**PROPOSAL**

**FOR RESEARCH PROJECT**

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| Project name (Vietnamese) | Phương pháp tìm kiếm tổ hợp dựa trên Compromise Programming |
| Project name (English) | An Adaptive Method Based on Compromise Programming for Multi-Objective Combinatorial Search: A case study in Team Selection Problem |
| Sub-committee | Information Technology |
| Group name | Team ZeroOne |

1. **Introduction**

Combinatorial search problems are often found in many different areas. In management, operational research and other fields, cross-functional team (CFT) selection [1] is an area of ​​interest. Selecting the right teams for the jobs brings success to the organization. A cross-functional team is defined as a group of suitable candidates who have excellent personal skills and can collaborate and support each other in their work. This team's skills are multidisciplinary from many different fields such as biology, math, mechanics, technology, and more.

This study presents an optimizer for selecting multiple groups from candidates who match the criteria in skills, which is an improvement from previous research [**2**]. The proposed multi-objective optimization model allows the selection of G groups. Various aspects of team members' skills are set as goals to be achieved by the optimizer. We use the compromise programming (CP) approach for MOP. We propose GA and ACO schemes to solve the proposed model. To evaluate the efficiency of the algorithms, we compare them with CPLEX's MIQP-solver. Our study suggests a new variant of team selection problems. It benefits researchers in the field of management, as well as in empirical research on combinatorial search.

1. **Overview of Research situation and the necessity of the project** 
   1. 2.1.Literature review

The optimization problems in modern team selection are usually considered to achieve many goals following business requirements. Therefore, it encounters the difficulties of the classical problem and the multi-objective optimization (MOP) problem. The desired goals are often performance, cost, or benefit aspects. The selected members/ teams must cooperate to solve common problems to achieve a specific purpose. Employers need to maximize profits when selecting team members from available candidates [**3**]. Ahmed et al. provide a MOP to choose their cricket team. The model uses objective functions to access three aspects of team performance: batting, bowling, and fielding [**4**]. In [**5**], Chand et al. also use the MOP model to select a cricket team with similar objective functions as [**4**] but with a different goal of minimizing cost. Toledano et al. introduced a bi-objectives optimization to their optimizer, including team valuation and cost [**6**]. Another research also introduced the bi-objectives problem [**2**]. The model aims to access both aspects of team performance to formulate a new team with many skills and mastering skills. Their approaches are different, while [**6**] uses a dominance-based algorithm to find solutions on praetor-frontier, [**2**] uses Compromise programming to define a compromise solution close to the most referential point. In [**7**], an optimization model is designed to form a team of players for football clubs maximizes the profits from transferring players in degrees. It consists of maximizing the expected net present value of the group, which includes the value of the players owned minus the money spent for buying and borrowing players and paying salaries, plus the income generated by selling and lending players. The problem with these studies is that they were used to select one group. Selecting multiple teams leaves no choice but to resolve the issues repeatedly by eliminating the selected candidates. It leads to the chosen later groups not being treated fairly*.*

* 1. 2.2. The necessity of the project

To solve the combinatorial search problems, the optimizer needs to scan a large amount of the available solutions in the search space during the search process. It is usually classified into the class of NP-Hard problems that requires an efficient search algorithm to maintain the quality of the solution with a reasonable computational cost. Team selection is one of the typical issues. This problem becomes more complicated to achieve multiple goals in the decision-making process. This study introduces a multiple cross-functional teams selection model with different skill requirements from candidates who meet the maximum required skills in both deep and wide aspects for the groups. Compromise programming is used to approach the formulated multi-objective optimization problem.

In the literature, The number of groups to be selected is usually more than one, corresponding to different tasks. An increase in the number of candidates or team size or the number of formulated teams significantly increases the search space. In this study, our goal is to choose G teams simultaneously to satisfy multiple objectives of business requirements from limited resources. The number of available solutions in the search space is where hg denotes the team size of the group gth and h0=0. The solution is represented as a graph , where V represents the set of C candidates and G Groups. Each existing edge in E illustrates the assignment of the corresponding candidate to the group.

* 1. 2.3. Probability of success

We have defined a Mathematics model and collected data of 500 candidates from codeforce.com with 37 skills. We also implemented an ant colony algorithm to solve the problems. After the experiment, we have some initial positive results.

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Figure 1: Experiment result of ACO

To compare with [2], we use ACO to solve single team selection and the results in table below.

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| **Algorithm** |  | **Objective Value** | **Execution Time (sec)** |
| ACO | 500 | 659108 | 50.7 |
| GA-1 | 500 | 659108 | 0.23 |
| ACO | 300 | 1005773 | 20.6 |
| GA-1 | 300 | 1005773 | 0.23 |

Although the ACO has defects like long execution time, in 2.1 many researches show that GA is better than ACO when using stochastic operations to obtain higher performance. Moreover, we can use Local search to improve results of GA and ACO.

1. **Objectives**

In this study, we design some metaheuristic algorithms to solve a multiple team selection problem with 5 members in 3 groups to optimize score value in both deep and wide aspect. We will use a data set to compare results of my algorithms and CPLEX – a optimization package developed by IBM.

1. **Research scope and content**

In this study, we will find the best team with 5 members and 3 groups from the top 500 highest score on codeforce.com - a website hosts competitive programming contests. Our 500 candidates are all from South East Asia with 37 skills and score like graph below*.*

Chart

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Figure 2: Statistical numbers on 37 skills in the dataset of 500 programming contestants.

1. **Approach**

In solving NP–hard problems, GA is one of the most popular metaheuristic algorithms and a part of bigger group of algorithms called Evolutionary Algorithms. GA starts by generate randomly a population of possible solution and make new generation iteratively until we get final solution. One more meta heuristic we design is ACO, which using pheromone mechanism to mimic how ant colony find the best path in their route.

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Figure 3: Basic flow of the GA.



Figure 4: Basic flow of the ACO.

1. **Expected results**

We expect our algorithms can obtain good results by winning defined CPLEX - an optimization software package developed by IBM- at least 10% and solve one NP-hard problem which can not be solved by traditional solutions. Moreover, we expect to implement Hybrid Optimization to improve our results.

**7. References**

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