namesofgroupmembers

October 27, 2025

1 Test Notebook

This is just an (almost) empty test notebook. You can run the following code to assert that Spark is installed and working within the container.

[2]:
```
from pyspark import SparkContext, SparkConf

conf = SparkConf().setMaster("local").setAppName("Spark Test")
sc = SparkContext(conf=conf)
```

[3]:
```
!pip install shapely
```

```
Requirement already satisfied: shapely in /opt/conda/lib/python3.11/site-
packages (2.1.2)
Requirement already satisfied: numpy>=1.21 in /opt/conda/lib/python3.11/site-
packages (from shapely) (1.24.4)
```

[4]:
```
!pip install shapely
```

```
Requirement already satisfied: shapely in /opt/conda/lib/python3.11/site-
packages (2.1.2)
Requirement already satisfied: numpy>=1.21 in /opt/conda/lib/python3.11/site-
packages (from shapely) (1.24.4)
```

[5]:
```
# Cell 0: imports and Spark session
from pyspark.sql import SparkSession
from pyspark.sql import functions as F
from pyspark.sql.window import Window
import json
from shapely.geometry import shape, Point
from pyspark.sql.types import StringType, DoubleType, LongType, IntegerType
import math

spark = SparkSession.builder \
    .appName("NYC Taxi Analysis - TP1") \
    .config("spark.sql.shuffle.partitions", "200") \
    .getOrCreate()
```

```
spark.sparkContext.setLogLevel("WARN")
```

[6]:
```
import os

# Cell 1: file paths (adjust for your container)
taxi_csv_path = "../data/Sample NYC Data.csv"   # <-- adjust path inside the␣
 ↪container
borough_geojson_path = "../data/nyc-boroughs.geojson"  # <-- adjust
output_dir = "../data/output_tp1"   # where results will be written

os.makedirs(output_dir, exist_ok=True)

print(os.path.exists(taxi_csv_path), os.path.exists(borough_geojson_path), os.
 ↪path.exists(output_dir))
```

```
True True True
```

[7]:
```
# Cell 2: load CSV (select only needed columns). adapt column names if sample␣
 ↪differs.
# Example column names:␣
 ↪'hack_license','pickup_datetime','dropoff_datetime','pickup_longitude','pickup_latitude','d
df_raw = spark.read.option("header", "true").option("inferSchema", "true").
 ↪csv(taxi_csv_path)

cols_needed = [
    "hack_license",
    "pickup_datetime",
    "dropoff_datetime",
    "pickup_longitude",
    "pickup_latitude",
    "dropoff_longitude",
    "dropoff_latitude"
]

# Check present columns
present = [c for c in cols_needed if c in df_raw.columns]
missing = [c for c in cols_needed if c not in df_raw.columns]
if missing:
    print("WARNING: missing columns (update names to match your CSV):", missing)

df = df_raw.select(*present).na.
 ↪drop(subset=["hack_license","pickup_datetime","dropoff_datetime"])
df = df.withColumnRenamed("hack_license","taxi_id")  # use taxi_id as unique␣
 ↪driver/car id
df.show(5)
```

```
+--------------------+--------------+----------------+---------------+--------
```

```
-------+----------------+----------------+
|             taxi_id|pickup_datetime|dropoff_datetime|pickup_longitude|pickup_l
atitude|dropoff_longitude|dropoff_latitude|
+--------------------+---------------+----------------+----------------+--------
-------+----------------+----------------+
|BA96DE419E711691B…| 01-01-13 15:11|  01-01-13 15:18|      -73.978165|
40.757977|       -73.989838|       40.751171|
|9FD8F69F0804BDB55…| 06-01-13 00:18|  06-01-13 00:22|      -74.006683|
40.731781|       -73.994499|        40.75066|
|9FD8F69F0804BDB55…| 05-01-13 18:49|  05-01-13 18:54|      -74.004707|
40.73777|       -74.009834|       40.726002|
|51EE87E3205C985EF…| 07-01-13 23:54|  07-01-13 23:58|      -73.974602|
40.759945|       -73.984734|       40.759388|
|51EE87E3205C985EF…| 07-01-13 23:25|  07-01-13 23:34|       -73.97625|
40.748528|       -74.002586|       40.747868|
+--------------------+---------------+----------------+----------------+--------
-------+----------------+----------------+
only showing top 5 rows
```

[8]:
```python
# Cell 3: load GeoJSON, build list of (borough_name, polygon) sorted by borough code and polygon area descending
with open(borough_geojson_path, "r", encoding="utf-8") as f:
    gj = json.load(f)

features = gj.get("features", [])
polys = []
for feat in features:
    props = feat.get("properties", {})
    geom = feat.get("geometry")
    bcode = props.get("boroughCode", None)   # if available
    bname = props.get("borough", props.get("boro_name", props.get("name", "UNKNOWN")))
    shapely_poly = shape(geom)
    area = shapely_poly.area
    polys.append({"borough": bname, "code": bcode if bcode is not None else 999, "area": area, "poly": shapely_poly})

# sort: boroughCode asc (manhattan=1) and within that area desc; but easier: sort by (code, -area)
polys_sorted = sorted(polys, key=lambda x: (x["code"], -x["area"]))

# Build a smaller broadcastable structure: list of tuples (borough, wkt) or keep shapely polygons directly.
# We'll broadcast a list of (borough, polygon) where polygon is shapely geometry
broad_list = [(p["borough"], p["poly"]) for p in polys_sorted]
```

```
bc_polys = spark.sparkContext.broadcast(broad_list)

print(bc_polys.value[:5])  # show first 5 borough polygons
print("Number of borough polygons broadcasted:", len(bc_polys.value))
```

```
[('Manhattan', <POLYGON ((-73.926 40.878, -73.926 40.877, -73.926 40.877,
-73.926 40.877, -…>), ('Manhattan', <POLYGON ((-73.921 40.801, -73.92 40.799,
-73.917 40.798, -73.915 40.797, -7…>), ('Manhattan', <POLYGON ((-74.017
40.693, -74.015 40.693, -74.015 40.693, -74.015 40.693, -…>), ('Manhattan',
<POLYGON ((-73.942 40.769, -73.943 40.768, -73.949 40.761, -73.952 40.758,
-…>), ('Manhattan', <POLYGON ((-73.907 40.876, -73.908 40.873, -73.908 40.873,
-73.909 40.872, -…>)]
Number of borough polygons broadcasted: 104
```

