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Evolutionary Computation Assignments

1. Effective Utilization of Disk Space.

We want to store a large number of files on a disk. The size of file $\boldsymbol{i}$ is $\boldsymbol{f_i}$ and the disk size is $\boldsymbol{d}$. We want to store all of our files on the disk, but the sum of the file sizes is much larger than the available disk size. So, unfortunately we can store only some of our files on the disk.

Our target is to select and store some of our files minimizing the free unused disk space. Optimally, the selected files will occupy the entire disk and the unused free disk space will be zero (0). We are not allowed to split the files.

Generalize the solution for the case of many $\boldsymbol{di}$-sized discs

2. Effective Process Distribution.

We want to run a program in a parallel or distributed computer system for example a parallel computer or a PC network. The program consists of a large number of processes $\boldsymbol{N}$, which will run on a much smaller number of processors $\boldsymbol{n}$.

Since the communication between processors can be very time consuming, it is desirable, to assign on the same processor, the processes that need to communicate with each other. Of course, to minimize the time of the communication between processes, you could assign all processes on the same processor, but this would negate the advantages of parallel processing. So there is a minimum communication limit, assigning the processes with heavy communication on the same processor.

At the same time we should take into consideration the computational requirements of each process. Processes should be assigned to processors in a way that the total computational load of each processor be equal.

Formalize the problem as follows: $\boldsymbol{C_{ij}}$ denotes the communication load between processes $\boldsymbol{i}$ and $\boldsymbol{j}$. Assume that each process requires the same computing power. Therefore, in order to assign the same computational load on each processor we only have to assign the same number of processes on each processor. Implement an evolutionary algorithm to assign the $\boldsymbol{N}$ processes on the $\boldsymbol{n}$ processors.

3. Wasp killing.

You’ve just bought a house and discover that the attic is full of wasps' nests. You’ve decided to kill the wasps, before you move into your new home. So, you visit your local store featuring insecticides but found only three (3) containers of type "insect-bomb" which have a specific effect range and must be placed very close to the nest to kill the wasps inside. Unfortunately the 3 containers are not enough to kill all the wasps in the attic. Fortunately, luck helps and you find:

- a map left by the previous owner, showing the location of the nests as well as the number of wasps that have each nest (using an array of 100x100, Table 1),

Table 1. Nest coordinates and wasp populations

Nest number	Wasp population	Nest position	
		X axis	Y axis
1	100	25	65
2	200	23	8
3	327	7	13
4	440	95	53
5	450	3	3
6	639	54	56
7	650	67	78
8	678	32	4
9	750	24	76
10	801	66	89
11	945	84	4
12	967	34	23

- a formula on the container of the "insect-bomb" which gives the relationship between distance from the nest, and the number of wasps that are destroyed (Eq. 1).

$$K = n * \frac{d\max}{20 * d + 0.00001} \qquad \text{(Eq. 1)}$$

where:
K: Wasp number that will be killed in a nest.
n: Wasps living in this nest.
d: Distance between bomb and nest.
$d\max$: Greatest distance between two nests (141.42 for Table 1 with size 100x100)
The distance between two nest positions is calculated by equation (2):

$$d = \sqrt{(x1 - x2)^2 + (y1 - y2)^2} \quad \text{(Eq. 2)}$$

The aim is to find the best placement of the containers so as to eliminate the greatest number of wasps.

Hints:

- In order to calculate the total number of wasps that are killed by an "insect-bomb", you have to sum the number of wasps that are killed in each nest. The total number of wasps that are killed by an "insect-bomb", can be computed by equation (3)

$$T = \sum_{i=1}^{n} K_i \quad \text{(Eq. 3)}$$

  where:
  K_i: Number of wasps that will be killed in nest i
  n: Number of nests (12 in our table)

- Be careful. The sum of the wasps that will be killed in a specific nest by all three "insect bombs" cannot exceed the number of wasps that leave in this nest. That is, if an "insect-bomb" kills all the wasps of a nest, then the other two "insect-bombs" will not kill any wasps in this nest.
- Generalize the solution in order to solve the problem for any position of the nests and not only for Table 1, i.e. the solution must solve the problem for any number of nests, in any position.

4. Longest CableWay (IEEE Extreme 5).

Historically, all cableways have been less than 100 kilometers in length and cable car speeds have not crossed 50 kmph. However, the discovery a new ore material, available directly in the form of long rods, in the Grand Canyon, led to the ability to create very high speed cable ways that can extend to thousands of kilometers. The US army decided to connect most of their air bases and navy bases using long-distance cable ways. However, there were a few constraints.

a. The cables were in the form of long and flexible rods with smooth edges that can be joined together using a very expensive but specialized grafting process. However, cutting the cables was not possible as it was not possible to retain the smoothness of the edges that is required to graft them.
b. The join process was not only very expensive but also inefficient as the speeds of the cable cars were affected by the joints and reduced by nearly 5% for every joint. Hence, there was a need to minimize the number of joints.
c. The cables, being naturally available rods of varying lengths, were available in specific sizes and there was limited inventory that was available.
d. The cable way should be connected using cable that is the exact length of the distance between the two locations (no higher and no lesser).

4.1 Task

Now your task is to help the engineer select the optimal combination of cables from the inventory to build the exact requested length of cable way such that the number of joints is minimized.

Write a program to achieve the same. Your program must output only the minimum number of joints possible.

4.2 Time Limit

Maximum five seconds for any combination of inventory and up to 5000 kilometers of cable way.

4.3 Input

The first line of the input D is the distance between the two air bases to be connected in kilometers. ($0 < D < 5000$)

Each subsequent line contains a pair of numbers Li Ni, indicating the length of the cable in kilometers and the quantity available in the inventory. ($0 < i <= 20$, $1 < Li <= 200$, $1 < Ni <= 100$)

The input is terminated by 0 0.

4.4 Output

a. The output should contain a single integer J representing the minimum number of joints possible to build the requested length of the cable way
b. If no solution is possible the program should print "No solution possible" in the output.

4.5 Note

There may be multiple solutions for the same number of minimum joints.
Identify the number of joints and the actual list of rods to be used.
Example: (see below for input formats)
Solutions for making 444 with 10 joints areQ
2 * 2 + 50 * 7 + 45 * 2 = 11 rods of cables i.e., 10 Joints
16 * 1 + 3 * 1 + 50 * 7 +45 * 1 = 11 rods of cables i.e., 10 Joints
However the following has 11 joints and hence not a solution
3 * 2 + 30 *1 + 50 * 8 + 8 *1 = 12 rods of cables i.e., 11 Joints

4.6 Sample Input - Scenario 1

```
444
16 2
3 2
2 2
30 3
50 10
45 12
8 12
0 0
```

4.7 Sample Output - Scenario 1

10 Joints (2 * 2 + 50 * 7 + 45 * 2)

4.8 Sample Input - Scenario 2

```
44
30 31
50 10
45 12
90 21
43 1
0 0
```

4.9 Sample Output - Scenario 2

No solution possible