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# HMS: A hybrid multi-start algorithm for solving binary linear programs

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**Abstract**

This work presents a hybrid multi-start algorithm for solving generic binary linear programs. This algorithm, called HMS, is based on a Multi-Start Metaheuristic and combines exact and heuristic strategies to address the problem. The initial solutions are generated by a strategy that applies linear programming and constraint propagation for defining an optimized set of fixed variables. In order to refine them, a local search, guided by a Variable Neighborhood Descent heuristic, is called, which, in turn, uses Local Branching cuts. The algorithm was tested in a set of binary LPs from the MIPLIB 2010 library and the results pointed out its competitive performance, resulting in a promising matheuristic.

*Keywords:* Binary Problems, Heuristic, Multi-Start, Variable Neighborhood Descent, Local Branching, Constraint Propagation.

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# 1 Introduction

This work focus on a novel approach for solving generic binary programs. This class of problems arises in several contexts, for example, in timetabling [4]. Due to the difficulty of solving them, many methods have appeared in the literature. Among them, we can cite the following: [5], [10] [2], [6] and [3].

In this paper, a hybrid algorithm based on a Multi-Start metaheuristic for solving generic binary programs is proposed, acting in partnership with the CBC (Coin-or branch and cut, `https://projects.coin-or.org/Cbc`) solver as a matheuristic. In its construction phase, the algorithm combines linear programming relaxations and constraint propagation to get an initial integer solution. After that, it applies a local search, guided by a Variable Neighborhood Descent – VND [8] heuristic, that performs Local Branching cuts. HMS is an improvement of the algorithm of [9]. The main improvement consists in changing the choice criteria of the variable to set to value 1 during the construction phase. Instead of choosing this variable in the traditional form of the GRASP construction phase, it is now chosen by the roulette wheel method, just as in the selection phase of genetic algorithms.

# 2 The proposed algorithm

The proposed Hybrid Multi-Start (HMS) algorithm for solving generic binary programs is outlined in Algorithm 1. It has as inputs: the linear program $LP$; the time limit for processing (*timeout*); the value $\gamma$ that defines which variables not fixed in $LP$ are candidates to be set to value 1; the maximum number of iterations $\text{iter}_{\max}$ in the construction phase; the maximum processing time $\text{VNDtime}_{\max}$ of VND; and the value $\theta_{\min}$ used to release the variables fixed with values 0 or 1 when the solver does not find feasible solutions.

**Algorithm 1** `HMS`

**Input:** $LP$, *timeout*, $\gamma$, $\text{iter}_{\max}$, $\text{VNDtime}_{\max}$, $\theta_{\min}$
**Output:** $s^\star$

1: $f^\star \leftarrow +\infty$; $t_{\text{current}} \leftarrow 0$;
2: **while** t < *timeout* **do**
3: $s \leftarrow \text{constructSolution}(LP, \gamma, \text{iter}_{\max}, \theta_{\min})$;
4: $\text{VNDtime} \leftarrow \min\{\textit{timeout} - t_{\text{current}}, \text{VNDtime}_{\max}\}$;
5: $\text{s} \leftarrow \text{VND}(LP, s, \text{VNDtime})$;
6: **if** $f(s) < f^\star$ **then**
7: $s^\star \leftarrow s$; $f^\star \leftarrow f(s^\star)$;
8: **end if**
9: **end while**
10: return $s^\star$;