[9]:
```
from pyspark.sql import SparkSession
spark = SparkSession.builder.getOrCreate()
spark
```

[9]:
```
<pyspark.sql.session.SparkSession at 0x7e0370249c10>
```

[10]:
```
!ls ../data
```

```
 nyc-boroughs.geojson.json   output_tp1   'Sample NYC Data.csv'
```

[11]:
```
# Cell 4: define UDF to map lon/lat to borough. Returns 'UNKNOWN' if not found␣
 ↪or coords invalid.
def lonlat_to_borough(lon, lat):
    try:
        if lon is None or lat is None:
            return "UNKNOWN"
        # some datasets use strings; cast
        lon_f = float(lon)
        lat_f = float(lat)
    except Exception:
        return "UNKNOWN"
    pt = Point(lon_f, lat_f)
    for borough, poly in bc_polys.value:
        # shapely contains
        if poly.contains(pt) or poly.touches(pt):
            return borough
    return "UNKNOWN"

from pyspark.sql.functions import udf
udf_lonlat_to_borough = udf(lonlat_to_borough, StringType())

print(udf_lonlat_to_borough)
```

```
<function lonlat_to_borough at 0x7e0369c62f20>
```

[12]:
```
# Cell 5: enrich dataframe with boroughs and timestamps (unix)
# create pickup_ts and dropoff_ts in seconds from epoch
df2 = df \
    .withColumn("pickup_ts", F.unix_timestamp("pickup_datetime")) \
    .withColumn("dropoff_ts", F.unix_timestamp("dropoff_datetime")) \
    .withColumn("pickup_borough", udf_lonlat_to_borough(F.
 ↪col("pickup_longitude"), F.col("pickup_latitude"))) \
    .withColumn("dropoff_borough", udf_lonlat_to_borough(F.
 ↪col("dropoff_longitude"), F.col("dropoff_latitude")))

# compute duration_seconds
df2 = df2.withColumn("duration_s", F.col("dropoff_ts") - F.col("pickup_ts"))

df2.show(5)
```

```
+--------------------+--------------+----------------+----------------+-------
-------+-----------------+----------------+---------+----------+-------------+-
-------------+----------+
|             taxi_id|pickup_datetime|dropoff_datetime|pickup_longitude|pickup_l
atitude|dropoff_longitude|dropoff_latitude|pickup_ts|dropoff_ts|pickup_borough|d
ropoff_borough|duration_s|
+--------------------+--------------+----------------+----------------+-------
-------+-----------------+----------------+---------+----------+-------------+-
-------------+----------+
|BA96DE419E711691B…| 01-01-13 15:11|  01-01-13 15:18|      -73.978165|
40.757977|       -73.989838|       40.751171|     NULL|      NULL|
Manhattan|      Manhattan|      NULL|
|9FD8F69F0804BDB55…| 06-01-13 00:18|  06-01-13 00:22|      -74.006683|
40.731781|       -73.994499|        40.75066|     NULL|      NULL|
Manhattan|      Manhattan|      NULL|
|9FD8F69F0804BDB55…| 05-01-13 18:49|  05-01-13 18:54|      -74.004707|
40.73777|       -74.009834|       40.726002|     NULL|      NULL|     Manhattan|
Manhattan|      NULL|
|51EE87E3205C985EF…| 07-01-13 23:54|  07-01-13 23:58|      -73.974602|
40.759945|       -73.984734|       40.759388|     NULL|      NULL|
Manhattan|      Manhattan|      NULL|
|51EE87E3205C985EF…| 07-01-13 23:25|  07-01-13 23:34|       -73.97625|
40.748528|       -74.002586|       40.747868|     NULL|      NULL|
Manhattan|      Manhattan|      NULL|
+--------------------+--------------+----------------+----------------+-------
-------+-----------------+----------------+---------+----------+-------------+-
-------------+----------+
only showing top 5 rows
```

[13]:
```
# Cell 5: enrich dataframe with boroughs and timestamps (unix)
# create pickup_ts and dropoff_ts in seconds from epoch
```

```
df2 = df \
    .withColumn(
        "pickup_ts",
        F.unix_timestamp("pickup_datetime", "dd-MM-yy HH:mm")
    ) \
    .withColumn(
        "dropoff_ts",
        F.unix_timestamp("dropoff_datetime", "dd-MM-yy HH:mm")
    ) \
    .withColumn(
        "pickup_borough",
        udf_lonlat_to_borough(F.col("pickup_longitude"), F.
 ↪col("pickup_latitude"))
    ) \
    .withColumn(
        "dropoff_borough",
        udf_lonlat_to_borough(F.col("dropoff_longitude"), F.
 ↪col("dropoff_latitude"))
    )

# compute duration_seconds
df2 = df2.withColumn("duration_s", F.col("dropoff_ts") - F.col("pickup_ts"))

# verify
df2.
 ↪select("pickup_datetime","dropoff_datetime","pickup_ts","dropoff_ts","duration_s","pickup_b
 ↪show(5)
```

```
+---------------+---------------+----------+----------+----------+-------------
-+---------------+
|pickup_datetime|dropoff_datetime|
pickup_ts|dropoff_ts|duration_s|pickup_borough|dropoff_borough|
+---------------+---------------+----------+----------+----------+-------------
-+---------------+
| 01-01-13 15:11|  01-01-13 15:18|1357053060|1357053480|       420|
Manhattan|      Manhattan|
| 06-01-13 00:18|  06-01-13 00:22|1357431480|1357431720|       240|
Manhattan|      Manhattan|
| 05-01-13 18:49|  05-01-13 18:54|1357411740|1357412040|       300|
Manhattan|      Manhattan|
| 07-01-13 23:54|  07-01-13 23:58|1357602840|1357603080|       240|
Manhattan|      Manhattan|
| 07-01-13 23:25|  07-01-13 23:34|1357601100|1357601640|       540|
Manhattan|      Manhattan|
+---------------+---------------+----------+----------+----------+-------------
-+---------------+
```

```
only showing top 5 rows
```

