Effective Material Flow Management for Unilever Foods and Beverages Site (Besan Factory)

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ABSTRACT

The purpose of this project is to design a decision support system that determines the best possible set of routes for raw material collection from suppliers to Besan Besin San. ve Tic. A.Ş., which is Food and Beverages Site of Unilever. The project consists of two main components; a solution method for the planning of collection routes and its implementation in the form of a decision-making tool. When there are changes in demands or in the current set of suppliers, the tool should be flexible enough to produce updated solutions in response to such changes. The mathematical model involves practical restrictions specified by the company. The decision is a coded implementation of the proposed solution method on a user-friendly interface (CPLEX) which outputs a set of collection routes based on user-specified problem parameters.

About Unilever

Unilever is one of the world's leading suppliers of Beauty & Personal Care, Home Care, and Foods & Refreshment products with sales in over 190 countries and reaching 2.5 billion consumers a day. It has 161,000 employees and generated sales of €53.7 billion in 2017. Over half (57%) of the company's footprint is in developing and emerging markets. Unilever has more than 400 brands found in homes all over the world, including Omo, Dove, Knorr, Domestos, Rexona, Hellmann's, Lipton, Algida, Magnum and Axe.

A photo from our first visit to company

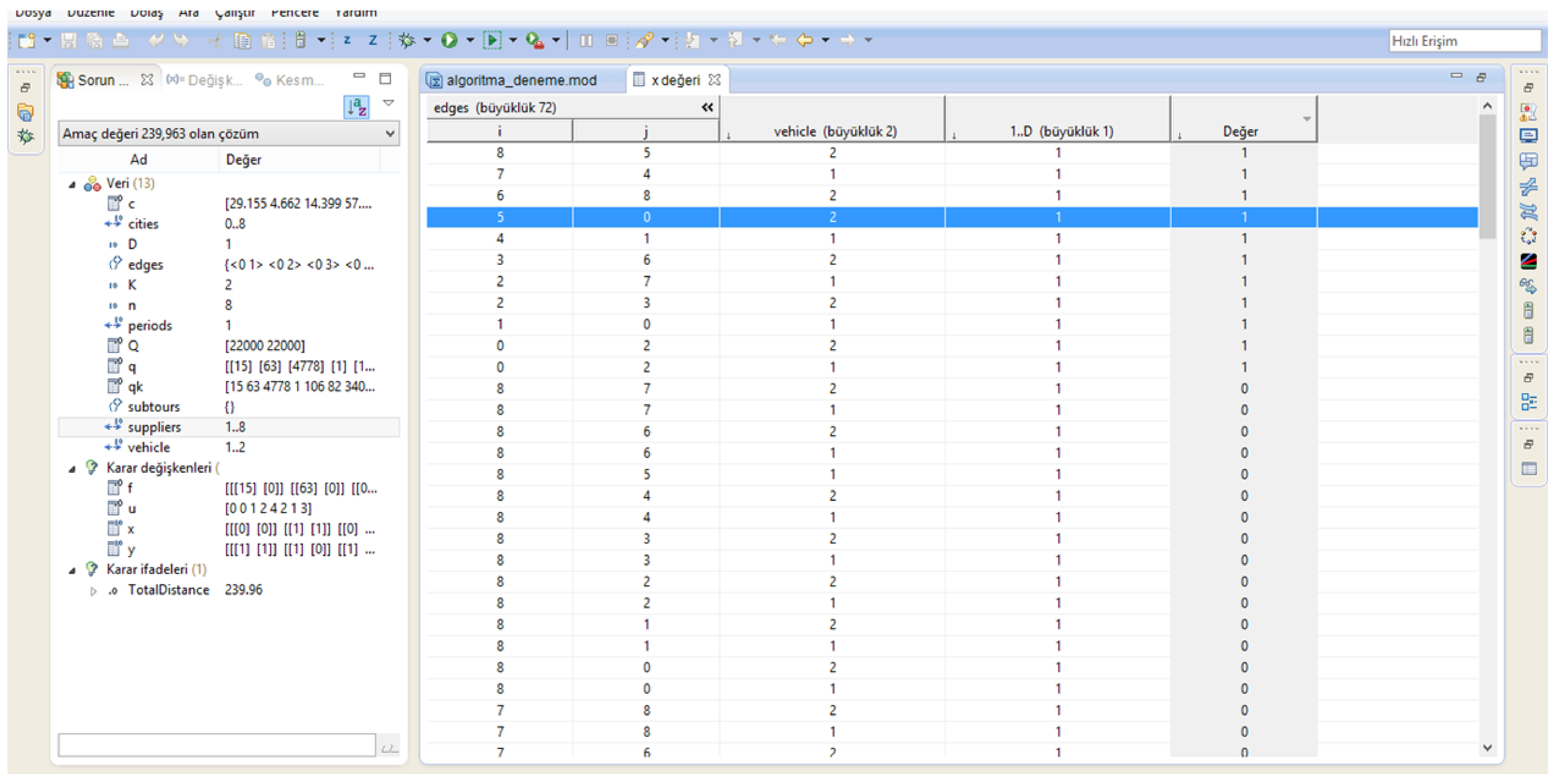
About the Project

- Unilever's Food and Beverages Site, Besan Besin San. ve Tic. A.Ş., conducts the production of the brands Knorr, Lipton and Carte d'Or in the factory located in Tuzla, İstanbul. The factory uses more than 44,000 tons of raw material per year which is supplied by 125 suppliers located all over Turkey.
