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Betting on Yourself: A Decision Model for HumanResource Allocation Enriched With Self-Assessment of Soft Skillsand Preferences

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ABSTRACT - Recently, many approaches were proposed to support human resource management in find- ing the best human resources for available jobs. However, existing solutions do not effectively evaluate employees' skills, or they do only partially, neither provide mechanisms to describe subjects' skills and desiderata. To face this issue, this paper proposes a decision model for assisting human resource management in effectively evaluating the degree of mutual satisfaction in job-employee assignments. In particular, the decision model has been devised with the following core characteristics: i) employees' skills are modeled by combining hard skills (e.g.: academic training and competencies) and soft skills (e.g.: socio-relational experiences); ii) employees' soft skills are self-evaluated, giving importance not so much to experiences possessed but rather how such skills have been applied over time; iii) employees and managers can self- evaluate their preferences to enable the achievement of the optimal allocation by maximizing the global mutual satisfaction iv) partial matches between characteristics and desires of both employees and jobs are measured through a set of tailored fuzzy metrics. The proposed decision model has been validated in a real case to support the allocation of newly hired employees among open job positions in a Public Administration. Results showed an adequate ability of the proposed model both to support the description of employees, skills, jobs and preferences, and to suggest the best allocation maximizing the global mutual satisfaction. Summarizing, a decision model for human resource management with innovative characteristics is proposed and used to support decisions for a real allocation problem.

INDEX TERMS: Human resource allocation, job search, recruiting, skills match, assignment problem, decision support, public administration.

I. INTRODUCTION

Public sector and companies have to continuously enhance their performance to survive the competitive market or budget cuts. This can be achieved not only focusing on improving technology, machinery, and software, but also on proper Human Resource (HR) management [1], [2].

One form of managing HRs is the process of employees allocation, for internal mobility or after hiring new employees. The goal of employees allocation is to get acquainted with jobs requirements and employees skills so that the right person can be selected for the right job. However, especially

The associate editor coordinating the review of this manuscript and approving it for publication was Gustavo Olague in large organizations and in the public sector, it is increasingly difficult for HR managers to assign an employee to the right job since i) two tasks have to be solved together, i.e., each job position should be covered by the best employee available for that job, and each new employee should be allocated at the most compatible available position; ii) each employee possesses multiple skills and personal preferences, as well as each job has its intrinsic characteristics and some specific desiderata indicated by HR managers and, thus, it is becoming increasingly complicated to evaluate, manage, update, and memorize this information for all employees and jobs; iii) in order to obtain the best overall satisfaction for both HR managers and employees, some assignments may be sub- optimal [3], [4]. This problem is an example of the assignment problem [5], which is balanced in the case where the number of employees is equal to the number of open job positions. Different algorithms able to solve this type of problem exist (e.g., [6]).

As a consequence, more and more computerized tools and systems have been proposed to help managers in decision- making and employees allocation [7]–[10]. These tools can extend cognitive capabilities of managers helping them in managing and evaluating large amounts of data, and in find- ing the best employee for each available job [11]. However, existing solutions still fail to assign the right jobs to the employees according to their skills since the evaluation of the skills of employees is not a simple task, and several limitations have not been overcome yet.

Firstly, partial matches between jobs requirements and employees skills are not admitted or evaluated. Existing solutions typically offer to HR managers the chance to search for employees based on skills. Still, if someone only partially possesses the queried skills or at a different (lower or higher) level, they are excluded from the results. Besides, not all skills may be necessary, and some may be a preference of the HR manager, which could be handled as a bonus to reward candidates who have them. Managers should be allowed to express the preferred skills for a given job and view and evaluate candidates who do not entirely fit their preferences. Thus, a supporting system should offer a degree of fit between skills owned and required.

Secondly, assigning the best employee to a job is often not sufficient since employees tend to work poorly or inefficiently if their expectations and personal preferences are frustrated [10]. Existing solutions typically allow employees to describe their technical skills and expertise but more advanced criteria, such as social factors, personal preferences and career objectives are rarely considered. Therefore, in order to assess the goodness of each job-employee pair, the matching degree between characteristics and desires of both employees and jobs should be measured, taking into account different points of view; in particular, characteristics of jobs should relate both to the job activity and to professional prospects.

Thirdly, characteristics of employees should include both hard skills (e.g.: academic training, technical competencies and job experiences) and soft skills (e.g.: socio- relational experiences). Existing solutions mainly consider hard skills, not properly including employees' soft skills. This knowledge represents the social experience gained by each employee and certainly impacts how employees react to a job assignment. Every company or business organization should utilize the soft skills of employees to share knowledge and keep learning to improve the satisfaction and capability of employees [12].

