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1   Introduction

In the field of Internet of things and wireless sensor networks, in particular, coverage is a very relevant issue. In this work, we consider the problem of maximizing the lifetime of a wireless sensor network that is required to cover some targets. The idea is to maximize the number of subfamilies that can efficiently cover all the targets. After that, we activate each subfamily alternately to extend the lifetime of the initial network. We then formulate this question as a binary bi-objective programming problem. Finally, we propose a hybrid method using a genetic algorithm and the Monte Carlo procedure based on the work of Bounceur et al. in [1].

2   Problem definition

Suppose we are given a wireless sensor network consisting of n sensors that must cover m targets. For the efficiency of our network, each target must be captured by at least one sensor. This number should be kept to a minimum for better energy management. In addition to this objective, in this work, we want to maximize the lifetime of the network by maximizing its service life. This second objective is ensured by using alternatively families of subsets within the network that provide the same service. In Figure 1, 3 targets are covered by 7 sensors, and we observe that we

FIG. 1 – Three targets covered by 6 sensors.

can cover the three targets by $\{S_1, S_4, S_7\}$, and $\{S_2, S_5, S_6\}$. By alternately activating these two subsets we can multiply the lifetime of the network by two. Our goal is then to find the maximum number of subfamilies that cover all targets, which will allow us to multiply the lifetime of the network by the number of subfamilies.
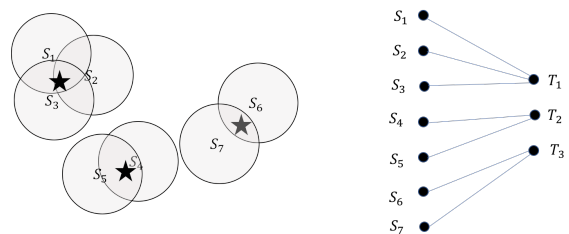
3   Problem formulation

We propose the following formulation for the problem outlined in the previous section with m targets and n sensors :

$$\begin{cases} \max & f_1(x,y) = \sum_{j=1}^{k} y_j \\ \min & f_2(x,y) = \sum_{i=1}^{n}\sum_{j=1}^{k} x_{ij}y_j \\ \text{s.t.} & \sum_{i=1}^{n} A_i x_{ij} \geq y_j, \forall j = 1,..,k \\ & x \in \{0,1\}^{n \times k}, y \in \{0,1\}^k \end{cases} \quad (1)$$

where :

$$x_{ij} = \begin{cases} 1, & \text{if } x_i \text{ is assigned in the set } y_j, \\ 0, & otherwise, \end{cases} \quad , \quad y_j = \begin{cases} 1, & \text{if } \sum_{i=1}^{n} x_{ij} \geq 1, \\ 0, & otherwise, \end{cases}$$

A is the target-sensor incidence matrix, whose size is $m \times n$, A_i is the ith line of A,
k is an estimated value of the number of subfamilies that can be formed. In our work we take $k = \frac{n}{2}$.

4   Presentation of the method

In this work, we propose a new hybrid method based on Monte Carlo generation and a genetic algorithm involving a modification of the crossover and mutation steps. Our procedure is described by the following algorithm :

Data: A : the A is the $m \times n$ target-sensor incidence matrix
Result: Efficient solutions ES for Problem 1
Initialization : $x^* = (1,...,1)$: the unit n-vector;
Let $ES = \emptyset$;
while *There is no feasible solution* **do**
    Generate a population of size T using Monte Carlo Method;
    Generate a population of I-mutations of x^* of size T;
    Generate a P' population of P crossovers;
    Let $x^* = \min\limits_{x \in P \ \& \ x \notin ES} f(x)$; $EF = EF \cup \{x^*\}$;
end

Algorithm 1: The proposed algorithm.

5   Conclusion

In this work, we have considered a network of n wireless sensors in which we must cover m targets. We have identified two objectives, the first is to cover each target with as few sensors as possible. The second objective is to maximize the number of subfamilies in order to increase the lifetime of the system. We have modelled this problem by using a bi-objective binary optimization problem, for which we proposed a hybrid solution algorithm. The preliminary results obtained in the simulation of some networks are very encouraging.

Références

[1] Bounceur Ahcène, Reinhardt Euler, and Kamel Beznia. *Génération et optimisation de vecteurs de test analogiques multifréquences.* ROADEF. 2011.