Fundamentals of Traffic Operations and Control
Patrick Stokkink
Exercise
Optimization of multi-modal and multi-purpose transport and logistics systems

In this exercise, we consider a small last-mile delivery system with one production location located outside the city and five delivery locations. The system and the corresponding coordinates are displayed in Figure 1. The goal of the exercise is to compare the performance of a crowd-shipping system to a traditional delivery system. Traditional delivery costs \$4 per unit of distance traveled and \$1 per stop made. For crowd-shipper delivery, depot maintenance costs \$5 per day, and every crowd-shipper is compensated \$1 per delivery. Every failed delivery in a crowd-shipping system is outsourced to a third party which is penalized by \$3 per parcel. The number of potential crowd-shippers that can make a delivery between every pair of nodes is indicated in matrix A.

Figure 1: Two-region network flow

For convenience, the coordinates of the production facility and the customer destinations can all be found in the *"lecture12-data.mat"* which can be found on Moodle. Coding for this exercise is generic and can be done in any programming language of your preference.

a) Given the coordinates of the production facility and the delivery locations, we first evaluate the total costs of traditional delivery. Use a nearest-neighbor heuristic to solve a Travelling Salesman Problem (TSP) that starts and ends at the production facility. Report the total distance traveled, and the cost involved. Also, plot the coordinate system and the shortest tour.

   Nearest neighbor heuristic:

   1. Select the start location.
   2. Find the nearest unvisited location and go there.
   3. Are there any unvisited locations left? If yes, go to step 2.
   4. Return to the start location.

b) Given the coordinates of the production delivery locations, determine the geographically central location for a depot. Limit the options to one of the coordinates. That is, out of the five nodes, select the one that minimizes the total distance to the other four nodes.

c) Evaluate the potential of every node to construct a depot. Evaluate whether from that node, the other delivery locations can be served, the costs of the truck to get from the production facility to the depot and the penalty for undelivered parcels.

d) Evaluate the difference in cost between the best option according to Question c) and the geographically central option derived in Question b).

e) Compare the results of the crowd-shipping system in Question c) to the traditional delivery evaluated in Question a). How would the results change if the cost per unit of distance traveled for traditional delivery are only \$2?