PHASE 3 SUBMISSION DOCUMENT

Project Title: TRAFFIC MANAGEMENT

Phase 3: *Development Part 1*

Topic: In this section begin building your project by loading and preprocessing the dataset.

Introduction:

The growing urbanization and increasing population in cities around the world have put immense pressure on transportation systems. Traffic congestion, air pollution, and accidents have become common challenges that cities face. To address these issues and create more efficient and sustainable transportation networks, cities are turning to emerging technologies, with the Internet of Things (IoT) at the forefront of this transformation. In this extensive exploration, we will delve into the significant role that IoT plays in traffic management, how it's changing the urban landscape, its associated benefits, challenges, and the potential future developments in this field.

IoT in Traffic Management: A Game Changer

IoT in traffic management involves the deployment of a network of interconnected sensors, cameras, and data processing devices throughout the urban infrastructure. These devices collect real-time data on various aspects of traffic flow, including vehicle movement, pedestrian activity, weather conditions, and road infrastructure status. The data collected is then analyzed and utilized to make informed decisions about traffic control, optimize road networks, and improve the overall urban mobility experience.

Benefits of IoT in Traffic Management:

1. Real-Time Monitoring: IoT enables real-time traffic monitoring, allowing authorities to promptly respond to accidents, congestion, or adverse weather conditions. This helps reduce traffic bottlenecks and enhance safety.

2. Smart Traffic Signals: Adaptive traffic signal systems adjust signal timings based on real-time traffic conditions, reducing idle time and minimizing congestion.

3. Data-Driven Decision Making: Traffic data collected through IoT is invaluable for urban planning. It informs decisions about road expansion, maintenance, and the development of public transit systems.

4. Environmental Benefits: By optimizing traffic flow and reducing congestion, IoT contributes to reduced fuel consumption and lower greenhouse gas emissions, making cities more environmentally friendly.

Challenges and Considerations:

1. Privacy and Security: Collecting and processing vast amounts of traffic data can raise privacy concerns. Ensuring data security and protecting the anonymity of individuals is a critical challenge.

2. Data Overload: Handling and analyzing the massive volumes of data generated by IoT devices can be overwhelming. Cities need robust infrastructure and data processing capabilities to manage this information effectively.**3. Integration and Standards:** Different cities and regions may use different technologies and standards, making interoperability and data sharing a challenge.**4. Cost and Infrastructure**: Implementing IoT systems requires significant investment in infrastructure and technology. Funding can be a barrier for some cities.

Future of IoT in Traffic Management:

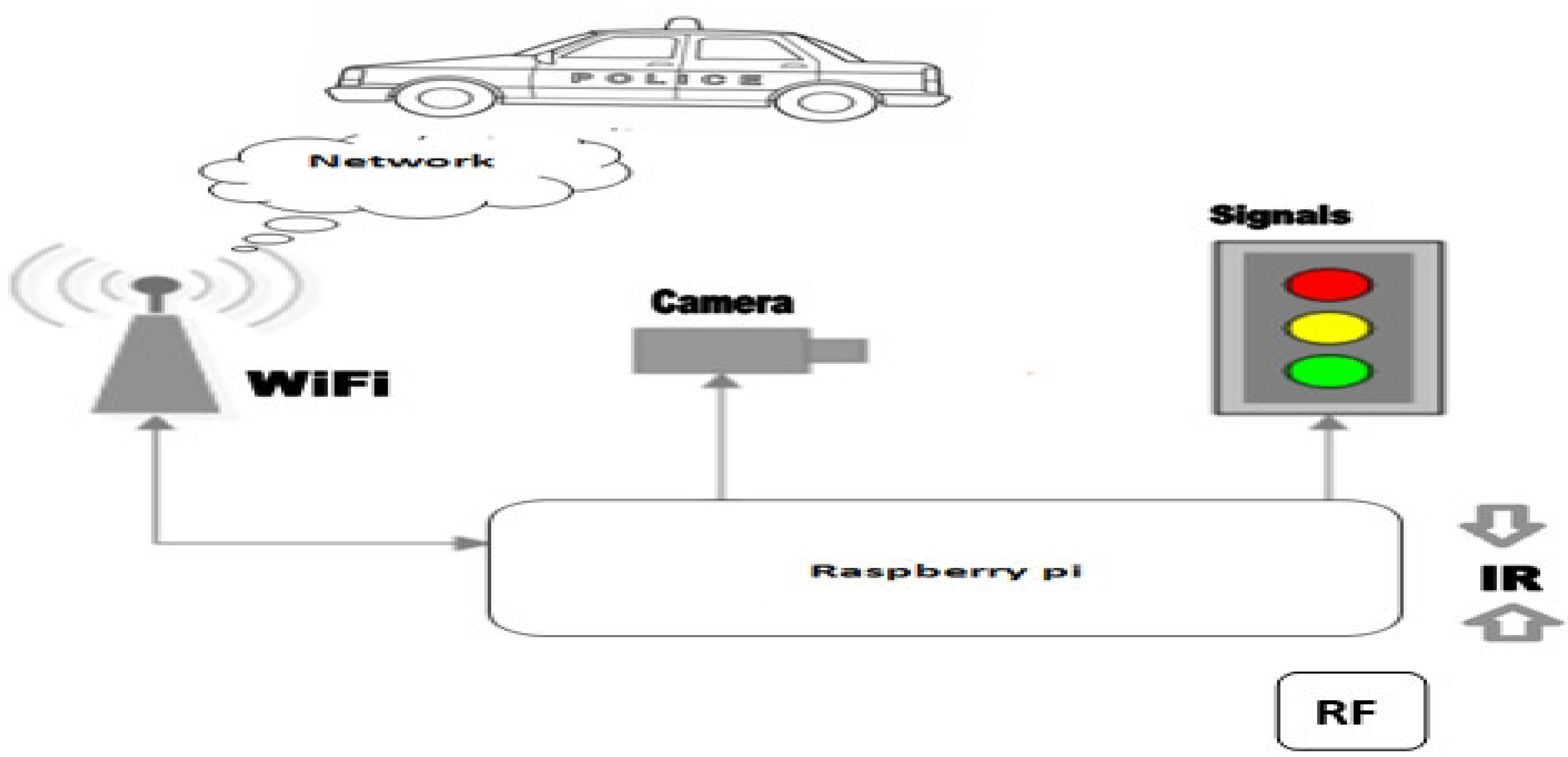
The potential for IoT in traffic management is vast and ever-evolving. Here are some future developments to watch for:

1. Autonomous Vehicles: The integration of IoT will be crucial for the success of autonomous vehicles. IoT can assist in vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, ensuring safer and more efficient transportation.

2. Predictive Analytics: Advanced data analytics, combined with AI, will enable cities to predict traffic patterns, making traffic management more proactive than reactive.

3. Smart Parking: IoT can be used to develop smart parking solutions, helping drivers find parking spaces more easily and reducing traffic congestion caused by the search for parking.

4. Sustainability: As cities prioritize sustainability, IoT can help optimize traffic flow in a way that reduces emissions and promotes cleaner transportation options, such as electric vehicles.



II. Data Processing: Understand the Current Situation

1. Import Datasets

Before starting to think about the Optimization Model, your priority is to understand the current situation.

Starting with unstructured data coming from several sources, we' ll need to build a set of data frames to model our network and provide visibility on the loading rate and list of stores delivered for each

Records of Deliveries per Store

Deliveries Records

Delveries_record_ccv

Date	Truck_ID	Store_ID	FTL	Order	BOX	SKU	Loading (Tons)
9/1/2016	Truck_ID1	Store_ID1	3.5	16	311	83	2.404
9/1/2016	Truck_ID1	Store_ID2	3.5	18	178	83	1.668

Date	Truck_ID	Store_ID	FTL	Order	BOX	SKU	Loading (Tons)
9/1/2016	Truck_ID2	Store_ID3	3.5	10	74	54	0.81
9/1/2016	Truck_ID2	Store_ID4	3.5	19	216	88	2.413
9/1/2016	Truck_ID3	Store_ID5	3.5	10	117	54	1.119
9/1/2016	Truck_ID3	Store_ID6	3.5	15	294	92	2.962
9/1/2016	Truck_ID4	Store_ID7	3.5	5	42	19	0.421
9/1/2016	Truck_ID4	Store_ID8	3.5	12	125	88	1.138
9/1/2016	Truck_ID5	Store_ID9	5	18	201	95	2.19

Store Address

Store_address.csv

Search this file…

Code	city	Long	Lat	address
Store_ID1	City_Store1	31.952792	118.8192708	Address_1
Store_ID2	City_Store2	31.952792	118.8192718	Address_2
Store_ID3	City_Store3	31.675948	120.7468221	Address_3
Store_ID4	City_Store4	31.664448	120.7700006	Address_4
Store_ID5	City_Store5	31.750971	119.9478857	Address_5
Store_ID6	City_Store6	31.791351	119.9232302	Address_6
Store_ID7	City_Store7	31.79233	119.9768294	Address_7
Store_ID8	City_Store8	31.982972	119.5832084	Address_8

Store_ID9	City_Store9	31.996161	119.6341775	Address_9
Store_ID10	City_Store10	31.885547	121.1886473	Address_10
Store_ID11	City_Store11	30.310079	120.1515734	Address_11
Store_ID12	City_Store12	31.383616	121.2569408	Address_12
Store_ID13	City_Store13	31.387863	121.2797154	Address_13

Transportation Costs

Transportation_cost.csv

Search this file…

City_En	3.5T (Rmb)	5T (Rmb)	8T (Rmb)	3.5T (Rmb/Ton)	5T (Rmb/Ton)	8T (Rmb/Ton)
City_1	485	650	800	139	130	100
City_2	640	700	820	183	140	103
City_3	690	780	890	197	156	111
City_4	810	1,000	1,150	231	200	144
City_5	1,300	1,568	1,723	371	314	215
City_6	1,498	1,900	2,100	428	380	263
City_7	980	1,250	1,450	280	250	181
City_8	1,350	1,450	1,500	386	290	188
City_9	1,350	1,450	1,500	386	290	188
City_10	850	1,000	1,200	243	200	150

2. Listing of stores delivered by each route

Let us process the initial data frame to list all stores delivered for each route.

