Capstone Project Report

Dynamic Pricing for Urban Parking using Real-Time Streams

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Project Title: Dynamic Pricing Capstone (Pathway Integrated)

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Project Objective

To simulate real-time pricing for 14 urban parking lots using streaming data and apply adaptive pricing models based on demand, traffic, and occupancy. The solution is implemented using the Pathway real-time data engine and visualized using Bokeh.

Dataset Overview

The dataset consists of streaming parking records with the following features:

- SystemCodeNumber – Unique lot ID
- Capacity, Occupancy, QueueLength
- TrafficConditionNearby – (low, medium, high)
- VehicleType – (car, bike, truck)
- IsSpecialDay – 1 or 0
- LastUpdatedDate, LastUpdatedTime – used for real-time timestamp

Model Architectures

Model 1: Baseline Linear Pricing

Logic:

$$Price_{t+1} = Price_t + \alpha \times (Occupancy / Capacity)$$

Parameters:

- Base price = ₹10
- α = 2.0
- Price is clamped between ₹5 and ₹20

Model 2: Demand-Based Pricing

Logic:

$$Demand = \alpha \times (Occupancy/Capacity) + \beta \times QueueLength - \gamma \times Traffic + \delta \times IsSpecialDay + \varepsilon \times VehicleTypeWeight$$

$$Price = BasePrice \times (1 + \lambda \times NormalizedDemand)$$

Parameters:

- $\alpha = 2.0$
- $\beta = 0.5$
- $\gamma = 1.0$
- $\delta = 2.0$
- $\varepsilon = 1.5$
- $\lambda = 0.2$

Real-Time Pipeline with Pathway

Pathway ingests the CSV dataset in streaming mode. Each row is processed in real time using a @pw.udf pricing function. Model type is chosen via a config flag (model_choice). The result is streamed out into a CSV (pathway_output.csv).

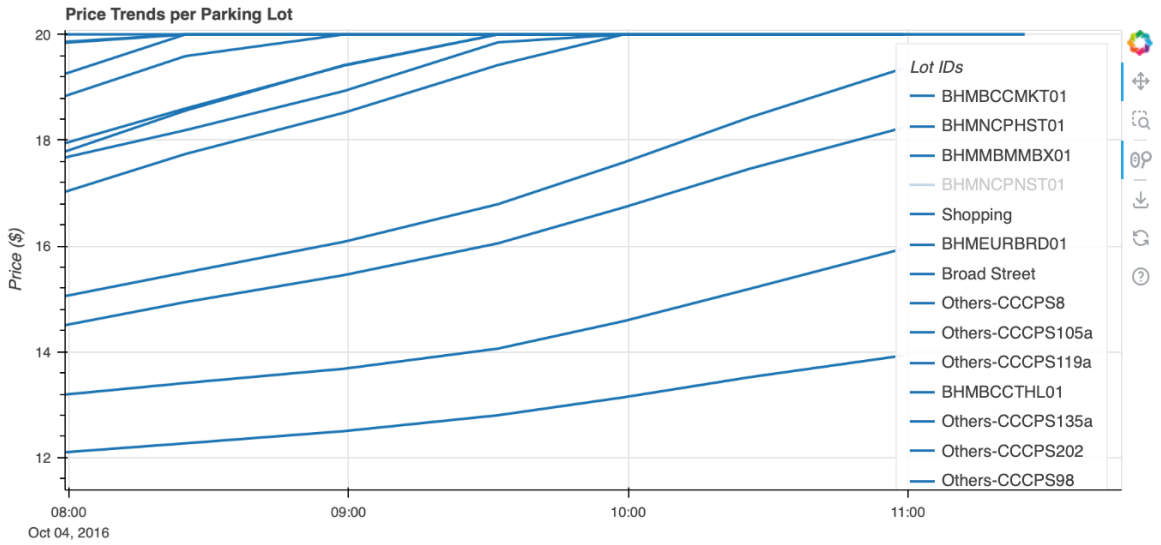
Visualization

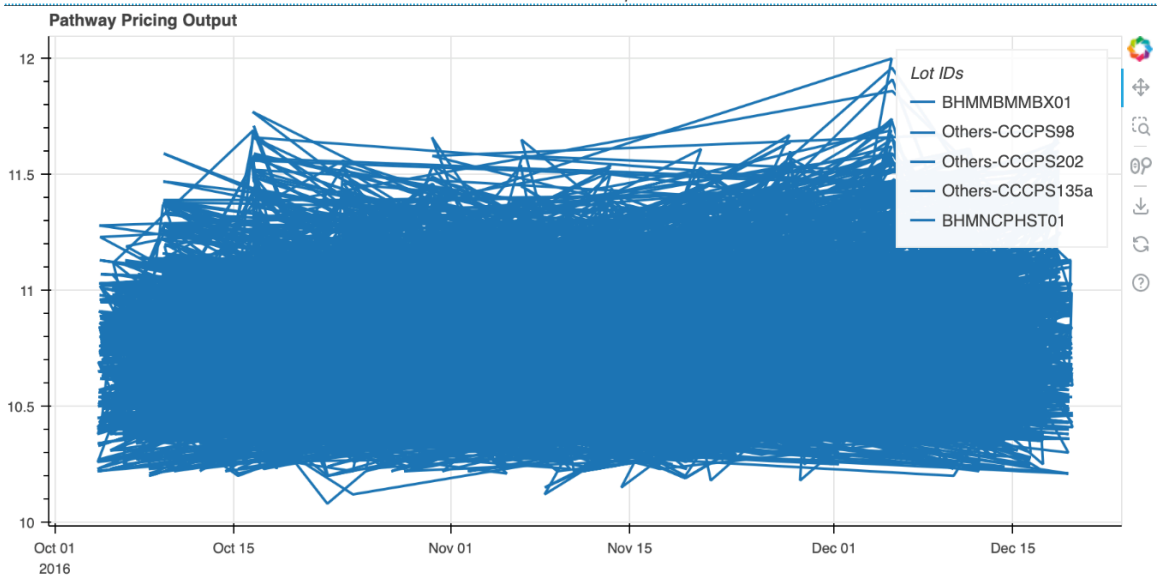
Final results were visualized using Bokeh, showing real-time price trends for selected lots. X-axis uses parsed timestamps to simulate live updates.

Key Highlights

- Real-time processing achieved using Pathway
- Model switching logic allows comparing pricing strategies
- Clean modular pricing logic
- Visualization integrated with live outputs

Sample Plot Screenshot





Conclusion

This project demonstrated a complete real-time pricing engine simulation for smart urban parking. It is scalable, explainable, and production-friendly — and integrates modern tools like Pathway and Bokeh for real-time ML workflows.

Future Work

- Add rerouting logic based on load balancing
- Deploy this pipeline with a UI dashboard (e.g. Streamlit)

Appendix

- Source code: https://colab.research.google.com/drive/1ZApbQxhuvHwvcacwk59Vpkx3wjA3gRfG#scrollTo=Nu-W9eh9kGng
- Dataset: dataset.csv
- Output: pathway_output.csv

- Libraries used: pandas, pathway, bokeh, math, datetime

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