The problem of finding guarantor professors supporting Italian academic programs: a sub-optimal approach

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***Abstract*—The Italian Ministry of University and Research (MIUR) requires universities to identify a set of reference professors ensuring coverage for each degree program. The selection of professors must satisfy various constraints, making the identification of an optimal solution non-trivial and iterative. This problem particularly impacts smaller universities, where the population of researchers and professors is modest, while the number of degree programs is growing fast because of the demand from the territory. In this paper we propose the use of a Genetic Algorithm (GA) to fast converge to a sub-optimal match between professors and programs. A prior interview we made to the involved University stakeholders allowed us to compute the saving in the time needed to establish a new degree program, which drops to 20% of the initials 197.66 hours, allowing universities to be smarter and more in line with the digital transition while coping with compliance to regulations.**

***Index Terms*—e-government, genetic algorithm, university, sustainability.**

I. Introduction

In the Italian educational system, a "Reference Professor" (RP) is a teacher designated by the University as a "guarantor" for a specific degree program. There are several constraints that make the selection process for RPs particularly complex, especially for smaller universities, including:

- C1: a RP can be the guarantor for only one degree program;
- C2: a RP guarantor for a degree program must deliver at least 1 course in the program;
- C3: 9 RPs are required to establish and sustain a bachelor's degree program, 6 for a master's degree;
- C4: at least 5 RPs should be Associate Professors (AP) or Full Professors (FP) for bachelor's degree programs, and 4 for master's degree programs;
- C5: RPs cannot share the same course;
- C6: optionally, the Ministry of Education and Research (MISE) recognizes a financial bonus if the RP's scientific field is a characterizing sector for the degree program.

All these constraints must be met when establishing a new degree program. Therefore, the process of appointing RPs proves to be extremely complex and iterative, especially when referring to smaller universities. In this context, the limited number of researchers and professors employed contrasts sharply with the rapid growth in the number of degree programs, driven by increasing demand from institutions, industries, and students. Furthermore, the situation is even more complicated because of retirements, professors changing affiliations, and the contract expiration of junior fixed-term researchers (RTDa).

To gain a deeper understanding of the RP identification process in the University context, we conducted an initial analysis which helped detecting the individuals involved, the activities they perform, and the time required for each activity. Through a series of preliminary interviews, a detailed identification of the process flow was obtained. In particular, the actors involved in the process include:

- The delegate appointed by the Rector for educational offerings;
- The delegate appointed by the Rector for performances;
- The heads of the didactic sector (for each department);
- The department for each degree program;
- The University's performances evaluation nucleus.

Currently, the referenced actors spend 197.66 hours at the PC and on VoIP phones to refactor the RP matching when a new program is created, because of a series of "what-if" trial and errors. In particular, the delegate appointed by the Rector for educational offerings spends averagely 192 hours on the computer, sends 140 emails, and makes 70 calls, while the head of the didactic sector spends 3 hours on the computer, sends 30 emails, and makes 10 calls. In the worst case, the launch of new degree programs is compromised by an inefficient distribution of RPs among the various programs, due to the multiple constraints that must be met.

To cope with the presented problem, in this study we propose and measure the introduction of a Genetic Algorithm (GA) [1] to fastly converge to a sub-optimal match between RPs and degree programs. GAs are inspired by the natural evolutionary process and are used to solve optimization and search problems. In the described context, the introduction of

a GA algorithm to support the University's secretariat is aimed ad reducing working time, and hence costs [2].

II. Solution

We created a prototype tailored for the specificity of University of Salento, a small University in southern Italy which counted 1,122 employees and 18,368 students in 2022. Universities often adopt GAs to find the best combinations of class schedules or room assignments. A GA operates by iteratively creating, selecting, and modifying a population of candidate solutions until it reaches an optimal or satisfactory solution, as will be explained in the following paragraph. In Fig. II, we show the operational flow of the tool we developed.