1 Route = 1 Truck ID + 1 Date

Create Transport Plan

```
Def transport_plan(data, dict_trucks, capacity_dict):
        # List of Stores per Truck for each DAY
        Df_plan = pd.DataFrame(data.groupby([‘Date’, ‘TruckID’])[‘Code’
].apply(list))
        Df_plan.columns = [‘List_Code’]
        # List of Box Quantity
        Df_plan[‘List_BOX’] = data.groupby([‘Date’, ‘TruckID’])[‘BOX’].apply(list)
        # Mean of FTL
        Df_plan[‘FTL’]  = data.groupby([‘Date’, ‘TruckID’])[‘FTL’].mean()
        Df_plan[‘Capacity(T)’] = df_plan[‘FTL’].map(capacity_dict)
        Df_plan[‘List_Loading’] = data.groupby([‘Date’, ‘TruckID’])[‘Loading(T)’
].apply(list)
        Df_plan[‘Count’] = df_plan[‘List_Loading’].apply(lambda t: len(t))
        Df_plan[‘Total_tons(T)’] = data.groupby([‘Date’, ‘TruckID’])[‘Loading(T)’
].sum()

        # Distribute: one shipment per col
        # Stores
        D = df_plan[‘List_Code’].apply(pd.Series)
        For col in d:
           Df_plan[“Store%d” % (col+1)] = d[col]
        # Boxes number
        D = df_plan[‘List_BOX’].apply(pd.Series)
        For col in d:
           Df_plan[“Box%d” % (col+1)] = d[col]
        # Shipments Tonnage
```

```
D = df_plan[‘List_Loading’].apply(pd.Series)
For col in d:
   Df_plan[“Tons%d” % (col+1)] = d[col]

# Fill NaN + Drop useless columns
Df_plan.fillna(0, inplace = True)
If 1 == 0:
        Df_plan.drop([‘List_Code’], axis = 1, inplace = True)
        Df_plan.drop([‘List_BOX’], axis = 1, inplace = True)
        Df_plan.drop([‘List_Loading’], axis = 1, inplace = True)

Return df_plan
```

Example Transport Plan

Transport_plan.csv

Search this file…

Date	TruckID	List_Code	Capacity(T)	List_Loading	Count	Total_tons(T)	Store1	Store2	Store3	Store4	Box1	Box2	Box3	Box4	Tons1	Tons2	Tons3	Tons4	Occupation(%)	Available(T)
9/1/2016	Truck_ID1	[‘Store_ID6’]	3.5	[2.91]	1	2.91	ID6	0	0	0	243	0	0	0	2.91	0	0	0	83.14	0.59
9/1/2016	Truck_ID2	[‘Store_ID34’, ‘Store_ID22’, ‘Store_ID9’]	3.5	[0.3, 1.37, 0.47]	3	2.14	ID34	ID22	ID9	0	31	116	44	0	0.3	1.37	0.47	0	61.14	1.36
9/1/2016	Truck_ID3	[‘Store_ID18’]	3.5	[1.5]	1	1.5	ID18	0	0	0	174	0	0	0	1.5	0	0	0	42.86	2
9/1/2016	Truck_ID4	[‘Store_ID37’]	3.5	[2.3]	1	2.3	ID37	0	0	0	179	0	0	0	2.3	0	0	0	65.71	1.2

9/1/2016	Truck_ID5	['Store_ID34', 'Store_ID48']	3.5	[2.14, 0.51] 2
	2.65	ID34	ID48	0	0	168	46	0	0	2.14	0.51	0
	0	75.71	0.85

Add cities covered by each route

Let us now calculate Transportation Costs invoiced by carriers for each route:

Pricing Functions

Def f_maxcity(list_cities, list_price):

Return list_cities[list_price.index(max(list_price))] # Index of Maximum Price

Def inner_stops(list_cities, max_city):

Return list_cities.count(max_city) – 1

Def outer_stops(list_cities, max_city):

Return len(list_cities) – (list_cities.count(max_city))

Def total_price(max_price, inner_stops, outer_stops, inner_price, outer_price):

Return max_price + inner_stops * inner_price + outer_stops * outer_price

Calculate Price

Def plan_price(df_strinfo, df_plan, inner_price, outer_price):

Dictionnary Ville

Dict_ville = dict(zip(df_strinfo.Code.values, df_strinfo.City.values))

Price per Truck Size： 3.5T, 5T, 8T

Dict_35, dict_5, dict_8 = [dict(zip(df_strinfo.City.values, df_strinfo[col].values)) for col in ['3.5T', '5T', '8T']]

```
# Mapping Cities
F_ville = lambda t: [dict_ville[i] for I in t] # literal_eval(t)

# Mapping Price
F_35 = lambda t: [dict_35[i] for I in t]
F_5 = lambda t: [dict_5[i] for I in t]
F_8 = lambda t: [dict_8[i] for I in t]

# Mapping Price
Df_plan['List_City'] = df_plan['List_Code'].map(f_ville)
Df_plan['List_Price35'] = df_plan['List_City'].map(f_35)
Df_plan['List_Price5'] = df_plan['List_City'].map(f_5)
Df_plan['List_Price8'] = df_plan['List_City'].map(f_8)

# Maximum Price City
F_maxprice = lambda t: max(t) # Maximum Price

# Mapping First City
Df_plan['Max_Price35'] = df_plan['List_Price35'].map(f_maxprice)
Df_plan['Max_Price5'] = df_plan['List_Price5'].map(f_maxprice)
Df_plan['Max_Price8'] = df_plan['List_Price8'].map(f_maxprice)
Df_plan['Max_City'] = df_plan.apply(lambda x: f_maxcity(x.List_City,
x.List_Price35), axis = 1)

# Inner City Stop
```

