

```
!pip install pathway bokeh
```



Collecting pathway

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  Downloading pathway-0.24.1-cp310-abi3-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (60 kB)
  _____ 60.4/60.4 kB 4.7 MB/s eta 0:00:00
Requirement already satisfied: bokeh in /usr/local/lib/python3.11/dist-packages (3.7.3)
Requirement already satisfied: aiohttp>=3.8.4 in /usr/local/lib/python3.11/dist-packages (from pathway) (3.11.15)
Requirement already satisfied: click>=8.1 in /usr/local/lib/python3.11/dist-packages (from pathway) (8.2.1)
Requirement already satisfied: geopy>=2.4.0 in /usr/local/lib/python3.11/dist-packages (from pathway) (2.4.1)
Collecting h3>=4 (from pathway)
  Downloading h3-4.3.0-cp311-cp311-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (18 kB)
Requirement already satisfied: numpy>=1.21 in /usr/local/lib/python3.11/dist-packages (from pathway) (2.0.2)
Requirement already satisfied: pandas>=2.1 in /usr/local/lib/python3.11/dist-packages (from pathway) (2.2.2)
Requirement already satisfied: scikit-learn>=1.0 in /usr/local/lib/python3.11/dist-packages (from pathway) (1.6.1)
Requirement already satisfied: shapely>=2.0.1 in /usr/local/lib/python3.11/dist-packages (from pathway) (2.1.1)
Requirement already satisfied: pyarrow<19.0.0,>=10.0.0 in /usr/local/lib/python3.11/dist-packages (from pathway) (18.1.0)
Requirement already satisfied: requests>=2.31.0 in /usr/local/lib/python3.11/dist-packages (from pathway) (2.32.3)
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Collecting diskcache>=5.2.1 (from pathway)
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Collecting boto3<1.36.0,>=1.26.76 (from pathway)
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Collecting aiobotocore==2.17.0 (from pathway)
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Requirement already satisfied: typing-extensions>=4.8.0 in /usr/local/lib/python3.11/dist-packages (from pathway) (4.14.0)
Requirement already satisfied: panel>=1.3.1 in /usr/local/lib/python3.11/dist-packages (from pathway) (1.7.2)
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Collecting aiohttp-cors>=0.7.0 (from pathway)
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Requirement already satisfied: multidict<7.0.0,>=6.0.0 in /usr/local/lib/python3.11/dist-packages (from aiobotocore==2.17.0->pathway)
Requirement already satisfied: urllib3!=2.2.0,<3,>=1.25.4 in /usr/local/lib/python3.11/dist-packages (from aiobotocore==2.17.0->pathway)
Requirement already satisfied: wrapt<2.0.0,>=1.10.10 in /usr/local/lib/python3.11/dist-packages (from aiobotocore==2.17.0->pathway) (1.1.1)
Requirement already satisfied: Jinja2>=2.9 in /usr/local/lib/python3.11/dist-packages (from bokeh) (3.1.6)
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Requirement already satisfied: narwhal>=1.13 in /usr/local/lib/python3.11/dist-packages (from bokeh) (1.45.0)
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Requirement already satisfied: pillow>=7.1.0 in /usr/local/lib/python3.11/dist-packages (from bokeh) (11.2.1)
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Requirement already satisfied: tornado>=6.2 in /usr/local/lib/python3.11/dist-packages (from bokeh) (6.4.2)
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Requirement already satisfied: yarl<2.0,>=1.17.0 in /usr/local/lib/python3.11/dist-packages (from aiohttp>=3.8.4->pathway) (1.20.1)
INFO: pip is looking at multiple versions of boto3 to determine which version is compatible with other requirements. This could take a
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Requirement already satisfied: gitdb<5,>=4.0.1 in /usr/local/lib/python3.11/dist-packages (from gitpython>=3.1.43->pathway) (4.0.12)
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Requirement already satisfied: google-api-core!=2.0.*,!=2.1.*,!=2.2.*,!=2.3.0,<3.0.0,>=1.31.5 in /usr/local/lib/python3.11/dist-packag
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Requirement already satisfied: google-resumable-media<3.0dev,>=2.0.0 in /usr/local/lib/python3.11/dist-packages (from google-cloud-big
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Requirement already satisfied: grpcio-status>=1.33.2 in /usr/local/lib/python3.11/dist-packages (from google-cloud-pubsub>=2.21.1->pat
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Requirement already satisfied: smmap<6,>=3.0.1 in /usr/local/lib/python3.11/dist-packages (from gitdb<5,>=4.0.1->gitpython>=3.1.43->pa
Requirement already satisfied: cachetools<6.0,>=2.0.0 in /usr/local/lib/python3.11/dist-packages (from google-auth!=2.24.0,!=2.25.0,<3.
Requirement already satisfied: pyasn1-modules>=0.2.1 in /usr/local/lib/python3.11/dist-packages (from google-auth!=2.24.0,!=2.25.0,<3.
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Requirement already satisfied: google-crc32c<2.0.dev0,>=1.0 in /usr/local/lib/python3.11/dist-packages (from google-resumable-media<3.0c
Requirement already satisfied: pyparsing!=3.0.0,!=3.0.1,!=3.0.2,!=3.0.3,<4,>=2.4.2 in /usr/local/lib/python3.11/dist-packages (from ht
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Downloading pathway-0.24.1-cp310-abi3-manylinux2_17_x86_64.manylinux2014_x86_64.whl (69.7 MB)

