounting for real-world issues like signal loss and changes in user behavior, ensuring a reliable and seemingly "magical" service.