# Transportation Logistics Part V-VII

## Exercise 21

Before Christmas, the major clients of the construction company 'Well Built' receive a hamper (Geschenkkorb) that contains a bottle of champagne, smoked salmon, cheese, mustard, oilive oil and number of other delicacies. The hampers are rather large and the company owned cars are Smarts. Therefore, at most three hampers may be transported at once and the CEO does not want any of his employees to be gone for more than 4 hours. In the matrix below, driving times (already including the time to deliver the hampers) between the office and the clients are given in multiples of 5 minutes (a 4 in the matrix indicates that it takes 20 minutes to go from A to B, including the delivery of the hamper at B). The objective is to minimize the total time needed to deliver the hampers.

| $t_{ij}$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 4 | 5 | 2 | 6 | 5 | 3 | 2 | 5 | 6 | 5 |
| 1 | 4 | 0 | 4 | 3 | 5 | 8 | 3 | 5 | 7 | 9 | 7 |
| 2 | 5 | 4 | 0 | 4 | 9 | 9 | 7 | 6 | 6 | 8 | 4 |
| 3 | 2 | 3 | 4 | 0 | 6 | 6 | 4 | 3 | 5 | 7 | 5 |
| 4 | 6 | 5 | 9 | 6 | 0 | 9 | 4 | 6 | 11 | 12 | 10 |
| 5 | 5 | 8 | 9 | 6 | 9 | 0 | 6 | 4 | 6 | 5 | 7 |
| 6 | 3 | 3 | 7 | 4 | 4 | 6 | 0 | 3 | 8 | 8 | 7 |
| 7 | 2 | 5 | 6 | 3 | 6 | 4 | 3 | 0 | 5 | 6 | 6 |
| 8 | 5 | 7 | 6 | 5 | 11 | 6 | 8 | 5 | 0 | 3 | 2 |
| 9 | 6 | 9 | 8 | 7 | 12 | 5 | 8 | 6 | 3 | 0 | 4 |
| 10 | 5 | 7 | 4 | 5 | 10 | 7 | 7 | 6 | 2 | 4 | 0 |

**a**) Formulate the problem situation as a mathematical program.

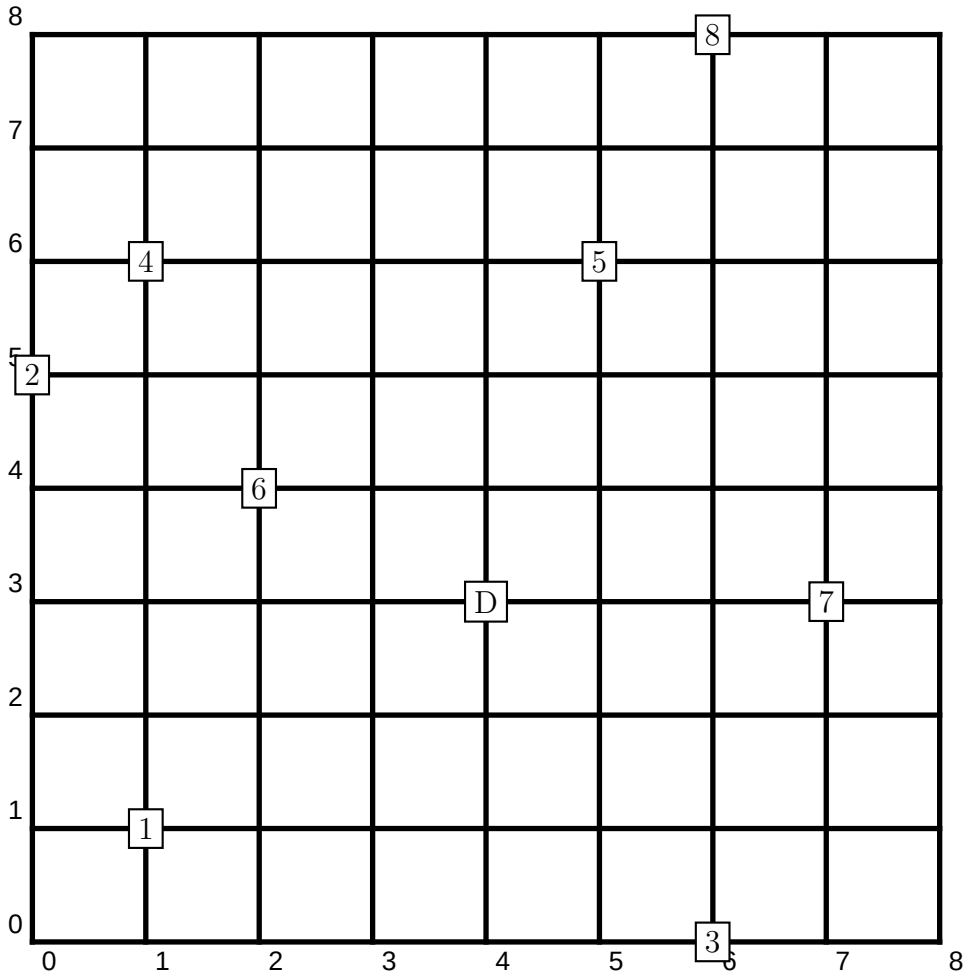
**b**) How many employees are needed at least in order to deliver all the hampers if the time limit of 4 hours is ignored?