Df_plan['Inner_Stops'] = df_plan.apply(lambda x: inner_stops(x.List_City, x.Max_City), axis = 1)

Df_plan['Outer_Stops'] = df_plan.apply(lambda x: outer_stops(x.List_City, x.Max_City), axis = 1)

Total Price

Df_plan['Price35'] = df_plan.apply(lambda x: total_price(x.Max_Price35, x.Inner_Stops, x.Outer_Stops,

Inner_price, outer_price), axis = 1)

Df_plan['Price5'] = df_plan.apply(lambda x: total_price(x.Max_Price5, x.Inner_Stops, x.Outer_Stops,

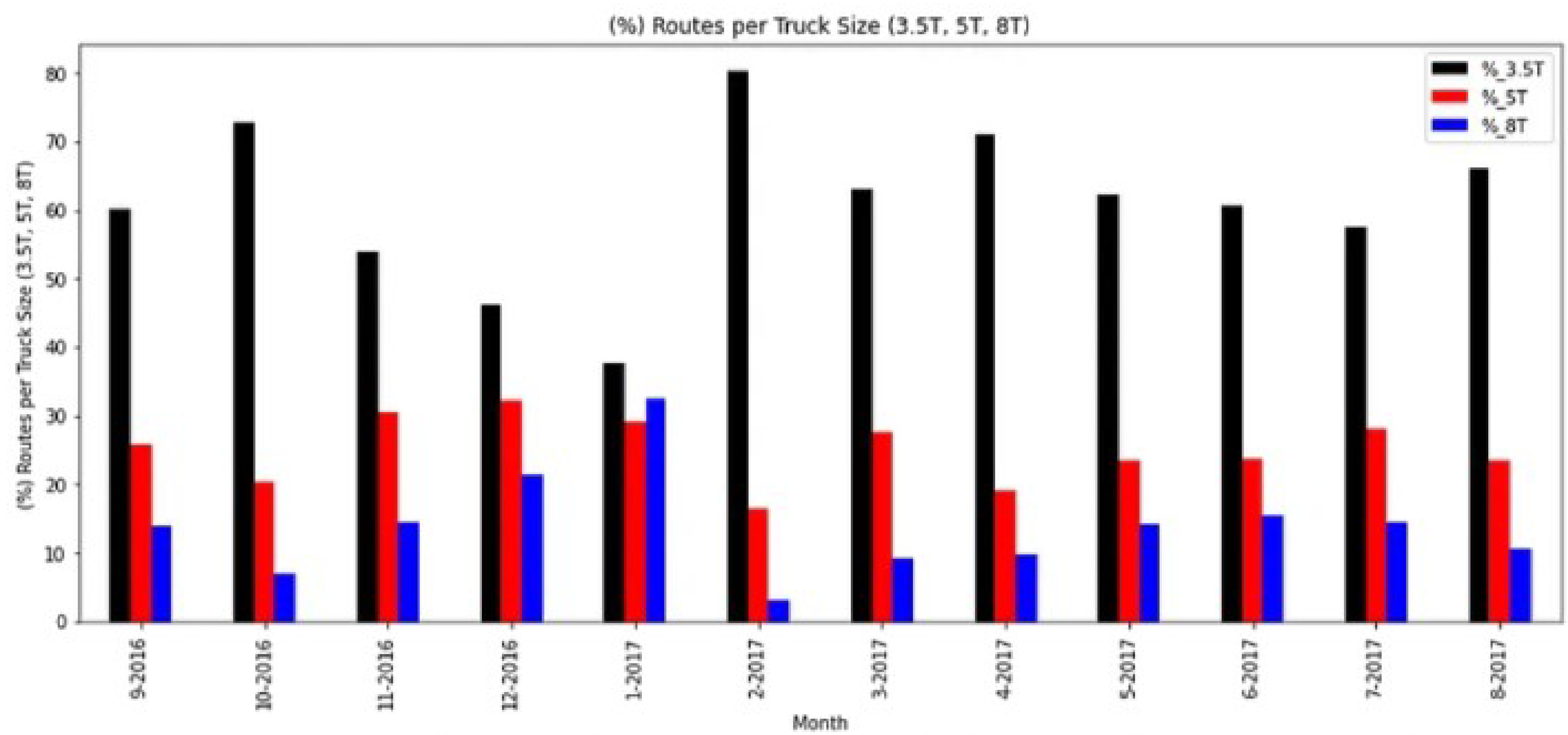
Inner_price, outer_price), axis = 1)

Df_plan['Price8'] = df_plan.apply(lambda x: total_price(x.Max_Price8, x.Inner_Stops, x.Outer_Stops,