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 Downloading opentelemetry_api-1.34.1-py3-none-any.whl (65 kB)
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 Downloading opentelemetry_sdk-1.34.1-py3-none-any.whl (118 kB)
 118.5/118.5 kB 6.9 MB/s eta 0:00:00
 Downloading opentelemetry_semantic_conventions-0.55b1-py3-none-any.whl (196 kB)
 196.2/196.2 kB 16.8 MB/s eta 0:00:00
 Downloading pydantic-2.9.2-py3-none-any.whl (434 kB)
 434.9/434.9 kB 30.5 MB/s eta 0:00:00
 Downloading pydantic_core-2.23.4-cp311-cp311-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (2.1 MB)
 2.1/2.1 MB 65.0 MB/s eta 0:00:00
 Downloading python_sat-1.8.dev17-cp311-cp311-manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_28_x86_64.whl (2.7 MB)
 2.7/2.7 MB 72.0 MB/s eta 0:00:00
 Downloading aioitertools-0.12.0-py3-none-any.whl (24 kB)
 Downloading appdirs-1.4.4-py2.py3-none-any.whl (9.6 kB)
 Downloading botocore-1.35.93-py3-none-any.whl (13.3 MB)
 13.3/13.3 MB 72.6 MB/s eta 0:00:00
 Downloading s3transfer-0.10.4-py3-none-any.whl (83 kB)
 83.2/83.2 kB 7.8 MB/s eta 0:00:00
 Downloading pyarrow_hotfix-0.7-py3-none-any.whl (7.9 kB)
 Downloading comm-0.2.2-py3-none-any.whl (7.2 kB)
 Downloading widgetsnbextension-4.0.14-py3-none-any.whl (2.2 MB)
 2.2/2.2 MB 64.8 MB/s eta 0:00:00
 Downloading jedi-0.19.2-py2.py3-none-any.whl (1.6 MB)
 1.6/1.6 MB 53.7 MB/s eta 0:00:00
 Installing collected packages: appdirs, widgetsnbextension, python-sat, pydantic-core, pyarrow-hotfix, opentelemetry-proto, jmespath, Attempting uninstall: widgetsnbextension
 Found existing installation: widgetsnbextension 3.6.10
 Uninstalling widgetsnbextension-3.6.10:
 Successfully uninstalled widgetsnbextension-3.6.10
 Attempting uninstall: pydantic-core
 Found existing installation: pydantic_core 2.33.2
 Uninstalling pydantic_core-2.33.2:
 Successfully uninstalled pydantic_core-2.33.2
 Attempting uninstall: pydantic
 Found existing installation: pydantic 2.11.7
 Uninstalling pydantic-2.11.7:
 Successfully uninstalled pydantic-2.11.7
 Attempting uninstall: ipywidgets
 Found existing installation: ipywidgets 7.7.1
 Uninstalling ipywidgets-7.7.1:
 Successfully uninstalled ipywidgets-7.7.1
 Attempting uninstall: google-cloud-bigquery
 Found existing installation: google-cloud-bigquery 3.34.0
 Uninstalling google-cloud-bigquery-3.34.0:
 Successfully uninstalled google-cloud-bigquery-3.34.0
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the source of bugs. It will be addressed in a future release.
 bigframes 2.8.0 requires google-cloud-bigquery[bqstorage,pandas]>=3.31.0, but you have google-cloud-bigquery 3.29.0 which is incompatible.
 Successfully installed aiobotocore-2.17.0 aiohttp-cors-0.8.1 aioitertools-0.12.0 appdirs-1.4.4 async-lru-2.0.5 beartype-0.15.0 boto3-1.19.10
WARNING: The following packages were previously imported in this runtime:
[google]
You must restart the runtime in order to use newly installed versions.

