PUBLIC TRANSPORTATION OPTIMIZATION

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In order to be environment-friendly, relieve traffic congestion, reduce pollution, and be green and sustainable, the optimization and development of public transportation, as the subject of people's long-term research, has always been shining. With the emergence of shared transportation, public transportation systems face more challenges. In order to better connect with bike-sharing, car-sharing, and other modes of transportation, public transportation will carry out important reforms, among which the optimization of line network is one of the most important tasks. The traditional bus route design is mainly based on the "four-stage" method model, which is mainly based on the investigation and analysis of the existing traffic system and land use. Through the work flow of "evaluation, calibration, and verification," the network balance optimization model is used to get the bus travel allocation prediction model. In this paper, the optimization problem of public transit network is studied from the point of view of the reliability

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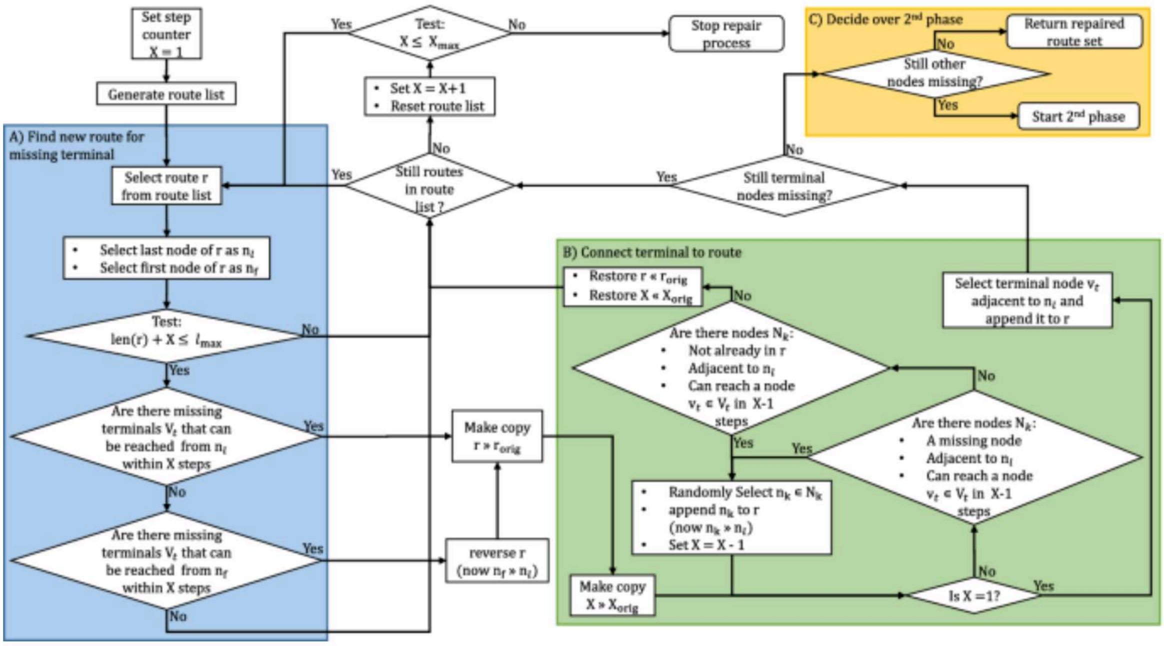
of public transit network. It is proposed that public transit network can be abstracted into series-parallel system and parallel-series system model from the three states of normal, short-circuit failure, and open-circuit failure and is analyzed and discussed through the hypothesis experiment. The research of this paper will provide a new perspective for the optimization of public transit network, complement the traditional methods, and support the optimization and reliability improvement of urban public transit network. More reliable bus networks and other modes of transportation, such as walking, bike-sharing, and rail, will become more suitable for people to get around.

FLOWCHART



DATA SHEET FOR PTO

Mode	Average Car	Compact Car	Electric Car	Van OR Pickup	Rideshare Passenger	Diesel Bus
Average Occupancy	1.5	1.5	1.5	1.5	1	8
Vehicle Ownership	0.272	0.237	0.387	0.354	0	0
Vehicle Operation	0.169	0.239	0.234	0.345	0.008	0
Operating Subsidy	0	0.123	0.304	0.035	0.011	1.982
Travel Time	0.234	0.456	0	0.087	0.201	2.675
Internet Crash	0.23	0.45	0	0.509	0.022	0.564
External Crash	0.245	0.453	0.345	0.303	0.452	0.345
Internal Health Ben	0.089	0.098	0.879	0.345	0.562	0.786
External Health Ben	0.344	0.034	0.341	0.562	0.709	0.431
Internal Parking	0.786	0.304	0.234	0.345	0.034	0.109
External Parking	0.346	0.345	0.555	0.987	0.345	0.054
Congestion	0.445	0.478	0.658	0.056	0.785	0.0435
Road Facilities	0.654	0.405	0.675	0.044	0.203	0.765
Land value	0.124	0.452	0.456	0.34	0.098	0.085
Traffic service	0.055	0.785	0.675	0.558	0.034	0.097
Transport Diversity	0.323	0.421	0.278	0.054	0.352	0.453
Air Pollution	0.345	0.321	0.513	0.095	0.766	0.0954
GHG	0.476	0.702	0.712	0.088	0.456	0.564
Noise	0.345	0.432	0.345	0.345	0.76	0.675
Resource Extemalitie	0.123	0.457	0.675	0.675	0.705	0.543
Land Yse Impacts	0.478	0.564	0.132	0.658	0.321	0.648
Water Pollution	0.378	0.872	0.358	0.488	0.781	0.546
Waste	0.0004	0.0004	0.0004	0.0004	0.0000	0.0004
TOTALS	6.4614	8.6284	8.7564	7.2734	7.605	11.4613

