PROJECT REPORT

Dynamic Pricing for Urban Parking Lots

By:

Darpan Rathi

TABLE OF CONTENTS

Introduction

Urban cities often face challenges in managing parking resources effectively. Static pricing models lead to inefficiencies such as congestion, underutilization, and lack of incentive-based allocation. This project addresses these issues by implementing a real-time dynamic pricing engine using **Pathway**, designed to simulate live parking data streams and generate intelligent price models.

Objective

To develop a real-time simulation of dynamic parking pricing using two models -

- Model 1: Linear pricing based on occupancy-to-capacity ratio
- Model 2: Demand-based pricing incorporating multiple real-time signals such as queue length, traffic condition, special days, and vehicle types

Dataset and Preprocessing

- The input dataset includes features like occupancy, capacity, queue length, traffic condition, vehicle type, and timestamp fields.
- Preprocessing steps: LastUpdatedDate and LastUpdatedTime were combined into a single Timestamp column.
- Records were sorted by Timestamp .
- Vehicle types were mapped to Vehicle_Weight : car = 2, bike = 1, truck = 3, cycle = 1
- Traffic conditions were mapped to Traffic_Weight : low = 1, medium = 2, high = 3
- The final processed data was exported as parking_stream.csv

Architecture and Workflow

- **Data Simulation** - parking_stream.csv is read using Pathway's replay_csv() function to simulate real-time data ingestion.
- **Schema Definition** - A custom schema (ParkingSchema) is defined to match the fields in the data stream.
- **Timestamp Parsing** -Timestamp is parsed into a datetime field t and a day-level field day .
- **Linear Model** -
  This model responds only to current parking load and encourages early filling. However it doesn't account for demand volatility.
- **Demand Based Model** -
  This model allows pricing to scale dynamically depending on real-world conditions (e.g., high traffic, longer queues, VIP events). The price is normalised so that uniformity is maintained throughout.
- **Visualisation** - The final prices are plotted using Bokeh and rendered in real-time using Panel

Results

- Model 1 provides basic linear price adaptation based on occupancy.
- Model 2 allows price to reflect actual demand conditions using real-time metrics.
- The output is visualized dynamically for monitoring and comparison.

Conclusion

- This project successfully demonstrates a real-time dynamic pricing simulation for smart parking management. By combining occupancy-driven pricing with multi-factor demand-based pricing, the system achieves more adaptive, efficient allocation of parking resources.

- Future enhancements could include integration with live APIs and development of Model 3 (competitive pricing based on nearby spots).