[14]:
```
# Cell 6: Filter - remove negative durations and durations greater than 4 hours␣
 ↪(14400s)
MAX_DURATION_S = 4 * 3600
df_clean = df2.filter((F.col("duration_s") >= 0) & (F.col("duration_s") <=␣
 ↪MAX_DURATION_S))
# optional: drop rows with UNKNOWN coords, but we keep UNKNOWN for counting if␣
 ↪needed
print("Total records after cleaning:", df_clean.count())
```

```
Total records after cleaning: 99999
```

[15]:
```
# Cell 7: Utilization computation per taxi
# For each taxi, sort by pickup_ts and compute previous dropoff_ts (lag)
w = Window.partitionBy("taxi_id").orderBy("pickup_ts")
df_sessions = df_clean \
    .withColumn("prev_dropoff_ts", F.lag("dropoff_ts").over(w)) \
    .withColumn("idle_s_raw", F.col("pickup_ts") - F.col("prev_dropoff_ts"))

# Consider idle only if prev exists and idle >0 and <= 4h (we ignore gaps > 4h␣
 ↪as new session)
df_sessions = df_sessions.withColumn(
    "idle_s",
    F.when((F.col("prev_dropoff_ts").isNotNull()) & (F.col("idle_s_raw") > 0) &␣
 ↪(F.col("idle_s_raw") <= MAX_DURATION_S),
           F.col("idle_s_raw")).otherwise(F.lit(0))
)

# sum per taxi: occupied_time (sum duration_s) and total_idle (sum idle_s)
per_taxi = df_sessions.groupBy("taxi_id").agg(
    F.sum("duration_s").alias("occupied_s"),
    F.sum("idle_s").alias("idle_s"),
    F.count("*").alias("trips_count")
)

# compute utilization: occupied / (occupied + idle). If both zero (shouldn't␣
 ↪happen), set to null or 0.
per_taxi = per_taxi.withColumn(
    "utilization",
    F.when((F.col("occupied_s") + F.col("idle_s")) > 0,
           F.col("occupied_s") / (F.col("occupied_s") + F.col("idle_s"))).
 ↪otherwise(F.lit(None))
)

per_taxi.cache()
```

```
per_taxi.select("taxi_id","trips_count","occupied_s","idle_s","utilization").
  ↪show(10, truncate=False)
```

```
+--------------------------------+-----------+----------+------+----------------
---+
|taxi_id                         |trips_count|occupied_s|idle_s|utilization
|
+--------------------------------+-----------+----------+------+----------------
---+
|001C8AAB90AEE49F36FCAA7B4136C81A|5          |2820      |12960
|0.17870722433460076|
|0025133AD810DBE80D35FCA8BF0BCA1F|2          |1440      |2400  |0.375
|
|002C093A2CB9FD40C8C54AB5D158FC47|17         |12600     |15300
|0.45161290322580644|
|00374328FBA75FBFCA7522671250F573|1          |960       |0     |1.0
|
|00447A6197DBB329FBF764139ACA6EC4|5          |6420      |13440
|0.32326283987915405|
|0046F1E91AA13DEDE4F6EE775C6293AB|19         |11580     |9960
|0.5376044568245125 |
|00567B1CBFD51DDFAC73359B09238922|21         |11520     |10080
|0.5333333333333333 |
|0057CCB5BA8D29E343B3D6D275AB22D3|1          |300       |0     |1.0
|
|006114F940CB87B3ABDCE9BF6DF6FCC4|25         |16380     |24000
|0.40564635958395245|
|006313464EC98A24BB4EBC1E2419E439|21         |11280     |31500
|0.26367461430575034|
+--------------------------------+-----------+----------+------+----------------
---+
only showing top 10 rows
```

[16]:
```
# Cell 8: Save per_taxi results
per_taxi_output = output_dir + "/per_taxi_utilization"
per_taxi.coalesce(1).write.mode("overwrite").option("header","true").
  ↪csv(per_taxi_output)
print("Saved per-taxi utilization to:", per_taxi_output)
```

```
Saved per-taxi utilization to: ../data/output_tp1/per_taxi_utilization
```