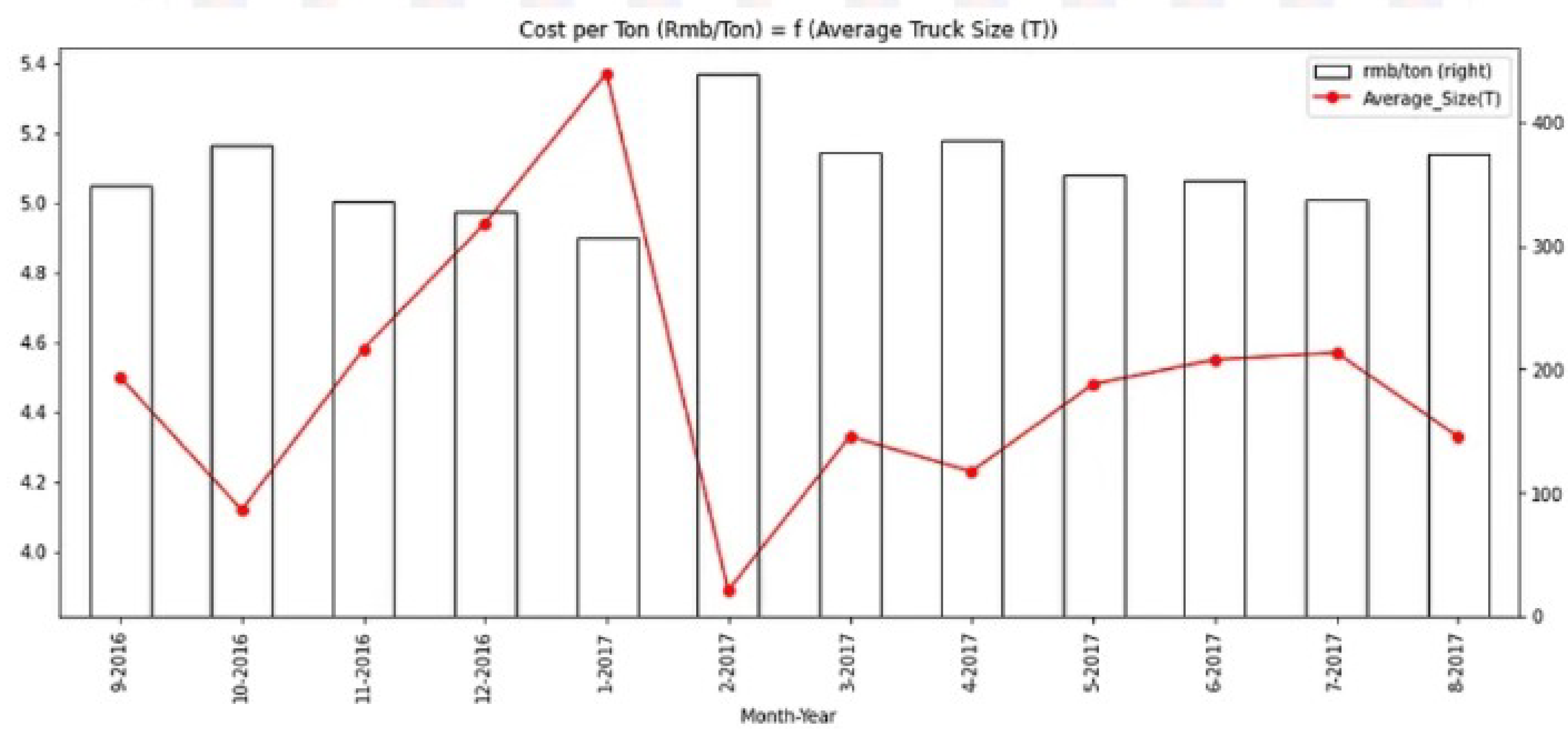
Inner_price, outer_price), axis = 1)

Return df_plan

Visualization: % Deliveries per Truck Size



(%) of Route per Truck Size (3.5T, 5T, 8T) — (Image by Author)



Impact of Average Truck Size (Ton) on Overall Cost per Ton (Rmb/Ton) — (Image by Author)

