Bi-objective assignment of telecommunication means for the optimal architecture of gas transport network

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1 Introduction

To increase its profitability and ensure its perenniality, in a modern evolutionary and competing world, a gas company must offer its customers a harmonious and effective service.

To full fill its obligations, the company must install a system which includes technical means to the routing of information between two arbitrary points at an unspecified distance. However, such a system is confronted with the tough need for a compromise between cost and reliability.

Our mission consists to develop a palliative solution for the disadvantages and the failures of the current management system. For that the objectives are summarized as follows:

1- Define the optimal architecture for the tele-exploitation system.
2- Assign telecommunication means for the network.

2 Mathematical modeling

The design of a tele-exploitation system needs a choice between several telecommunication means to connect stations between them and to the control center. The choice depends on several criteria like the cost and design features (reliability, speed of transmission, etc.). The choice of reliability for a network results from a compromise between the sought performances and cost. Setting as an objective the minimization of the capital cost and the maximization of the reliability, the mathematical model can be formulated as follows:

$$\begin{cases} MinZ_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} c_{ij}\ x_{ij} \\ MaxZ_2 = \sum_{i=1}^{n}\sum_{j=1}^{m} f_i\ x_{ij} \\ \sum_{i=1}^{n} x_{ij} = 1 & ,\quad j = 1,\dots,m \\ \sum_{i=1}^{n} f_i\ x_{ij} \geq \delta & ,\quad j = 1,\dots,m \\ \sum_{j=1}^{m}\sum_{i=1}^{n} f_i\ x_{ij} \geq \Delta & ,\quad m\delta \leq \Delta \leq mMax(f_i) \\ x_{ij} \in \{0,1\}. \end{cases} \tag{1}$$

where,

n = number of possible transmission resources,
m = number of edges of the optimal architecture,
f_i = reliability of transmission resource i,
δ = minimum flow rate of transmission emitted from each station,
Δ = minimum flow rate of transmission emitted from the tele-exploitation network,
c_{ij} = cost associated if the assignment of the transmission means i to edge j is done,
x_{ij} = decision variable representing the assignment of the means of transmission i to the edge j, taking value 1 if the assignment is done and 0 otherwise.

3 Approach of resolution

The selected model is a relaxed bi-criteria assignment model known as a hard problem. It is impossible to find a solution which optimizes both criteria simultaneously, since the objectives are contradictory. Thus a compromise should be found between the two criteria, knowing that there are several possibilities. Our objective by solving this problem, is to find a set of potentially efficient solutions, which will subsequently be proposed to the decision maker, who makes the final decision. This problem was finally solved by an evolutionary algorithm NSGA-II (**N**on-Dominated **S**orting **G**enetic **A**lgorithm).

4 Experimental results

For the application we have chosen Bouira brigade, composed with 20 posts. Assuming to have 5-media telecommunication, the cost and flow rate vectors will be size 5:

	Telephone line	X25	VSAT	GSM	Optical fibre
flow rate	56	128	256	384	512
unit cost	1000	2000	5000	10000	20000
code	1	2	3	4	5

After using the Prim algorithm, the tree of minimum weight was found. The number of generations in our example has fixed to 4000, the size of the initial population to 40, the minimum flow rate to 128, the rate of crossing P_c to 0.9, and the rate of mutation P_m to 0.01. Implementation of the NSGA-II algorithm gave finally all potentially effective solutions to witch are associated the cost and reliability, as shown in Table 3.

solutions																				cost	reliability
Sol. 1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	452701,45	128
Sol. 2	2	2	2	2	4	2	2	2	2	2	4	2	2	2	2	2	3	2	2	611228,64	161,68
Sol. 3	3	5	2	3	2	3	2	2	4	2	2	2	2	2	2	2	3	2	2	788488,12	188,63
Sol. 4	3	5	3	3	2	3	2	3	2	2	2	3	4	3	2	2	3	2	3	894986,45	222,32
Sol. 5	2	2	2	2	4	3	2	2	4	2	4	4	4	5	3	3	3	2	2	102028,3,97	242,52
Sol. 6	2	5	2	2	4	3	2	2	4	2	4	4	4	5	3	3	3	2	2	1087539,17	262,73
Sol. 7	4	5	4	3	5	2	2	2	4	2	3	4	4	5	3	3	3	2	2	1281412,43	289,68
Sol. 8	4	5	3	3	5	3	2	2	4	2	4	4	4	5	3	3	3	4	3	1490605,87	316,63
Sol. 9	4	5	3	3	5	3	2	2	4	2	4	4	4	5	3	5	4	4	3	1697493,,30	336,84
Sol. 10	4	5	3	3	5	5	2	4	4	3	5	4	4	5	3	3	3	4	3	1930840,66	357,05
Sol. 11	4	5	4	4	5	3	2	4	4	4	4	5	5	4	3	5	3	4	3	2119352,23	377,26
Sol. 12	4	5	4	4	5	3	2	4	4	3	5	4	5	5	5	5	3	4	3	2271243,55	390,73
Sol. 13	5	5	5	4	5	4	4	3	4	3	5	5	5	4	2	5	4	4	3	2458615,93	404,21
Sol. 14	5	3	5	4	5	4	4	3	4	4	5	5	5	4	5	5	4	4	3	2756284,56	417,68
Sol. 15	5	5	5	4	5	4	4	3	4	4	4	5	5	5	4	5	5	5	3	2981793,50	437,89
Sol. 16	5	5	5	4	5	4	4	5	4	4	4	5	5	5	4	5	5	5	3	3236806,54	451,36
Sol. 17	5	5	5	4	5	4	4	5	4	4	4	5	5	5	4	5	5	5	5	3485614,54	464,84
Sol. 18	5	4	5	5	5	5	3	5	5	3	5	5	5	5	5	5	5	5	5	3849736,28	478,31
Sol. 19	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	4199559,65	498,52
Sol. 20	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4527014,54	515

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