[17]:
```
# Cell 9: Average time to next fare per destination borough (dropoff borough)
# For each taxi ordered by pickup_ts compute lead(pickup_ts) to know next␣
  ↪pickup; delta = next_pickup_ts - dropoff_ts (time to next fare)
df_next = df_clean.withColumn("next_pickup_ts", F.lead("pickup_ts").over(w)) \
```

```
    .withColumn("time_to_next_s_raw", F.col("next_pickup_ts") - F.
 ↪col("dropoff_ts"))

# consider only positive and <= 4h (session continuation)
df_next = df_next.withColumn(
    "time_to_next_s",
    F.when((F.col("time_to_next_s_raw") > 0) & (F.col("time_to_next_s_raw") <=␣
 ↪MAX_DURATION_S), F.col("time_to_next_s_raw")).otherwise(F.lit(None))
)

# Group by dropoff_borough and compute average
avg_time_to_next = df_next.filter(F.col("time_to_next_s").isNotNull()).
 ↪groupBy("dropoff_borough").agg(
    F.count("*").alias("count_samples"),
    F.avg("time_to_next_s").alias("avg_time_to_next_s"),
    F.expr("percentile_approx(time_to_next_s, 0.5)").
 ↪alias("median_time_to_next_s")
).orderBy("dropoff_borough")

avg_time_to_next.show(truncate=False)
avg_time_to_next.coalesce(1).write.mode("overwrite").option("header","true").
 ↪csv(output_dir + "/avg_time_to_next_per_dropoff_borough")
```

```
+--------------+-------------+------------------+---------------------+
|dropoff_borough|count_samples|avg_time_to_next_s|median_time_to_next_s|
+--------------+-------------+------------------+---------------------+
|Bronx          |303          |2223.5643564356437|1560                 |
|Brooklyn       |2593         |2086.903200925569 |1380                 |
|Manhattan      |78228        |912.8708390857494 |420                  |
|Queens         |4157         |2676.7187875872023|2040                 |
|Staten Island  |8            |4710.0            |3960                 |
|UNKNOWN        |1943         |1498.7339166237778|720                  |
+--------------+-------------+------------------+---------------------+
```

[18]:
```
# Cell 10: Trips that started and ended within the same borough
same_borough = df_clean.filter(
    (F.col("pickup_borough").isNotNull()) & (F.col("dropoff_borough").
 ↪isNotNull()) &
    (F.col("pickup_borough") == F.col("dropoff_borough")) & (F.
 ↪col("pickup_borough") != "UNKNOWN")
).groupBy("pickup_borough").agg(F.count("*").alias("num_trips_same_borough")).
 ↪orderBy("num_trips_same_borough", ascending=False)

same_borough.show(truncate=False)
same_borough.coalesce(1).write.mode("overwrite").option("header","true").
 ↪csv(output_dir + "/trips_same_borough")
```

```
+--------------+----------------------+
|pickup_borough|num_trips_same_borough|
+--------------+----------------------+
|Manhattan     |83561                 |
|Queens        |1396                  |
|Brooklyn      |1065                  |
|Bronx         |51                    |
|Staten Island |1                     |
+--------------+----------------------+
```

[19]:
```
# Cell 11: Trips that started in one borough and ended in another
cross_borough = df_clean.filter(
    (F.col("pickup_borough") != F.col("dropoff_borough")) &
    (F.col("pickup_borough") != "UNKNOWN") &
    (F.col("dropoff_borough") != "UNKNOWN")
).groupBy("pickup_borough", "dropoff_borough").agg(F.count("*").
 ↪alias("num_trips")).orderBy(F.desc("num_trips"))

cross_borough.show(50, truncate=False)
cross_borough.coalesce(1).write.mode("overwrite").option("header","true").
 ↪csv(output_dir + "/trips_cross_borough")
```

```
+--------------+---------------+---------+
|pickup_borough|dropoff_borough|num_trips|
+--------------+---------------+---------+
|Manhattan     |Queens         |3943     |
|Queens        |Manhattan      |3698     |
|Manhattan     |Brooklyn       |1923     |
|Brooklyn      |Manhattan      |774      |
|Queens        |Brooklyn       |597      |
|Manhattan     |Bronx          |244      |
|Brooklyn      |Queens         |115      |
|Queens        |Bronx          |100      |
|Bronx         |Manhattan      |25       |
|Manhattan     |Staten Island  |9        |
|Bronx         |Queens         |2        |
|Queens        |Staten Island  |2        |
|Staten Island |Queens         |1        |
+--------------+---------------+---------+
```

[20]:
```
# Cell 12: Basic summaries and write to one summary CSV
summary = {
    "total_trips_cleaned": df_clean.count(),
    "total_unique_taxis": per_taxi.count(),
    "avg_trips_per_taxi": df_clean.count() / max(per_taxi.count(), 1)
```

```
}
import json, os
os.makedirs(output_dir, exist_ok=True)
with open(os.path.join(output_dir, "summary.json"), "w") as f:
    json.dump(summary, f, indent=2)

print("Summary:", summary)
```

```
Summary: {'total_trips_cleaned': 99999, 'total_unique_taxis': 9990,
'avg_trips_per_taxi': 10.00990990990991}
```