Insights

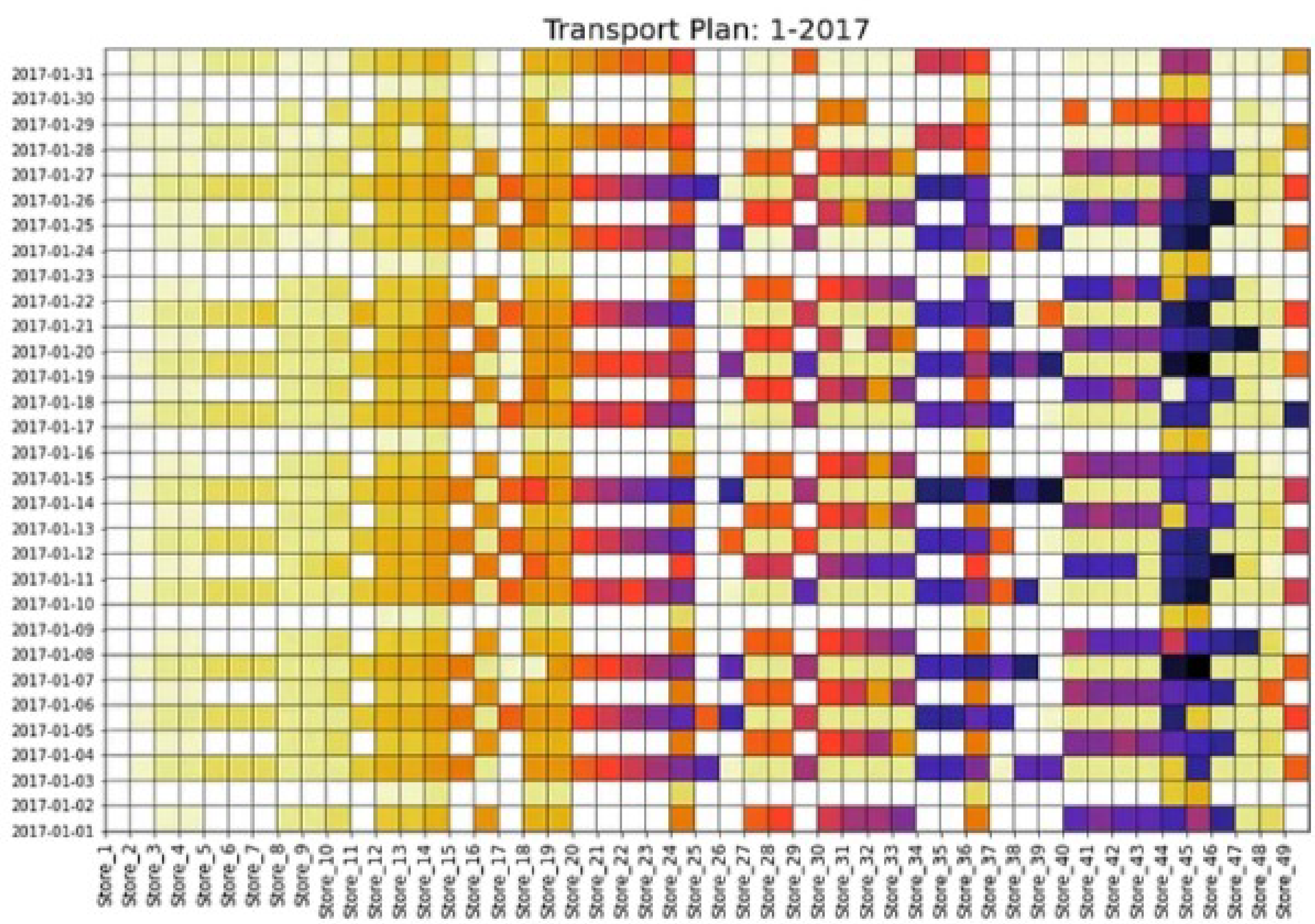
- **Average Truck Size:** a large majority of small trucks

- **Cost per ton:** the inverse proportion of cost per ton and average truck size

Understand Current Situation: Visualisation

1. Transportation Plan Visualisation

Objective: Get a simple visualisation of all deliveries per day with a focus on the number of different routes.



Transportation Plan: January 2017 — (Image by Author)

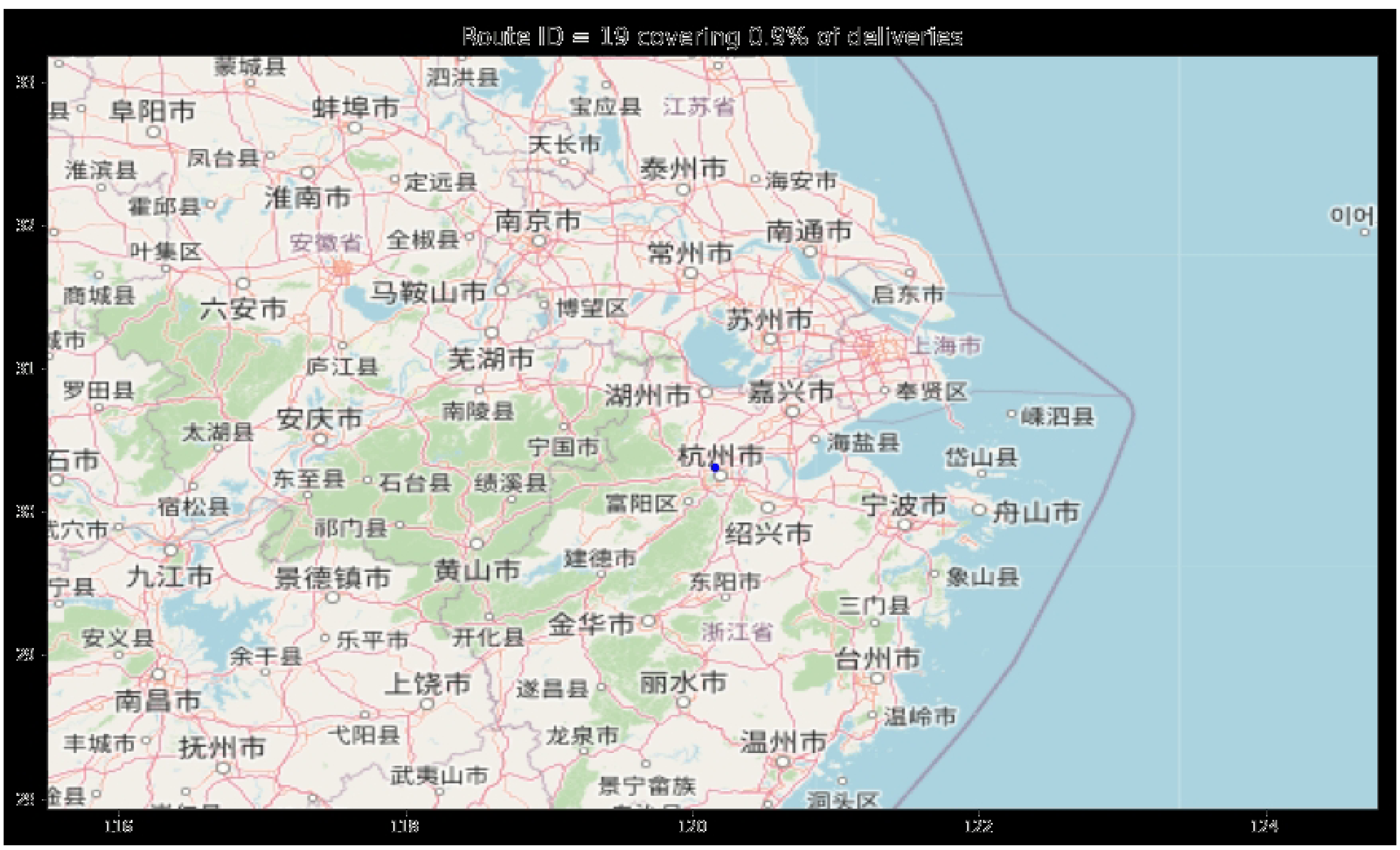
Solution: Python’ s Matplotlib grid function