**c**) One of the employees suggests to compute a solution using the savings algorithm. Determine the total time required to deliver the hampers following the employee's suggestion (take into account both, the capacity of the vehicles and the duration limit of each tour).

**d**) The CEO has studied management and he remembers that the problem could also be solved via a giant tour algorithm. Compute a solution using the giant tour approach. Use the nearest neighbor algorithm to obtain the giant tour. Whose algorithm leads to the better solution?

## Exercise 22

'Homemadejam' supplies eight grocery stores in downtown Miami. Like many other cities in the United States, Miami's street network has a grid like structure. The following picture shows the locations of the grocery stores (1...8) and the depot (D) of 'Homemadejam'.




The different grocery stores have the following demands:

| store | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $d_i$ | 5 | 10 | 6 | 8 | 5 | 4 | 5 | 3 |

The company owned vehicles have a capacity of 25 and 'Homemadejam' aims at minimizing the total distance traveled by its vehicles.

**a**) Compute the distance matrix.

**b**) In a first step, 'Homemadejam' decides to use a sequential insertion algorithm to find an initial solution. They decide that the vertex farthest from the depot shall serve as

the seed vertex and each vertex shall be inserted according to the cheapest insertion criterion. Thereafter, the obtained solution shall be improved by intra-tour node exchanges (swap the position of two nodes) in a best improvement manner.

**c**) 'Homemadejam' would like to have a second opinion. Apply a parallel insertion algorithm, using the two vertices most distant to each other as seed vertices and insert one vertex after the other, in the order of their names (insert the first vertex first, then the second one and so on), at its best position. The obtained solution shall be improved using inter-tour vertex moves (of exactly one vertex) in a first improvement manner. Is the obtained solution better or worse than the previously computed one?

## Exercise 23

Assume the following graph given by the triplets $(i, j, t_{ij})$:
$(1,2,2)$, $(1,4,4)$, $(2,1,1)$, $(2,4,3)$, $(3,2,10)$, $(3,4,1)$, $(3,5,3)$, $(3,7,5)$, $(3,8,6)$, $(4,1,3)$, $(4,2,6)$, $(4,5,4)$, $(4,6,8)$, $(5,4,4)$, $(5,8,5)$, $(5,1,6)$, $(6,3,3)$, $(6,9,8)$, $(7,6,2)$, $(7,8,9)$, $(8,5,7)$, $(8,7,8)$, $(8,9,3)$, $(9,3,8)$, $(9,7,4)$, $(9,8,6)$

Assume further that the depot is located at node 1 and that at most 5 vertices may belong to one route.

**a**) Generate a distance matrix by computing the shortest path between each pair of nodes.

**b**) Apply the savings algorithm to obtain a solution, minimizing the total travel time.

**c**) Now assume that there are exactly 2 vehicles available and again, that there may not be more than 5 vertices on one tour. Apply the Fisher-Jaikumar algorithm. Use as seed vertices 3 and 9. Solve the generalized assignment problem with Excel's solver. Then, compute its solution in a greedy way and compare the outcome. Solve the TSP of each cluster by means of the nearest neighbor algorithm and compute the total distance traveled in your solution.

## Exercise 24

Assume the following tour:

$$0 - 1 - 2 - 3 - 4 - n + 1$$

The relevant travel times are as follows:

| from | to | time |
|---|---|---|
| 0 | 1 | 3 |
| 1 | 2 | 2 |
| 2 | 3 | 4 |
| 3 | 4 | 5 |
| 4 | n+1 | 4 |

The time windows $[e_i, l_i]$ and the service times $s_i$ are given in the following table:

| $i$ | $e_i$ | $l_i$ | $s_i$ |
|---|---|---|---|
| 0 | 0 | 10 | 0 |
| 1 | 5 | 11 | 1 |
| 2 | 11 | 13 | 1 |
| 3 | 19 | 21 | 1 |
| 4 | 23 | 25 | 1 |
| n+1 | 0 | 40 | 0 |

**a**) Compute the minimum route duration.