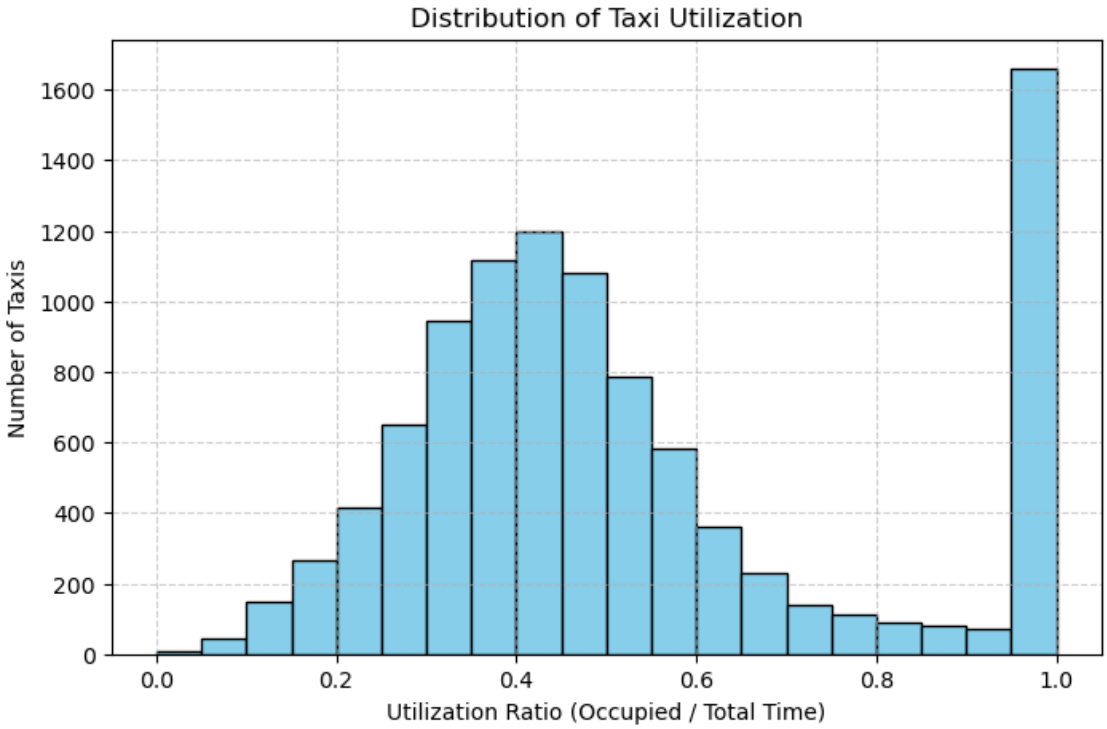
[21]:
```
# Cell 13: OPTIONAL: show some example trips (head) to include in report
df_clean.
  ↪select("taxi_id","pickup_datetime","dropoff_datetime","pickup_borough","dropoff_borough","d
  ↪show(20, truncate=False)
```

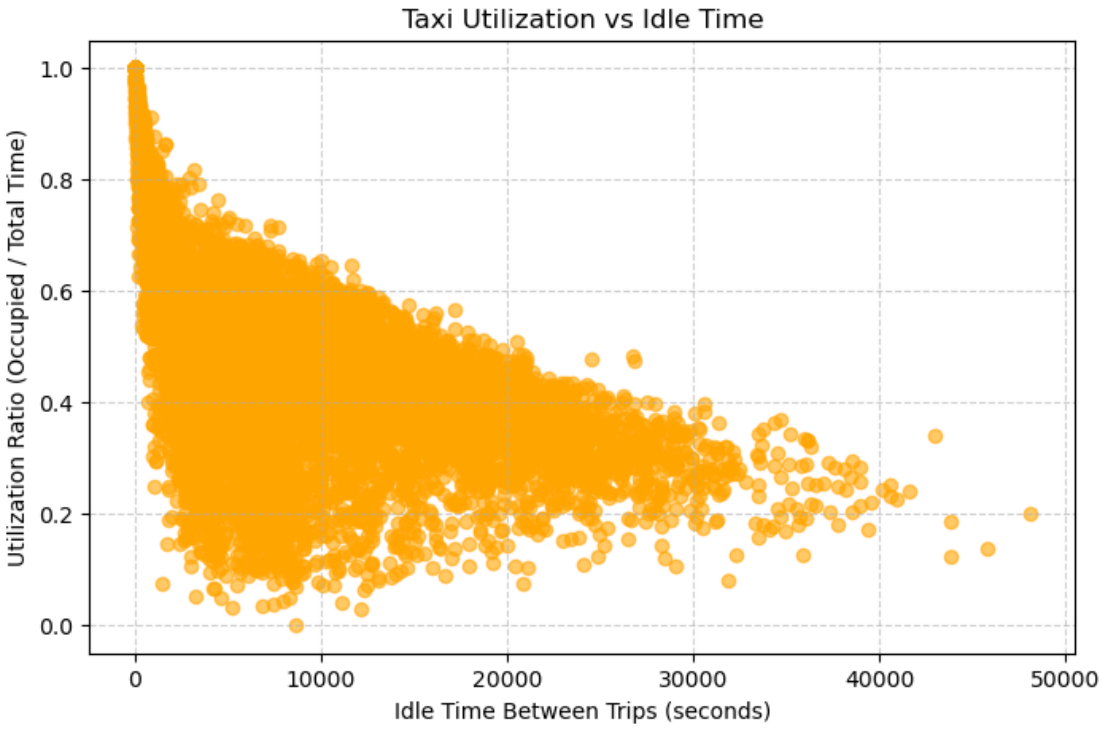
```
+--------------------------------+--------------+---------------+-------------
-+--------------+----------+
|taxi_id
|pickup_datetime|dropoff_datetime|pickup_borough|dropoff_borough|duration_s|
+--------------------------------+--------------+---------------+-------------
-+--------------+----------+
|BA96DE419E711691B9445D6A6307C170|01-01-13 15:11 |01-01-13 15:18  |Manhattan
|Manhattan      |420       |
|9FD8F69F0804BDB5549F40E9DA1BE472|06-01-13 00:18 |06-01-13 00:22  |Manhattan
|Manhattan      |240       |
|9FD8F69F0804BDB5549F40E9DA1BE472|05-01-13 18:49 |05-01-13 18:54  |Manhattan
|Manhattan      |300       |
|51EE87E3205C985EF8431D850C786310|07-01-13 23:54 |07-01-13 23:58  |Manhattan
|Manhattan      |240       |
|51EE87E3205C985EF8431D850C786310|07-01-13 23:25 |07-01-13 23:34  |Manhattan
|Manhattan      |540       |
|598CCE5B9C1918568DEE71F43CF26CD2|07-01-13 15:27 |07-01-13 15:38  |Manhattan
|Manhattan      |660       |
|513189AD756FF14FE670D10B92FAF04C|08-01-13 11:01 |08-01-13 11:08  |Manhattan
|Manhattan      |420       |
|CCD4367B417ED6634D986F573A552A62|07-01-13 12:39 |07-01-13 13:10  |Manhattan
|Queens         |1860      |
|1DA2F6543A62B8ED934771661A9D2FA0|07-01-13 18:15 |07-01-13 18:20  |Manhattan
|Manhattan      |300       |
|CD2F522EEE1FF5F5A8D8B679E23576B3|07-01-13 15:33 |07-01-13 15:49  |Manhattan
|Manhattan      |960       |
|06918214E951FA0003D1CC54955C2AB0|08-01-13 13:11 |08-01-13 13:19  |Manhattan
|Manhattan      |480       |
|06918214E951FA0003D1CC54955C2AB0|08-01-13 09:50 |08-01-13 10:02  |Manhattan
|Manhattan      |720       |
|E949C583ECF62C8F03FDCE1484954A08|10-01-13 12:07 |10-01-13 12:17  |Manhattan
|Manhattan      |600       |
```

```
|93C363DDF8ED9385D65FAD07CE3F5F07|07-01-13 07:35 |07-01-13 07:46  |Manhattan
|Manhattan      |660       |
|7CE849FEF67514F080AF80D990F7EF7F|10-01-13 15:42 |10-01-13 16:04  |Manhattan
|Manhattan      |1320      |
|7CE849FEF67514F080AF80D990F7EF7F|10-01-13 14:27 |10-01-13 14:45  |Manhattan
|Manhattan      |1080      |
|351BE7D984BE17DB2FA80A748E816472|07-01-13 22:09 |07-01-13 22:19  |Manhattan
|Manhattan      |600       |
|460C3F57DD9CB2265DB75B14CD70224D|07-01-13 17:18 |07-01-13 17:20  |Manhattan
|Manhattan      |120       |
|36773E80775F26CD1158EB5450A61C79|07-01-13 06:08 |07-01-13 06:13  |Manhattan
|Manhattan      |300       |
|D2363240A9295EF570FC6069BC4F4C92|07-01-13 22:25 |07-01-13 22:36  |Manhattan
|Manhattan      |660       |
+-------------------------------+--------------+---------------+------------
-+---------------+----------+
only showing top 20 rows
```