- **Columns:** 1 Column = 1 Store
- **Rows:** 1 Row = 1 Day
- **Colour = White:** 0 delivery
- **Colours:** 1 Color = 1 Route (1 Truck)

Geographical Visualization of Store Deliveries

Objective

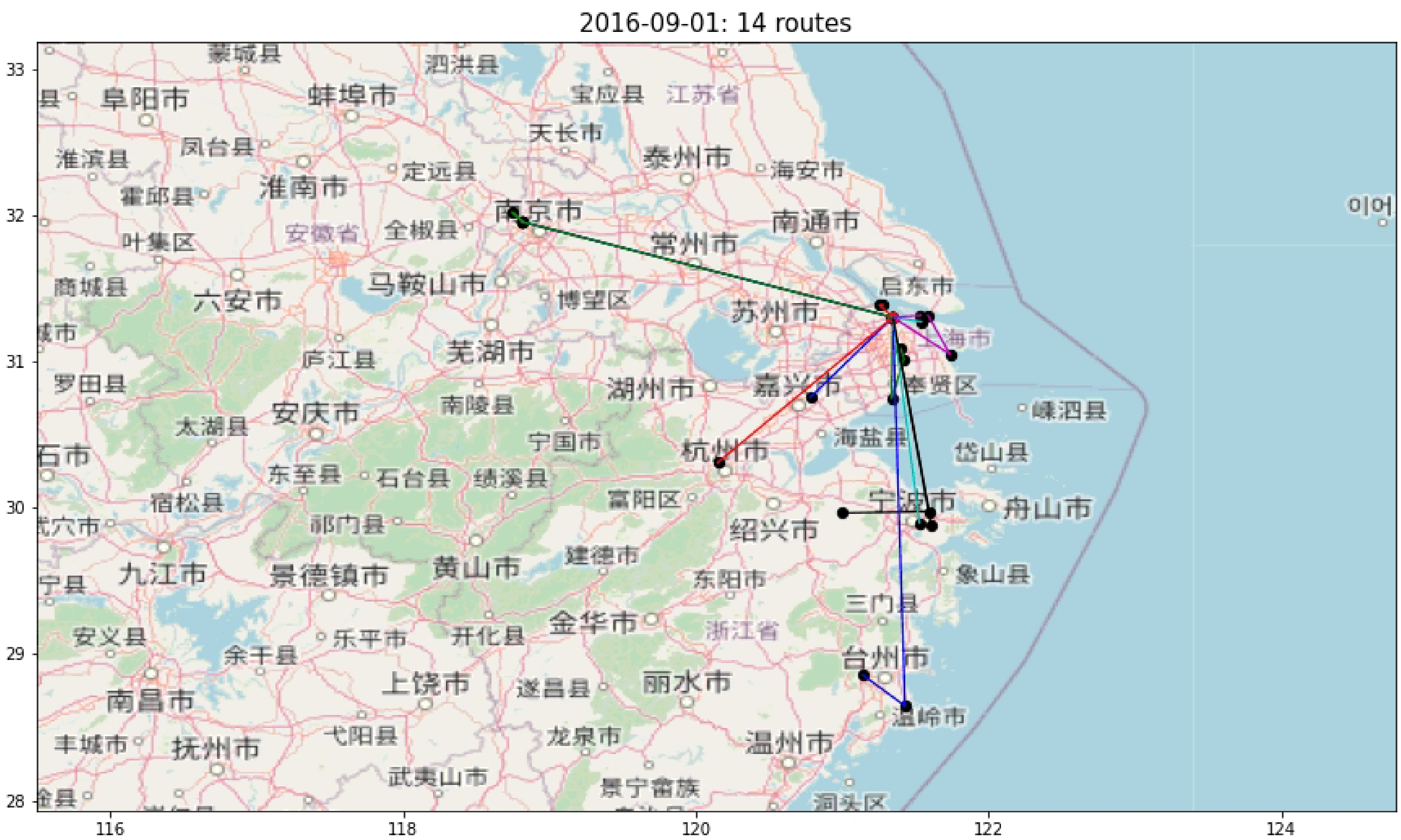
Visualisation of geographical locations delivered in the same route