Finally, to the best of our knowledge, none of the existing systems let managers and employees to self-evaluate how their expectations have to be weighted in the calculation of the optimal assignment. Personal preferences can substantially impact the mutual satisfaction of employees and managers after a given allocation. Even if personal preferences are considered during the allocation process, individuals' perceptions can be very different. If the same metric is used for each individual, the generated allocation may be skewed by incorrect assumptions.

To face these issues, this paper proposes a decision model, based on Artificial Intelligence (AI) methodologies, for assisting HR management in effectively evaluating the degree of mutual satisfaction in job-employee assignments. The purpose of this model is to allow the HR management to acquire a more advanced awareness about the experiences, preferences, and unique characteristics of its personnel, and to promote an increasingly adequate meeting between them and the characteristics of the job activities to be carried out.

In particular, the decision model has been devised by integrating: i) descriptions of employees based on both their hard and soft skills and on their desires about their ideal job; ii) descriptions of job positions based on their intrinsic characteristics and on the desires of the managers about the ideal employ; iii) partial matches between characteristics and desires of both employees and jobs, measured through a set of specifically defined fuzzy distance metrics; iv) an efficient AI-based optimization algorithm to select the most satisfactory set of assignments. In particular, employees' soft skills are self-evaluated qualitatively on the basis of the frequency with which they occurred in job behaviors, in other words giving importance not so much to experiences possessed but rather how such skills have been applied over time. Moreover, employees and managers are also allowed to self-evaluate their preferences, weighting them by means of an approach based on tokens, in order to achieve the optimal allocation by maximizing the global mutual satisfaction.

The proposed model has been experimented and validated in a real case study at the Italian Ministry of Economy and Finance (MEF), with a number of new employees, hired through public competition, to be assigned to open job positions. The results has been presented as suggestions to the human in charge of the allocation, to save time and efforts associated with the full decision-making process. The comparison between suggestions and final decisions have been reported and discussed, to prove the efficiency of the pro- posed model.

The paper is organized as follows. Section 2 reports related work on HR allocation, describing different approaches and systems proposed in literature. Section 3 describes the pro- posed decision model. Section 4 presents the real case where the projected framework has been applied. Then, Section 5 presents and discusses the results achieved, followed by conclusions in Section 6.

II. RELATED WORK

Employees skills, knowledge and competence highly impact the success of a job [3], [13]. However, getting the right employee to be assigned to the right job is not a trivial process, and, as a consequence, many approaches and tools have been proposed to support HR managers in decision-making.

A. ALGORITHMS AND MODELS

The first algorithms and models appeared a couple of decades ago are based on evolutionary, genetic and simulated annealing techniques.

In more detail in [14] a multi-purpose evolutionary technique has been presented to optimize the expansion of competency sets by multiple criteria.

In [15] a genetic algorithm has been introduced for resource allocation of a software project including project activities and human resources available.

A hybrid model has been discussed in [16], based on multi- criteria decision making to assess the company's expertise.

In [17] a method based on the rough set theory has been outlined to explore high-performers' required competencies. A constraint-based approach has been proposed in [18] for optimizing the scheduling of HR allocation with accelerated simulated annealing.

Successively, in the last decade, different techniques have been introduced to handle also inexact matches in HR allocation task as well as to allow the search for the right information and the reschedule of resources based on it.

In detail, an indexing technique has been proposed in [19] in order to retrieve the proximity of the keyword when exact match is not found. This technique is used to help managers in retrieving relevant information when exact match does not exist, and providing adequate resources to improve skill sets of the closest match selected.

A multi-objective algorithm has been proposed in [20] to minimize the cost during the scheduling process taking advantage of the knowledge to perform sequential search and to reassign and readjust the resources to respective tasks.

A decision model for dynamically scheduling software projects has been discussed in [21], based on employees skills which can improve over time as well as motivation and learning ability.

More recently, in [22] a model based on Formal concept analysis has been proposed in order to perform both skill extraction and skill matching of the projects to a team of students. The skill extraction involves both technical and non- technical skill extraction while for skill matching formal concept analysis and project-oriented stable marriage algorithm have been employed.

The decision model described in [23] has been devised with the aim of assisting a software company to evaluate existing resource for making decisions on whether the estimation of the tender is feasible, and assisting to make human resource allocation for team formation in fixed project duration with labor skill and budget constraint.