[30]:
```python
# ============================================================
#   VISUALIZATIONS FOR NYC TAXI DATA ANALYSIS (TP1)
# ============================================================

import matplotlib.pyplot as plt
import pandas as pd

# --- 1  Load saved results (replace paths if needed) ---
utilization_df = spark.read.csv(f"{output_dir}/per_taxi_utilization",␣
 ↪header=True, inferSchema=True).toPandas()
waiting_df = spark.read.csv(f"{output_dir}/
 ↪avg_time_to_next_per_dropoff_borough", header=True, inferSchema=True).
 ↪toPandas()
same_borough_df = spark.read.csv(f"{output_dir}/trips_same_borough",␣
 ↪header=True, inferSchema=True).toPandas()
cross_borough_df = spark.read.csv(f"{output_dir}/trips_cross_borough",␣
 ↪header=True, inferSchema=True).toPandas()

# ------------------------------------------------------------
# 1   Utilization distribution histogram
# ------------------------------------------------------------
plt.figure(figsize=(8,5))
plt.hist(utilization_df["utilization"], bins=20, color='skyblue',␣
 ↪edgecolor='black')
plt.title("Distribution of Taxi Utilization")
plt.xlabel("Utilization Ratio (Occupied / Total Time)")
plt.ylabel("Number of Taxis")
plt.grid(True, linestyle='--', alpha=0.6)
```

```
plt.show()

# ------------------------------------------------------------
# 2  Utilization vs Idle Time (scatter)
# ------------------------------------------------------------
plt.figure(figsize=(8,5))
plt.scatter(utilization_df["idle_s"], utilization_df["utilization"], alpha=0.6,␣
 ↪color='orange')
plt.title("Taxi Utilization vs Idle Time")
plt.xlabel("Idle Time Between Trips (seconds)")
plt.ylabel("Utilization Ratio (Occupied / Total Time)")
plt.grid(True, linestyle='--', alpha=0.6)
plt.show()
```