Solution

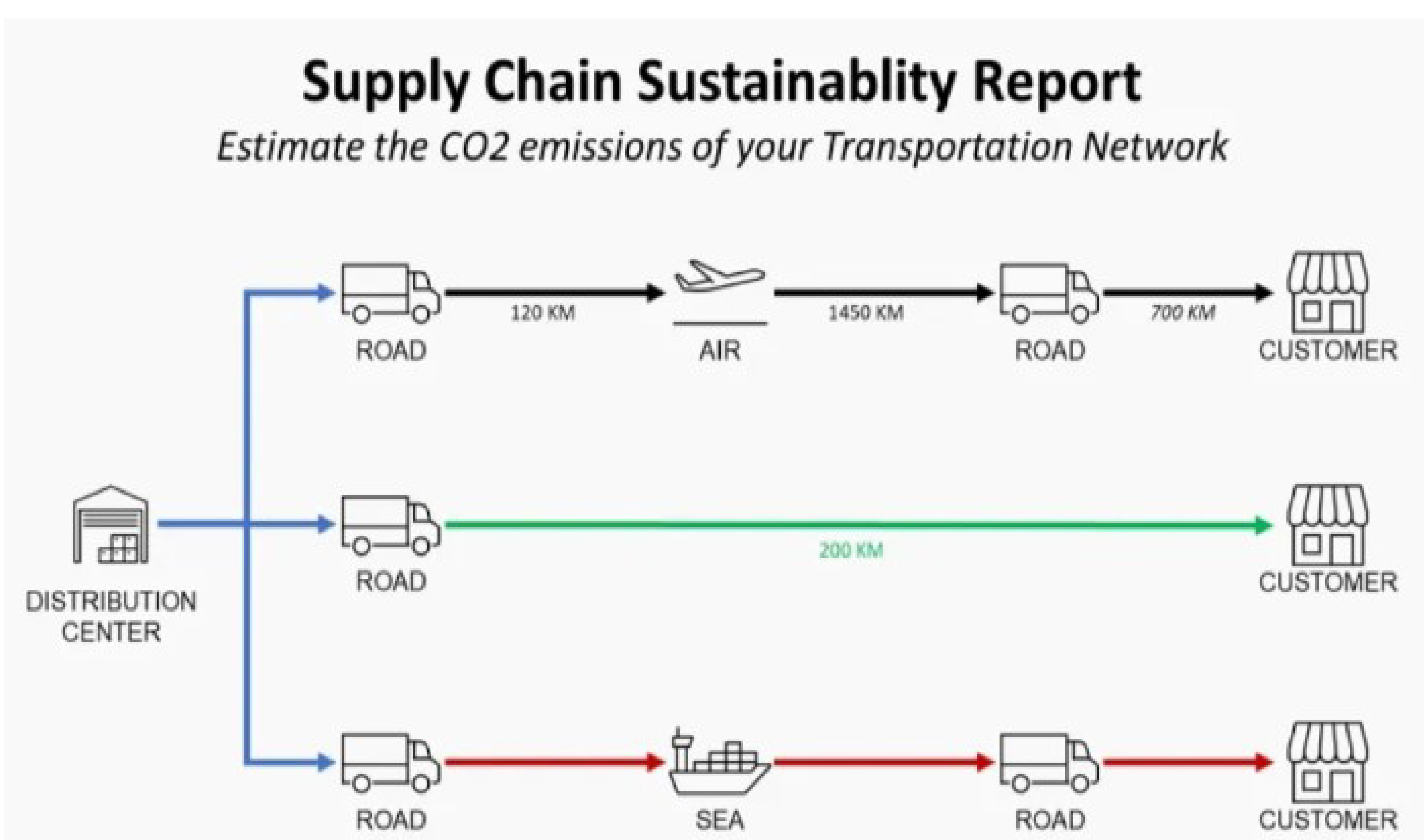
OpenStreet Map + Matplotlib Scatter Plot

Visualization of the different routes covered per day



Next Steps

1. Measure the Environmental Impact



In addition to cost reduction, you can also target CO_2 Emissions reductions by Optimizing your Transportation Network.

Routing Optimization: Number of Deliveries per Route

Dataframe with historical records processed

Current transportation plan

A model to calculate transportation cost per route based on cities delivered

Visualisation of the number of different routes per day

Visualisation of geographical locations delivered per Route

Next steps are

Routing: increase the number of stores delivered for each route

Fleet Allocation: ensure uniform workload distribution

Delivery Frequency: reduce the number of deliveries per week to increase the quantity per shipment

Simulate Impact: savings we can get from optimization listed above

Conclusion:

In the realm of public transport management in the Internet of Things (IoT), the significance of data cannot be overstated. This journey through the amalgamation of smart technology and public transportation has demonstrated the transformative power of data-driven insights. The utilization of IoT datasets has not only redefined public transportation but has also set the stage for a more efficient, reliable, and passenger-centric future.

As we draw this exploration to a close, it's evident that IoT datasets are the cornerstone upon which all optimization efforts are built.