- The project has two main goals:
  1. To reduce transportation costs (towards a sustainable economy and environment)
  2. To increase the efficiency of raw material collection planning process with an optimization application that outputs user-friendly route estimation

Decision Tool

IBM ILOG CPLEX

The proposed model is implemented using IBM/ILOG CPLEX optimization software and integrated with Microsoft Office Excel.



A snapshot of OPL CPLEX solution window

OBJECTIVE

Decreasing transportation costs by reducing number of trucks dispatched and the distance traveled by them.

MATHEMATICAL MODEL

The problem is formulated as a Periodic Vehicle Routing Problem.

Math Model:
Consider a complete directed graph $G = (N, A)$ with $N = \{0, \dots, n\}$ and $A = \{(i,j) : i, j \in N, j \neq i\}$ where node 0 is the depot and each node in $n \setminus \{0\}$ corresponds to a supplier. Let K be the set of vehicles and D be the set of days within the planning horizon. Also, let c_{ij} be the cost of traversing arc (i,j), Q_k be the capacity of vehicle k, q_i be the weekly amount that needs to be picked up from supplier i, and q_i^d be the maximum amount that can be collected from supplier i on day d. Define the following decision variables:

- $x_{ijk}^d = \begin{cases} 1 \text{ if vehicle } k \in K \text{ traverses arc } (i,j) \in A \text{ on day } d \in D, \\ 0 \text{ otherwise.} \end{cases}$
- $y_{ik}^d = \begin{cases} 1 \text{ if vehicle } k \in K \text{ visits node } i \in N \text{ on day } d \in D, \\ 0 \text{ otherwise.} \end{cases}$
- f_{ik}^d = the amount collected from supplier $i \in N \setminus \{0\}$ by vehicle $k \in K$ on day $d \in D$.