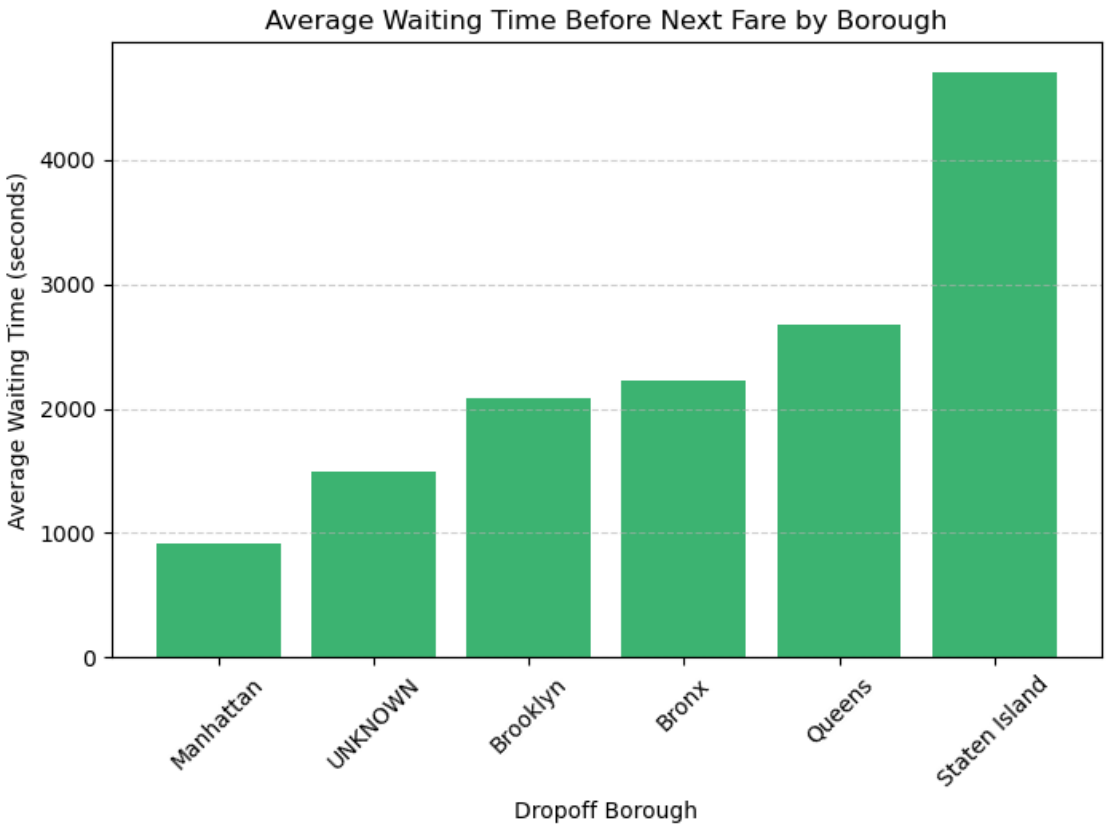




[23]:
```
# ------------------------------------------------------------
# 3  Average Waiting Time by Borough (bar)
# ------------------------------------------------------------
print("Columns in waiting_df:", list(waiting_df.columns))  # check real column␣
 ↪names first

# Normalize column names (lowercase)
waiting_df.columns = [c.lower() for c in waiting_df.columns]

# Detect column for average time
time_col = None
for c in waiting_df.columns:
    if "avg" in c and "time" in c:
        time_col = c
        break

if time_col is None:
    raise KeyError("Could not find average time column in waiting_df!")

# Detect borough column
borough_col = None
for c in waiting_df.columns:
    if "boro" in c:
```

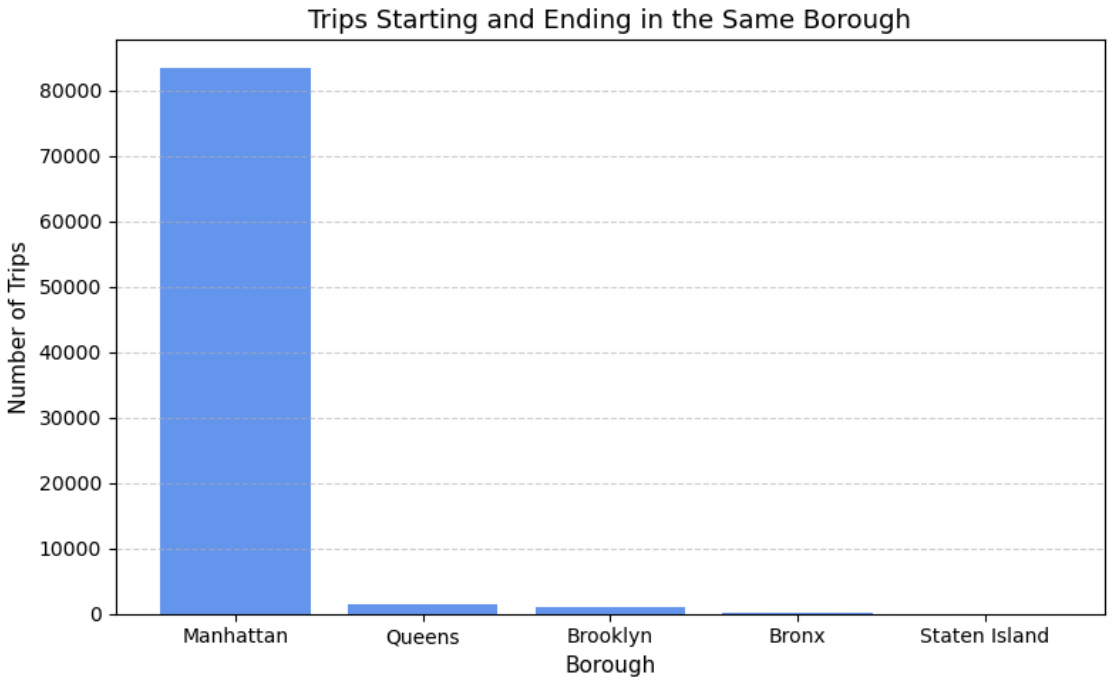
```
        borough_col = c
        break

if borough_col is None:
    raise KeyError("Could not find borough column in waiting_df!")

# Now plot safely
waiting_df = waiting_df.sort_values(time_col, ascending=True)
plt.figure(figsize=(8,5))
plt.bar(waiting_df[borough_col], waiting_df[time_col], color='mediumseagreen')
plt.title("Average Waiting Time Before Next Fare by Borough")
plt.xlabel("Dropoff Borough")
plt.ylabel("Average Waiting Time (seconds)")
plt.xticks(rotation=45)
plt.grid(axis='y', linestyle='--', alpha=0.6)
plt.show()
```

```
Columns in waiting_df: ['dropoff_borough', 'count_samples',
'avg_time_to_next_s', 'median_time_to_next_s']
```



