Metaheuristic Algorithms Assignment

The Warehouse Location Problem

Introduction

In this assignment you are asked to design an algorithm to solve the Warehouse Location Problem (WLP). A distribution company uses warehouses to provide goods to many different customers. The goal of this problem is to determine which warehouses will be the most cost effective for serving the customers. The complexity of the problem comes from the fact that each warehouse has different costs and storage capabilities.

Assignment

Write an algorithm to solve the WLP. The problem is mathematically formulated in the following way: there are $N=0 \ldots n-1$ warehouses to choose from and $M = 0 \ldots m-1$ customers that need to be served. Each warehouse, $w \in N$ has a capacity cap_w and a setup cost s_w. Each customer, $c \in M$, has a demand d_c and travel cost t_{cw} based on which warehouse, $w \in N$ serves it. Lastly, all customers must be served by exactly 1 warehouse. Let a_w be a set variable denoting the customers assigned to warehouse w. Then the warehouse location problem is formalized as the following optimization problem:

$$\text{minimize:} \quad \sum_{w \in N} \left((|a_w| > 0) s_w + \sum_{c \in a_w} t_{cw} \right)$$

$$\text{subject to:}$$

$$\sum_{c \in a_w} d_c \leq cap_w \quad (w \in N)$$

$$\sum_{w \in N} (c \in a_w) = 1 \quad (c \in M)$$

Data Format

The input consists of |N | + 2|M | + 1 lines. The first line contains two numbers, |N | followed by |M |. The first line is followed by |N | lines, where each line represents a warehouse capacity cap_w and setup cost s_w. The last 2|M | capture the customer information. Each customer block begins with a line with one number, the customer's demand, d_c. The following line has |N | values, one for each warehouse. These values capture the cost to service that customer from each warehouse, t_{cw}.

Input Format

```
|N| |M|
cap_0 s_0
cap_1 s_1
...
cap_|N|-1 s_|N|-1
d_0
t_0_0 t_0_1 t_0_2 ... t_0_|N|-1
d_1
t_1_0 t_1_1 t_1_2 ... t_1_|N|-1
...
d_|M|-1
t_|M|-1_0 t_|M|-1_1 t_|M|-1_2 ... t_|M|-1_|N|-1
```

The output has two lines. The first line contains one value: *obj*. *obj* is the cost of the customer warehouse assignment (i.e. the objective value) as a real number. The next line is a list of |M | values in N – this is the mapping of customers to warehouses.

Output Format
obj
c_0 c_1 c_2 ... c_|M|-1

Input Example:

3 4

100 100.123

100 100.456

500 100.789

50

100.1 200.2 2000.3

50

100.4 200.5 2000.6

75

200.7 100.8 2000.9

75

200.10 200.11 100.12

Output example:

1002.888

1 1 0 2

This output represents the assignment of customers to warehouses, $a_0 = \{2\}$, $a_1 = \{0, 1\}$, $a_2 = \{3\}$. That is, customers 0 and 1 are assigned to warehouse 1, customer 2 is assigned to warehouse 0, and customer 3 is assigned to warehouse 2.