We can model the problem as follows:

$$\min \sum_{(i,j)\in A} \sum_{k\in K} \sum_{d\in D} c_{ij} x_{ijk}^d,$$

$$\text{s.t.} \sum_{j\in N\setminus\{i\}} x_{ijk}^d = y_{ik}^d \qquad i \in N, k \in K, d \in D,$$

$$\sum_{j\in N\setminus\{i\}} x_{ijk}^d - \sum_{j\in N\setminus\{i\}} x_{jik}^d = 0 \qquad i \in N \setminus \{0\}, k \in K, d \in D,$$

$$\sum_{i,j\in S} x_{ijk}^d \leq |S| - 1 \qquad S \subset N \setminus \{0\}, k \in K, d \in D,$$

$$\sum_{i\in N\setminus\{0\}} f_{ik}^d \leq Q_k \qquad k \in K, d \in D,$$

$$f_{ik}^d \leq q_i^d y_{ik}^d \qquad i \in N \setminus \{0\}, k \in K, d \in D,$$

$$\sum_{k\in K} f_{ik}^d \leq q_i^d \qquad i \in N \setminus \{0\}, d \in D,$$

$$\sum_{k\in K} \sum_{d\in D} f_{ik}^d \geq q_i \qquad i \in N \setminus \{0\},$$

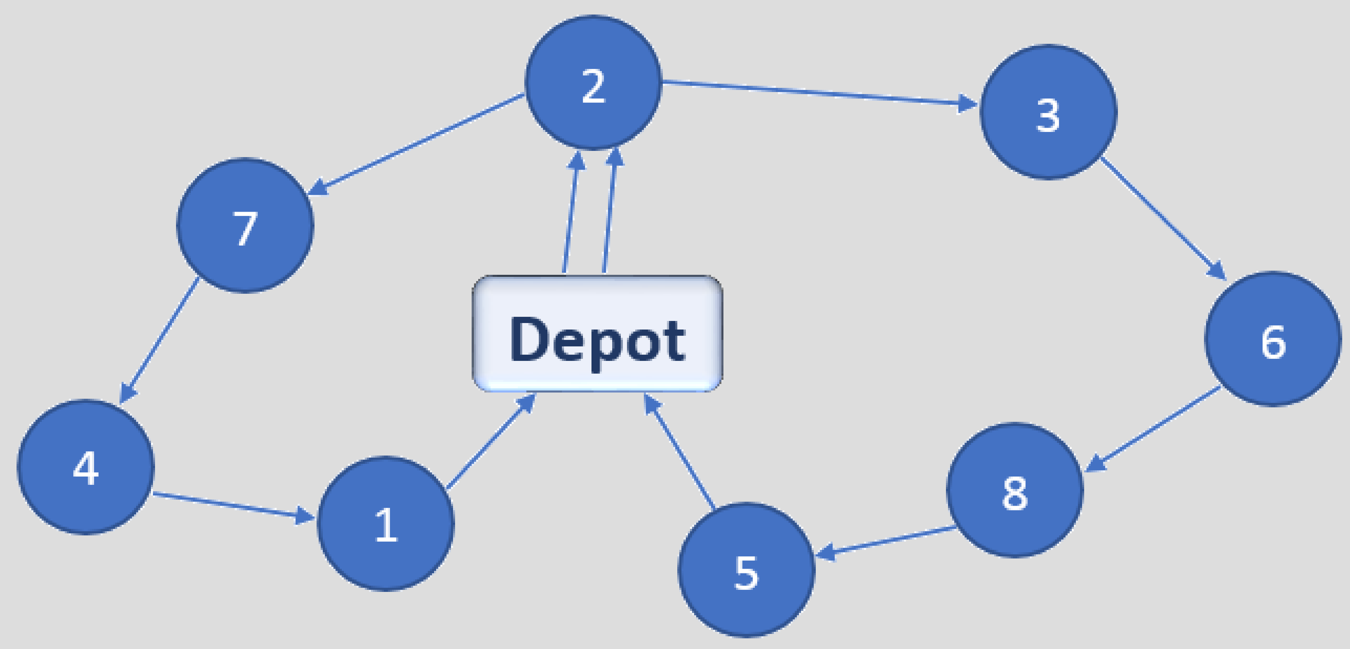
$$x_{ijk}^d \in \{0,1\} \qquad i,j \in N, k \in K, d \in D,$$

