Underground Logistics System Network Design

Project for Algorithm: Analysis and Theory

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Abstract. This project introduces the concept of underground logistics system network design. It lists all the requirements and rules for each group. Please read this document carefully and complete the corresponding tasks.
Keywords: Underground Logistics System, Nodes Selection ,Passage Network Design

1 Underground Logistics System

Terrible traffic conditions impede the efficiency of freight and logistics distribution in large cities. The conflict between urban development and logistics demands on land and road resources has become increasingly intense, necessitating a new transportation mode to meet the growing demand for freight volume. Underground logistics system (ULS), which transfers some of the cargo in the city to underground pipelines or tunnels, can effectively ease traffic congestion, enhance freight efficiency, save land, energy and other resources, and reduce environmental pollution and traffic accidents. An urban ULS is one important means of solving urban traffic problems that has unique advantages.

Basic characteristics of underground logistics system:

1. Underground logistics cannot completely replace ground logistics, "multimodal transport" is an important mode of transport organization. (Multimodal Transport: The transport process jointly completed by two or more means of transportation is called composite transport, which is customarily called multimodal transport in China. For example, underground logistics - highway transportation, highway - railway.)
2. The underground logistics system can meet the transportation needs of different goods, and the diameter of pipeline or tunnel can be designed according to the needs. The running speed can reach 20-60 km/h, and the running interval of two coaches in the same direction on the same line is more than 2 minutes.
3. The underground logistics network is composed of primary and secondary nodes and underground passages between nodes. Nodes at all levels connect with the ground and realize multimodal transport. The first-level node is connected with the logistics park and underground transportation of 10 tons of large vehicles. It can transport goods across regions. The total amount of goods sent and received from the ground is up to 4000 tons. The first-level nodes are connected with each other. The upper limit of the total amount of goods sent and received by the secondary nodes from the ground is 3000 tons, and the primary nodes in the non-local area are connected only through the primary nodes in the local area.

The paper gives the traffic cargo regional partition map and the corresponding freight OD (Origin Destination) flow matrix of Xianlin area of Nanjing (only considering the cargo flow of the origin and destination, not considering the route between them), the central point and area of each region, and the traffic congestion coefficient of each region (to simplify the calculation, some data are processed).Other relevant data can be searched by yourselves to collect data that you think are relevant to the establishment of the "underground logistics system" network in the region.

2 Tasks and Requirements

There are two direct objectives of developing urban underground logistics network: one is to alleviate traffic congestion until the traffic is smooth, at least basically; the other is to reduce logistics costs.

1. **Selection of underground logistics nodes**According to your point of view and the actual situation of the region, please establishes the node selection model of the region, and determines the node group of underground logistics network in the region.

2. **Underground passage network design** Please select suitable underground routes on the basis of underground logistics network nodes to establish the "underground logistics system" network in the region. When the transshipment rate does not change much, the location of primary and secondary nodes can be adjusted appropriately if the optimal network is considered. Underground transportation vehicles of 5 tons are used in all underground passages except the underground passages from the park to the first node.

2.1 Problem Analysis and Algorithm Design

Firstly, please judge the difficulty of this problem. Whether it is in P, NP, NP-Complete, or NP-Hard? Prove or clarify your conclusion.

Next, please design an efficient algorithm to solve the problem in polynomial time with respect to the input size. You need to describe your design first, and introduce the necessary concepts, symbols, definitions, etc.

2.2 Problem Requirements

The calculation results need but are not limited to submission: the number and location of primary and secondary nodes, the service scope of each node (the area formed by the starting or ending points of the goods entering or leaving the ground), the actual freight volume of each node, and the transshipment rate of each primary node; network composition (node and channel location), actual freight volume of each node, and location and actual flow of all levels of channels.

1. The value of traffic congestion index ranges from 0 to 10, each of which is a grade. It corresponds to the five grades of "0-2 unblocked", "2-4 unblocked", "4-6 mild congestion", "6-8 moderate congestion" and "8-10 severe congestion". The higher the value, the more serious the traffic congestion is. Since the region is not a highly populated area, it can be approximated that the regional traffic congestion index is proportional to the total regional freight volume (the sum of inward and outward) reflected by OD data, and the maximum value of the index given by the proportional relationship can be greater than 10.To simplify the calculation, the congestion index is calculated only on the basis of freight volume.
2. Transfer rate of primary node (): The percentage of goods transported from the logistics park to all other primary nodes through the nearest primary node in the total shipment of the logistics park is called the transfer rate of the primary node. Due to the need to replace transport vehicles, low transshipment rate can reduce the workload on the premise of meeting transport requirements.
3. Considering that the ratio of freight volume to area in some regions is too small, if the node covers the central point of a region, it can be regarded as covering the region.
4. The service radius of all nodes is freely chosen within 3 km, and the distance between nodes is not limited.
5. Cargo is transported by manpower or small vehicles from secondary nodes to the ground in the service area of nodes, which can be considered as not affecting traffic.
6. Goods entering and leaving the four logistics parks are transported underground as far as possible. Goods within the area are considered according to congestion.
7. The goods in underground nodes and passages should be cleared every day.
8. The two-way dimension of underground logistics corridor between two adjacent nodes is the same, and the design principle is that the one-way flow is larger.
9. The minimum total cost is required. The total daily cost consists of transportation cost of goods and depreciation of underground logistics tunnels and nodes. Assuming that the average transportation cost per ton of cargo per kilometer is always equal, it is about 1 yuan per ton per kilometer (depreciation of vehicles and equipment is included), independent of the size of the tunnel through which it passes. The construction costs of underground logistics tunnels and joints are: bidirectional four-track (double-hole) (10 tons) cost 500 million yuan/km, bidirectional double-track (double-hole) (10 tons) cost 400 million yuan/km, bidirectional four-track (double-hole) (5 tons) cost 350 million yuan/km, bidirectional double-track (double-hole) (5 tons) cost 300 million yuan/km, and the construction costs of primary and secondary joints are about 150 million yuan/km and 100 million yuan respectively. The design life of channels and joints is 100 years, and the annual comprehensive depreciation rate is 1
10. The construction of logistics park and underground nodes in the park are not considered, but the length of the passage from the park should be included in the total cost.

2.3 Data Format

The attachment contains: The traffic and freight area division map of the Xianlin area of Nanjing and the corresponding freight OD flow matrix (unit: ton, the data in the table indicates the horizontal axis to the vertical axis), the area of each region and the coordinates of the center point (unit: meter), traffic congestion factor in each region.

3 Report Requirements

You need to submit a report for this project, with the following requirements:

1. Your report should have the title, the author names, IDs, email addresses, the page header, the page numbers, figure for your simulations, tables for discussions and comparisons, with the corresponding figure titles and table titles.
2. Your report is English only, with a clear structure, divided by sections, and may contain organizational architecture like itemizations, definitions, or theorems and proofs.
3. Please include reference section and acknowledgement section. You may also include your feelings, suggestion, and comments in the acknowledgement section.
4. Please define your variables clearly. If needed, a symbol table is strongly recommended to help readers catch your design.
5. Please also include your latex source and simulation codes upon submission.