Real-Time Parking Dynamic Pricing Report

Overview

This project builds a dynamic pricing model for parking using real-time occupancy data, queue lengths, traffic levels, and vehicle types. It utilizes Pathway for real-time stream processing and Bokeh + Panel for interactive visualization.

Two models are developed:
1. Model-1: A simple price function based on occupancy range.
2. Model-2: A more comprehensive model incorporating demand prediction based on multiple features.

Technology Stack

Component	Tool/Library Used
Real-Time Stream Processing	Pathway
Data Manipulation	Pandas, Numpy
Visualization	Bokeh, Panel
Dataset	Real-time parking logs
Plotting & Dashboard	Bokeh, Panel

Architecture Flow

Raw CSV Data → Preprocessing & Timestamp Parsing → Stream via Pathway CSV Replay → Model-1 (Occupancy-Based Price) and Model-2 (Demand-Based Pricing) → Price Streams → Visualization using Bokeh + Panel

Model-1 (Simple):

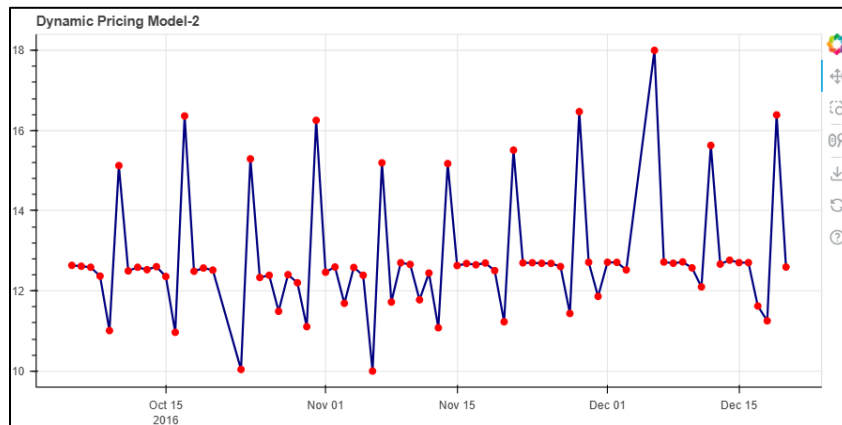$$Price = BasePrice + (Occ\_max - Occ\_min) / Capacity$$
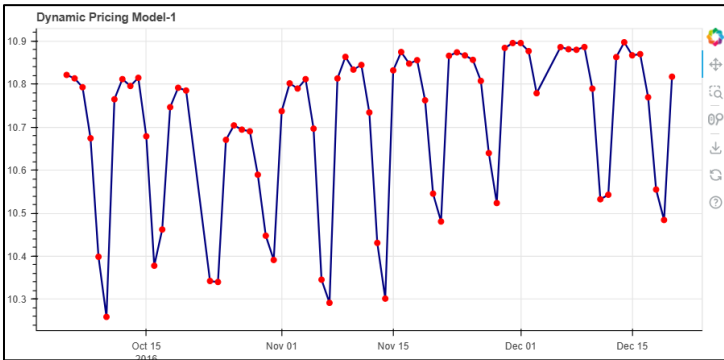
Model-2

Demand Function:

$$D(t) = \alpha * ((Occ\_max - Occ\_min) / Capacity) + \beta * Queue + \delta * IsSpecialDay + \varepsilon * VehicleTypeWeight - \gamma * TrafficLevel$$

Price Function

1. Compute demand
2. Normalize demand (min-max)
3. RawPrice = BasePrice * $(1 + \lambda *$ norm_demand$)$
4. Clamp to [0.5x, 2x] base_price

Assumptions

- Occupancy change reflects demand variability.
- Queue length is a proxy for latent demand.
- High traffic discourages parking.
- Vehicle type affects pricing (trucks > bikes).
- Base price is arbitrarily set at ₹10.

Price Response to Demand and Competition

Factor	Effect on Price
High Occupancy Range	Increases
Long Queues	Increases
Heavy Traffic	Decreases
Special Events	Increases
More Trucks	Increases
More Cycles	Decreases

Final Thoughts

This system is an extensible, real-time dynamic pricing engine for smart parking. By integrating streaming data with normalized demand metrics, cities and facility operators can optimize space usage and revenue while improving user convenience.