$$y_{ik}^d \in \{0,1\} \qquad i \in N, k \in K, d \in D,$$

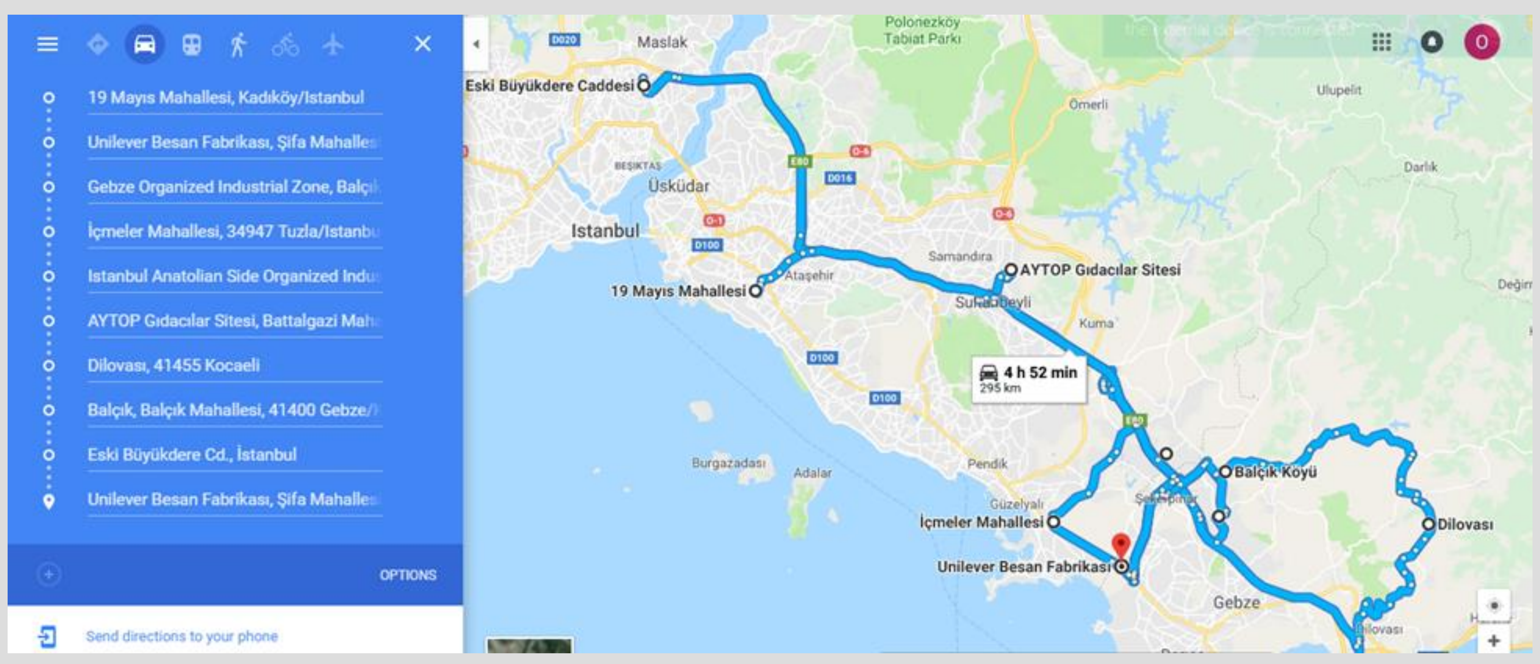
$$f_{ik}^d \geq 0 \qquad i \in N, k \in K, d \in D.$$

CONCLUSION

We have successfully designed a mathematical model that adheres well to the problem definition. We have also implemented this math model on CPLEX. After the final stage of implementation, a simulation was performed and we have observed that the transportation cost was significantly reduced.



A representative map of routes



A snapshot from Google Maps for the routes represented above

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