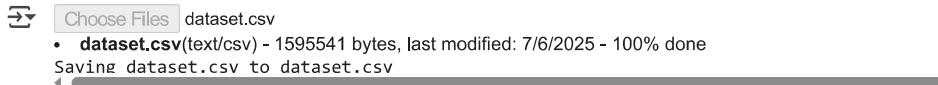
RESTART SESSION


```
import pandas as pd
import numpy as np
import pathway as pw
from bokeh.plotting import figure, show, output_notebook
from bokeh.io import push_notebook
from bokeh.layouts import column
import time
from IPython.display import display

output_notebook()
```



```
from google.colab import files
uploaded = files.upload()
```



```
import pandas as pd

df = pd.read_csv("dataset.csv") # No need for /content/ path if uploaded manually
print("Shape:", df.shape)
df.head()
```

Shape: (18368, 12)

	ID	SystemCodeNumber	Capacity	Latitude	Longitude	Occupancy	VehicleType	TrafficConditionNearby	QueueLength	IsSpecialDay	LastU
0	0	BHMBCCMKT01	577	26.144536	91.736172	61	car	low	1	0	
1	1	BHMBCCMKT01	577	26.144536	91.736172	64	car	low	1	0	
2	2	BHMBCCMKT01	577	26.144536	91.736172	80	car	low	2	0	
3	3	BHMBCCMKT01	577	26.144536	91.736172	107	car	low	2	0	
4	4	BHMBCCMKT01	577	26.144536	91.736172	150	bike	low	2	0	

Next steps: [Generate code with df](#) [View recommended plots](#) [New interactive sheet](#)

```
# Load the dataset (uploaded in the Files section)
df = pd.read_csv("/content/dataset.csv")
```

```
# Display basic structure
print("Shape:", df.shape)
df.head()
```

Shape: (18368, 12)

	ID	SystemCodeNumber	Capacity	Latitude	Longitude	Occupancy	VehicleType	TrafficConditionNearby	QueueLength	IsSpecialDay	LastU
0	0	BHMBCCMKT01	577	26.144536	91.736172	61	car	low	1	0	
1	1	BHMBCCMKT01	577	26.144536	91.736172	64	car	low	1	0	
2	2	BHMBCCMKT01	577	26.144536	91.736172	80	car	low	2	0	
3	3	BHMBCCMKT01	577	26.144536	91.736172	107	car	low	2	0	
4	4	BHMBCCMKT01	577	26.144536	91.736172	150	bike	low	2	0	