Mode
Average Occupancy
Vehicle Ownership
Vehicle Operation
Operating Subsidy
Travel Time
Internet Crash
External Crash
Internal Health Ben
External Health Ben
Internal Parking
External Parking
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Resource Extemalitie	
Land Yse Impacts	
Water Pollution	
Waste	
TOTALS	

Electric Trolley	Motor-cycle	Bicycle	Walk	Telework	Internet	Fixed	Market
10	1	1	1	1			
0	0.333	0.066	0	0.264	100%	100%	100%
0	0.264	0.066	0	0.264	100%	100%	100%
1.802	0.000	0.654	0.654	0.000	0%	0%	100%
3.828	0.000	0.098	0.673	0.000	100%	100%	0%
0.098	0.000	0.43	0.613	0.000	100%	0%	20%
0.054	0.000	0.985	0.912	0.000	0%	0%	20%
0.986	0.000	0.543	0.431	0.000	100%	0%	20%
0.134	0.000	0.621	0.312	0.000	0%	0%	20%
0.431	0.000	0.342	0.412	0.000	100%	0%	100%
0.543	0.988	0.612	0.324	0.000	0%	0%	100%
0.456	0.543	0.154	0.813	0.000	0%	100%	50%
0.123	0.903	0.041	0.512	0.001	0%	0%	100%
0.034	0.043	0.812	0.432	0.000	0%	0%	100%
0.564	0.000	0.564	0.442	0.000	0%	0%	100%
0.564	0.094	0.513	0.221	0.000	0%	0%	0%
0.435	0.654	0.543	0.012	0.000	0%	100%	0%
0.054	0.765	0.754	0.412	0.004	0%	0%	0%
0.453	0.432	0.342	0.812	0.000	0%	0%	0%
0.321	0.675	0.614	0.221	0.000	0%	0%	50%
0.45	0.000	0.142	0.612	0.000	0%	100%	0%
0.876	0.875	0.531	0.342	0.083	0%	0%	50%
0.0004	0.000	0.0000	0	0.0000	0%	0%	0%

12.2064	6.5694	9.427	9.162	0.616

PROGRAM FOR PTO

```
#CreateTransportPlan
                    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
```