[26]:
```
import pandas as pd
import matplotlib.pyplot as plt

# Load the same-borough trip results from the saved CSV
same_df = pd.read_csv("../data/output_tp1/trips_same_borough/
 ↪part-00000-5325a43b-fa14-4809-9629-923c9c64f545-c000.csv")

print("Loaded Same-Borough Trips:")
print(same_df.head())

# Normalize column names to lowercase
same_df.columns = [c.lower() for c in same_df.columns]

# Detect column names automatically
boro_col = next((c for c in same_df.columns if "boro" in c), same_df.columns[0])
count_col = next((c for c in same_df.columns if "count" in c or "num" in c),␣
 ↪same_df.columns[-1])

# Sort by trip count
same_df = same_df.sort_values(count_col, ascending=False)

# ---- Visualization ----
plt.figure(figsize=(8,5))
plt.bar(same_df[boro_col], same_df[count_col], color="cornflowerblue")
plt.title("Trips Starting and Ending in the Same Borough", fontsize=13)
plt.xlabel("Borough", fontsize=11)
plt.ylabel("Number of Trips", fontsize=11)
plt.grid(axis="y", linestyle="--", alpha=0.6)
plt.tight_layout()
plt.show()
```

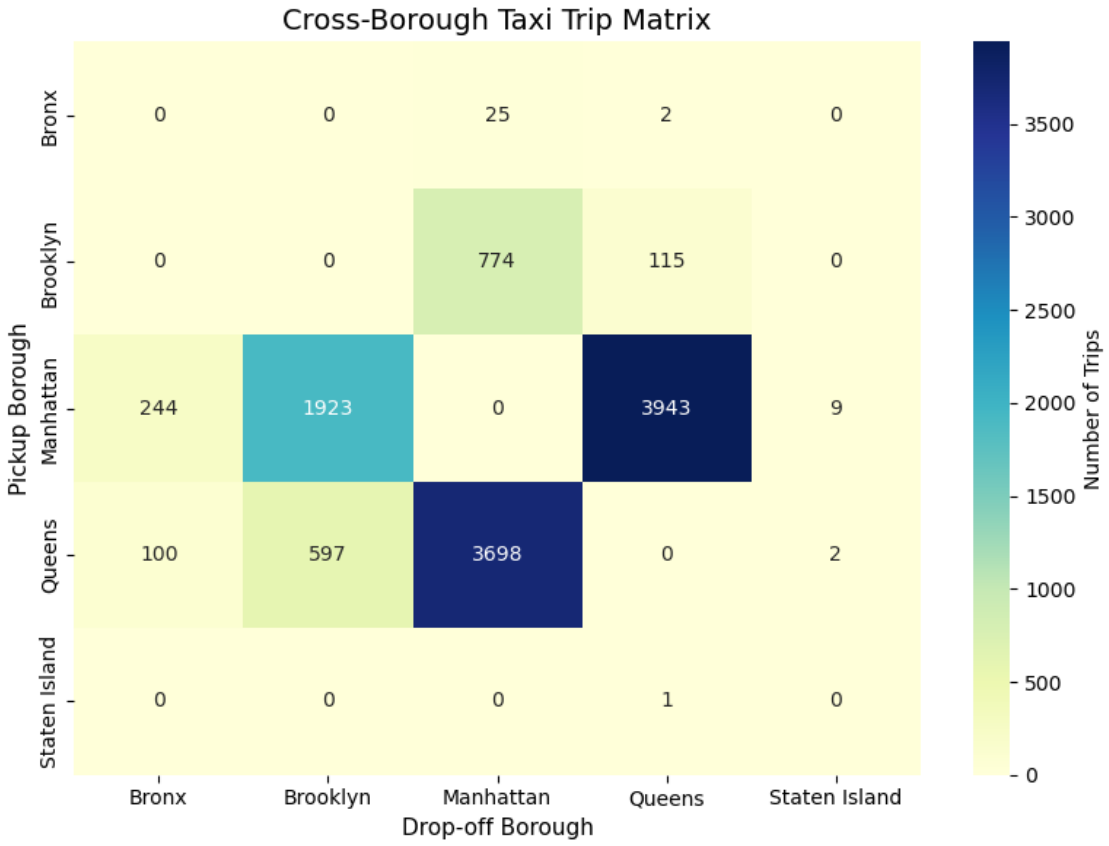
```
Loaded Same-Borough Trips:
  pickup_borough  num_trips_same_borough
0      Manhattan                   83561
1         Queens                    1396
2       Brooklyn                    1065
3          Bronx                      51
4  Staten Island                       1
```



[28]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import glob

# ---- Load the cross-borough trips CSV ----
# (your PySpark notebook saved it in ../data/output_tp1/trips_cross_borough)
csv_path = glob.glob("../data/output_tp1/trips_cross_borough/part-00000*.
 ↪csv")[0]
cross_df = pd.read_csv(csv_path)

print("Loaded Cross-Borough Trips:")
print(cross_df.head())

# ---- Normalize column names ----
cross_df.columns = [c.lower() for c in cross_df.columns]

# ---- Detect relevant columns automatically ----
pickup_col = next((c for c in cross_df.columns if "pickup" in c), None)
dropoff_col = next((c for c in cross_df.columns if "dropoff" in c), None)
count_col = next((c for c in cross_df.columns if "num" in c or "count" in c),␣
 ↪None)

# ---- Pivot table to make matrix ----
```

```
pivot_df = cross_df.pivot_table(index=pickup_col, columns=dropoff_col,␣
 ↪values=count_col, aggfunc="sum", fill_value=0)

# ---- Heatmap Visualization ----
plt.figure(figsize=(8,6))
sns.heatmap(pivot_df, annot=True, fmt=".0f", cmap="YlGnBu", cbar_kws={'label':␣
 ↪'Number of Trips'})
plt.title("Cross-Borough Taxi Trip Matrix", fontsize=14)
plt.xlabel("Drop-off Borough", fontsize=11)
plt.ylabel("Pickup Borough", fontsize=11)
plt.tight_layout()
plt.show()
```

```
Loaded Cross-Borough Trips:
  pickup_borough dropoff_borough  num_trips
0      Manhattan          Queens       3943
1         Queens       Manhattan       3698
2      Manhattan        Brooklyn       1923
3       Brooklyn       Manhattan        774
4         Queens        Brooklyn        597
```



[ ]: