IE-479 Fall 2024
Cold Chain Distribution Network Project
Due Date: December 24, 23:59

1 Introduction

This project aims to design an optimized cold chain logistics network for a food production company that specializes in manufacturing and distributing perishable goods, including fresh fruits and vegetables, dairy products, meat, seafood, and frozen items. The company is a leading producer of these products, operating multiple factories across Turkey, each specializing in a different category.

In response to customer demand, each factory produces its designated products. Once production is complete, the items are transported to the nearest **Local Cold Station (LCS)**. LCSs serve as the first nodes in the cold chain network, functioning as collection and sorting points where shipments from various factories are organized for further distribution.

From the LCS, the products are transported to **Central Cold Storage Hubs (CCSHs)**. These hubs act as regional distribution centers, consolidating shipments and enabling efficient handling of long-distance deliveries. Each LCS is assigned to a specific CCSH, where products are temporarily stored, sorted and prepared for the next leg of their journey. If the delivery involves another region, the goods are transported between CCSHs. This stage involves direct transport from one CCSH to another. At the destination CCSH, products of different factories are grouped based on their final destinations. The final delivery then proceeds from the second CCSH to the destination LCS closest to the customer's location. From this local LCS, the products are dispatched to the customer's market or grocery store, ensuring the cold chain is maintained throughout the journey.

The transportation process can be divided into three primary legs:

1. **First Leg:** The journey from the originating LCS to a CCSH.
2. **Second Leg:** Transport between two CCSHs.
3. **Third Leg:** The journey from the destination CCSH to the final LCS near the customer's location.

In some cases, the first and second CCSHs may coincide.

In Turkey, the transportation of these goods predominantly relies on ground transportation, with trucks equipped with advanced refrigeration systems playing a crucial role. The routes connecting LCSs to CCSHs are called **main lines**, while those connecting two CCSHs are called **express lines**. Larger refrigerated trucks are used on express lines to facilitate long-distance deliveries. The second leg of the journey is completed when the express truck arrives at its designated CCSH. The first and third legs, involving transport between LCSs and CCSHs, rely on main lines.

In this project, the goal is to design a cold chain logistics network that minimizes the travel time spent on each route wanted to be minimized to preserve the quality of the parcels.

2 Case Questions

Part 1: As it is explained above, we have a network consisting of main lines and express lines. The network consists of all cities of Ege, Marmara, Akdeniz and Ic Anadolu Regions (40 cities). However, because of the logistics constraints, the CCSH can be located only in Adana, Ankara, Antalya, Bursa, Edirne, Eskişehir, Mersin, İstanbul, İzmir, Kocaeli, Konya and Muğla (12 cities). Assume that every city in the network has one LCS. Design issues related to this network include selecting the location of CCSHs and the assignment of LCSs to CCSHs. Assume that there is no fleet size restriction and an express line truck is available for every CCSH pair. Trucks for main lines travel at 100km/hrs. Trucks for express lines travel 1.1 times faster than main lines. Construct a delivery network with 4 CCSH while minimizing the maximum travel time spent on one trip. (Please note that trip means either the route connecting LCS to CCSH or routes between two CCSH, NOT the whole route that connects the origin LCS and the destination LCS). Report the locations of these centers, their related assignments and your objective value.

Part 2: During its journey from the LCS to the assigned CCSH, the delivery truck may stop at various other LCSs, which are also assigned to the same CCSH, to pick up their parcels. Similarly, during its journey from the CCSH to the LCS, the delivery truck may stop at various other LCSs, which are also assigned to the same CCSH, to deliver the parcels. There is no capacity restriction for the trucks. However, one thing to consider is the duration of these trips. Since the working hours of a driver are between 6.00 pm and 6.00 am, a truck on the main lines can work at most 12 hours. Locate 4 CCSH as you found in Part 1. The firm wants to minimize the number of trucks to utilize to satisfy the demand of each customer. Provide your results and routes clearly.

Part 3:

- Assume that you found $X*$ trucks in the previous part; however, the firm can afford only $X < X*$ trucks. Provide a feasibility analysis on how much more a truck driver has to work in one day.
- Assume that you found X* trucks in the previous part; however, the firm already has $X' > X*$ trucks. Provide an analysis on how much the total travel distance will change (when it is minimized for X' trucks).
- It is enough to provide an analysis with 3 steps for each case.

Part 4: (Bonus) Assume that you have to give the location and routing decisions at the same time. The objective of the problem is to construct a network such that the longest delivery time is as small as possible (our objective). There are 20 trucks available on the main lines and there is no bound on the number of trucks for the express lines. The trucks on the main line can work up to 8 hours, and additionally the trucks on the express lines cannot travel longer than 12 hours. Other data utilized in Part 1 are valid here too.

How would you model the problem? What would be your results while locating 4 CCSH? What would be your comments? How would you compare the results with the previous parts?