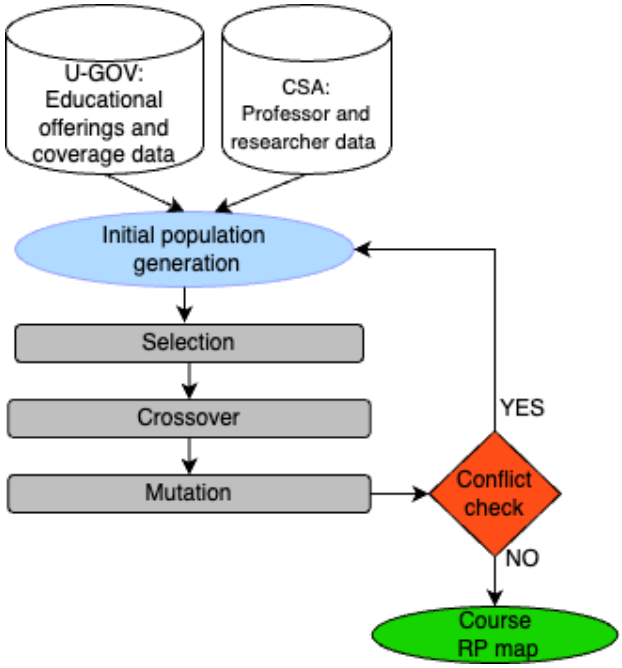

Fig. 1. RP selection GA-based tool workflow.

The tool was developed using Python version 3.9.6. The GA algorithm uses the following libraries: numpy (1.26.4), pandas (2.2.1), and openpyxl (3.1.2). The tool consists of two parts: the algorithm that processes the data extracted from the databases and creates the dataset, and the GA that uses the dataset to return the programs guarantors. The source databases are Cineca's U-GOV, where the educational offerings and coverage are defined, and CSA, which contains information about professors and researchers. The University's secretariat extracted for us the needed information in Excel format. The data pre-processing is handled by a Python script which loads the Excel sheets and creates a comprehensive CSV file containing the courses taught by the teachers for all degree programs. Afterwards, our script feeds the dataset into the GA. We hard-coded the constraints within the GA's fitness function in the following manner:

- C1-C2-C3: the code begins by setting the boolean variable "conflict" to False. A conflict means that a teacher is a RP in multiple degree programs. Subsequently, it iterates through all elements in the solution, checking for conflicts. If a conflict is found, the fitness value is penalized by decrementing it by 1, Otherwise it gets incremented by 1.
- C4: if the teacher holds the position of Associate or Full Professor, their fitness value gets increased by 1.
- C5: for each pair of teachers, the intersection of their common courses is calculated and stored in the variable "common_courses". In case of two RPs teaching exactly the same courses, the fitness_value gets decremented by 1.
- C6: an "if" statement checks whether the RP's scientific sector is a characterizing sector for the degree program. If this condition is met, the fitness value gets increased by 1.

III. Results and Future Challenges

We performed the tests over a 2020 Apple MacBook Air, featuring a M1 processor (8 core @ 3.2 GHz) and a 8GB memory. The initial dataset contained 30 degree programs. An initial population of 1,800 individuals (i.e. possible solutions) was used. On average, the application takes 2 hours and 4 minutes to achieve a result that satisfied all constraints, with an average of 48 generations.

The prototype contains several limitations. The most important one is related to the GA starting to compute the best match from scratch at every run. Therefore, the next step consists in providing the GA with the current RP mapping, as well as the information related to new degree programs that the University wants to activate. This is mandatory in order to keep a static baseline of current RPs, and incrementally update this mapping at every new program.

This work is inserted as a case study in the Sustainability Agenda of our University, which is committed to playing a crucial role in the transition towards sustainable development within and outside the University community. A side research effort we are employing is to measure how much the digitalization of the RP selection process is in line with the ecological transition. Particularly, we want to verify that the GA-based tool does not consume more energy than it saves.

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