HTML CODE

```
#CreateTransportPlan
def transport_plan(data, dict_trucks, capacity_dict):
        # List of Stores per Truck for each DAY
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```python
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```

Explaination for Public Transportation Optimization

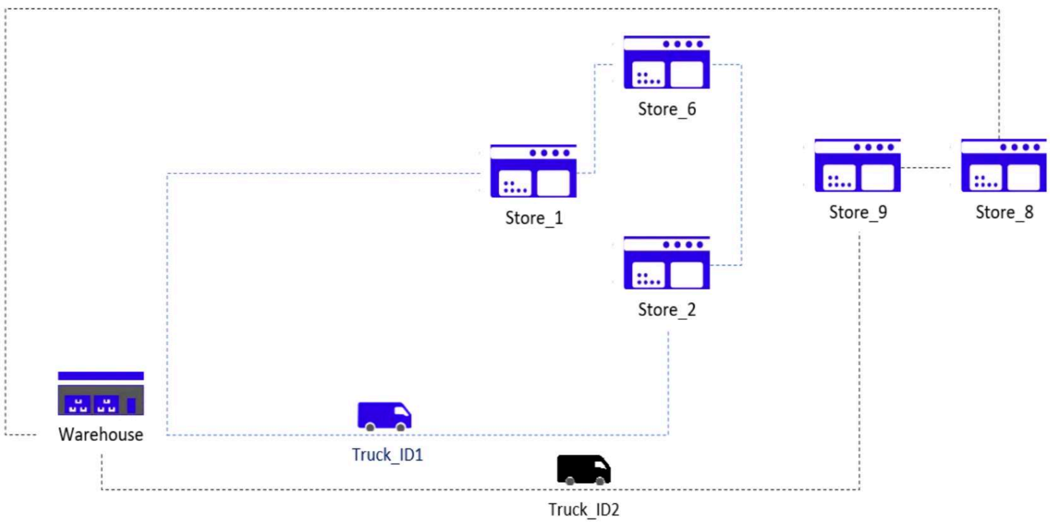
How do you make a transport plan with Python?

1. Problem Statement

Retail Stores Distribution with **Full Truck Load (FTL)**

- **1 Warehouse** delivering stores by using **three** types of Trucks (3.5T, 5T, 8T)
- **49 Stores** delivered
- **12 Months** of Historical Data with **10,000 Deliveries**

- **7 days** a week of Operations
- **23 Cities**
- **84 Trucks** in your fleet



Date	Store	Truck_ID	Vol (T)
XX/XX/XXXX	Store_2	Truck_ID1	1.2
XX/XX/XXXX	Store_6	Truck_ID1	0.3
XX/XX/XXXX	Store_1	Truck_ID1	1.9
XX/XX/XXXX	Store_9	Truck_ID2	1.2
XX/XX/XXXX	Store_8	Truck_ID2	0.3

2. Objective: Reduce the Cost per Ton

Method: Shipment Consolidation

In this scenario, you are using 3rd party carriers that charge full trucks per destination:

s.no	City_En	3.5T (Rmb)	5T (Rmb)	8T (Rmb)	3.5T (Rmb/Ton)	5T (Rmb/Ton)	8T (Rmb/Ton)
1	City_1	485	650	800	139	130	100
2	City_2	640	700	820	183	140	103
3	City_3	690	780	890	197	156	111
4	City_4	810	1,000	1,150	231	200	144
5	City_5	1,300	1,568	1,723	371	314	215
6	City_6	1,498	1,900	2,100	428	380	263
7	City_7	980	1,250	1,450	280	250	181
8	City_8	1,350	1,450	1,500	386	290	188
9	City_9	1,350	1,450	1,500	386	290	188

10	City_10	850	1,000	1,200	243	200	150

The table above shows rates applied by carriers for each city delivered for each type of truck. Observing **costs per ton are lower for larger trucks**, one lever of improvement is **maximizing shipments consolidation when building routes**.

Thus, the **Route Transportation Planning Optimization's** main target will be to cover a maximum number of stores per route.

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 route.

Records of Deliveries per Store

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
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

Store Address

Code	city	Long	Lat	address	Code	city	Long
Store_ID1	City_Store1	31.952792	118.8192708	Address_1	Store_ID1	City_Store1	31.952792
Store_ID2	City_Store2	31.952792	118.8192718	Address_2	Store_ID2	City_Store2	31.952792
Store_ID3	City_Store3	31.675948	120.7468221	Address_3	Store_ID3	City_Store3	31.675948
Store_ID4	City_Store4	31.664448	120.7700006	Address_4	Store_ID4	City_Store4	31.664448
Store_ID5	City_Store5	31.750971	119.9478857	Address_5	Store_ID5	City_Store5	31.750971
Store_ID6	City_Store6	31.791351	119.9232302	Address_6	Store_ID6	City_Store6	31.791351
Store_ID13	City_Store13	31.387863	121.2797154	Address_13	Store_ID13	City_Store13	31.387863

Transportation Costs

s.no	City_En	3.5T (Rmb)	5T (Rmb)	8T (Rmb)	3.5T (Rmb/Ton)	5T (Rmb/Ton)
1	City_1	485	650	800	139	130
2	City_2	640	700	820	183	140
3	City_3	690	780	890	197	156
4	City_4	810	1,000	1,150	231	200
5	City_5	1,300	1,568	1,723	371	314
6	City_6	1,498	1,900	2,100	428	380
7	City_7	980	1,250	1,450	280	250

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

What is the Internet of Things?

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. Thanks to the arrival of super-cheap computer chips and the ubiquity of wireless networks, it's possible to turn anything, from something as small as a pill to something as big as an aeroplane, into a part of the IoT. Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate real-time data without involving a human being. The Internet of Things is making the fabric of the world around us more smarter and more responsive, merging the digital and physical universes.

- **The Internet of Things? It's really a giant robot and we don't know how to fix it**

What is an example of an Internet of Things device?

Pretty much any physical object can be transformed into an IoT device if it can be connected to the internet to be controlled or communicate information.

A lightbulb that can be switched on using a smartphone app is an IoT device, as is a motion sensor or a smart thermostat in your office or a connected streetlight. An IoT device could be as fluffy as a child's toy or as serious as a driverless truck. Some larger objects may themselves be filled with many smaller IoT components, such as a jet engine that's now filled with thousands of sensors collecting and transmitting data back to make sure it is operating efficiently. At an even bigger scale, smart cities projects are filling entire regions with sensors to help us understand and control the environment.

What is the history of the Internet of Things?

The idea of adding sensors and intelligence to basic objects was discussed throughout the 1980s and 1990s (and there are arguably some much earlier ancestors), but apart from some early projects -- including an internet-connected vending machine -- progress was slow simply because the technology wasn't ready. Chips were too big and bulky and there was no way for objects to communicate effectively.

Processors that were cheap and power-frugal enough to be all but disposable were needed before it finally became cost-effective to connect up billions of devices.
The adoption of RFID tags -- low-power chips that can communicate wirelessly -- solved some of this issue, along with the increasing availability of broadband internet and cellular and wireless networking. The adoption of IPv6 -- which, among other things, should provide enough IP addresses for every device the world (or indeed this galaxy) is ever likely to need -- was also a necessary step for the IoT to scale