Next steps: [Generate code with df](#) [View recommended plots](#) [New interactive sheet](#)

```
# Add base price for each lot
df['Price'] = 10.0 # Base price
```

```
# Get list of all unique parking lot IDs (or use Lat-Long as unique ID)
df['LotID'] = df['Latitude'].astype(str) + " " + df['Longitude'].astype(str)

# Sort by time (assuming there's a timestamp column or simulated time index)
df['TimeIndex'] = np.tile(np.arange(0, df.shape[0] // 14), 14)
df = df.sort_values(by=['TimeIndex', 'LotID']).reset_index(drop=True)
```

```
def linear_price_update(prev_price, occupancy, capacity, alpha=2):
    usage_ratio = occupancy / capacity if capacity > 0 else 0
    return prev_price + alpha * usage_ratio
```

```
import time
from bokeh.plotting import figure, show, output_notebook
from bokeh.io import push_notebook
from bokeh.layouts import column
```

```
output_notebook()
```

```
# Initialize storage
lot_prices = {}
price_history = {lot: [] for lot in df['LotID'].unique()}
```

```
# Setup Bokeh plots
plots = []
for lot in df['LotID'].unique():
    p = figure(title=f"Price Trend - Lot {lot}", width=400, height=300)
    p.line([], [], line_width=2, legend_label="Price", name="price_line")
    plots.append(p)
```

```
layout = column(*plots)
handle = show(layout, notebook_handle=True)
```

```
# Set number of time steps to simulate
max_steps = 10 # change this to more if needed
```

```
# Linear Pricing Function
def linear_price_update(prev_price, occupancy, capacity, alpha=2):
    usage_ratio = occupancy / capacity if capacity > 0 else 0
    return prev_price + alpha * usage_ratio
```

```
# Run real-time simulation
for t in range(min(df['TimeIndex'].max() + 1, max_steps)):
    current_time_slice = df[df['TimeIndex'] == t]

    for idx, row in current_time_slice.iterrows():
        lot = row['LotID']
        prev_price = lot_prices.get(lot, 10.0)
        new_price = linear_price_update(prev_price, row['Occupancy'], row['Capacity'])
        lot_prices[lot] = new_price
        price_history[lot].append(new_price)
```

```
# Update plots
for i, lot in enumerate(df['LotID'].unique()):
    line = plots[i].select(name="price_line")[0]
    line.data_source.data = {
        'x': list(range(len(price_history[lot]))),
        'y': price_history[lot]
    }
```

```
push_notebook(handle=handle)
time.sleep(0.05) # fast visualization delay
```



```
# Vehicle weight mapping
```

```
vehicle_weights = {
    'car': 1.0,
    'bike': 0.5,
    'truck': 1.5
}
```

```
# Hyperparameters (tune these later)
alpha = 2.0
```

```

beta = 0.1
gamma = 0.3
delta = 1.0
epsilon = 0.5
lambda_ = 0.5 # price sensitivity to demand

# Base price
BASE_PRICE = 10.0

def demand_based_price(row, prev_price):
    # Extract features
    occ_ratio = row['Occupancy'] / row['Capacity'] if row['Capacity'] > 0 else 0
    queue = row['QueueLength']
    traffic = row['Traffic']
    is_special = row['IsSpecialDay']
    vehicle_type = row['VehicleType'].lower()

    # Assign vehicle type weight
    vehicle_weight = vehicle_weights.get(vehicle_type, 1.0)

    # Raw demand
    demand = (alpha * occ_ratio +
               beta * queue -
               gamma * traffic +
               delta * is_special +
               epsilon * vehicle_weight)

    # Normalize demand using sigmoid (to keep within [0,1])
    norm_demand = 1 / (1 + np.exp(-demand))

    # Price update formula
    new_price = BASE_PRICE * (1 + lambda_ * norm_demand)

    # Bound price between
    return max(5, min(20, new_price))

```

```
print(df.columns.tolist())
```

```
→ ['ID', 'SystemCodeNumber', 'Capacity', 'Latitude', 'Longitude', 'Occupancy', 'VehicleType', 'TrafficConditionNearby', 'QueueLength', 'Is
```

```

def demand_based_price(row, prev_price):
    # Extract features
    occ_ratio = row['Occupancy'] / row['Capacity'] if row['Capacity'] > 0 else 0
    queue = row['QueueLength']
    traffic = row['TrafficConditionNearby'] # ✓ corrected
    is_special = row['IsSpecialDay']
    vehicle_type = row['VehicleType'].lower()

    # Assign vehicle type weight
    vehicle_weight = vehicle_weights.get(vehicle_type, 1.0)

    # Raw demand score
    demand = (alpha * occ_ratio +
               beta * queue -
               gamma * traffic +
               delta * is_special +
               epsilon * vehicle_weight)

    # Normalize demand (sigmoid)
    norm_demand = 1 / (1 + np.exp(-demand))

    # Compute price
    new_price = BASE_PRICE * (1 + lambda_ * norm_demand)

    # Bound the price
    return max(5, min(20, new_price))

```

```
# STEP 1: Data Cleaning (do this once after loading the dataset)
df['TrafficConditionNearby'] = pd.to_numeric(df['TrafficConditionNearby'], errors='coerce').fillna(0)
df['QueueLength'] = pd.to_numeric(df['QueueLength'], errors='coerce').fillna(0)
```