A combination of Fuzzy approaches with genetic algorithms has been proposed in [24] to handle uncertainty in subjective knowledge and evaluate the potential assignment of candidates to job vacancies based on their competency and the significance of each

position. In [25] a multifactor human performance evaluation approach based on the factor space theory has been designed. A fuzzy approach is used to not only evaluate the performance of candidates based on some criteria, but also provide some constructive criticism or suggestions for employees in professional and personal improvement.

Reference [26] proposed a hybrid of Tabu search and simulated annealing algorithms, and a hybrid of ant colony optimization and simulated annealing algorithms, to minimize the total cost for allocation of multi-skilled workers and outsource service usage in dynamic cellular manufacturing systems.

The study described in [27] attempted to investigate the effects of personal competency on job commitment and satisfaction through talent donation in the field of cosmetology. Results revealed a highly significant correlation among personal competency and talent donation, job commitment, and job satisfaction. Furthermore, there was a highly significant correlation between job commitment and job satisfaction. Therefore, this study proposed that it is a necessity to seek diverse options to enhance competency.

A team building method based on competency modelling has been proposed in [28] for supporting project leaders to organise the actors into teams. The authors suggested that incorporating a clustering algorithm as a step of the method results in preserving expertise and thus helps project man- agers to find better trade-offs between project cost (short term goal) and competency dynamics (long term goal).

The study described in [29] evaluated the impact of individual and social harmful factors on creativity inaction period in supply chains. Results showed that the harmful individual and social factors impose adverse effects on individual employees that cause different inaction periods named short-term, long-term, and organizational death of individual creativity inertia. Finally, in [9] a mathematical framework has been presented to calculate the soft and hard skills of employees based on time and achievements as skill increases or decreases over time.

B. TOOLS AND SYSTEMS

Many commercial services and systems offers visual inter- faces to identify employees with a heightened risk of a burnout, by highlighting the employees assigned to many multiple activities and evaluating them on various criteria, such as location, availability, and skills. Microsoft Project,[1] Silverbucket,[2] Zoho People,[3] and Clarizen One[4] are few examples of such services. They are quite similar and pro- vide a very basic level of decision support for the allocation decision RésuMatcher [30] is a personalized job-résumé matching system for ranking relevance between candidate curricula and a database of available jobs.

CASPER is case-based profiling for electronic recruitment system designed to improve the usability of the JobFinder web site search engine [31]. CASPER tracks user behavior within the JobFinder site, and constructs a user profile with which to generate personalized recommendations based on preferences of users with a similar profile. [32] presented a job recommender systems integrating content-based filtering and collaborative filtering in order to overcome limitations resulting from the problem of rating data sparsity by lever- aging synergies between the two approaches in a combined model.

In [11] a decision support system is proposed for identifying the key components required for effective human resource allocation, which makes it easier for organisations to implement similar systems.

Some attempts were made in evaluating a matching degree between workers and jobs. For example, Skill Matcher[5] allows people searching for a job by filling professional skills levels, and gives as response a list of the best matching types of career. Instead, Skills Match[6] allows to insert previous professional experiences, and shows the types of job that use the same skills.

III. THE PROPOSED DECISION MODEL

The proposed decision model, schematized in Fig. 1 is com- posed of two main elements specially devised to support HR management in finding the best job-employee assignments able to maximize the global mutual satisfaction.

Firstly, a data model has been devised to formally describe available jobs and assignable employees, as well as preferences of HR managers and employees on potential assignments. Jobs are mainly described in terms of general area of activity and professional prospects which may be generated in performing the jobs. Employees are mainly described in terms of their hard and soft skills. A peculiarity of this data model is the self-evaluation of employees' soft skills on the basis of the frequency with which they occurred in job behaviors. But, to prevent employees to state to have done all the socio-relational experiences at the maximum frequency, a budget of points is assigned to each employee and is consumed on the basis of the peculiar frequency chosen for a soft skill.

Moreover, the description of available jobs and assignable employees is enriched with the preferences of individuals on potential assignments, taking into account both the preferences of HR managers on hard and soft skills they would like to find in the employee assigned to a job, and the preference of employees on the characteristics of the job they would like to be assigned. As another characteristic element of this

[5]https://www.careeronestop.org/Toolkit/Skills/

[6]https://joboutlook.gov.au/career-tools/skills-match/

data model, there is the self-evaluation of the importance employees and HR managers want to place on each expressed preference by weighting it through some tokens taken from an available budget. The number of tokens bet for each preference will enable the computation of the importance given by employees and managers to their preferences, as described in detail later.

Secondly, the proposed decision model provides an efficient AI-based optimization algorithm to select the optimal allocation, where the cost of potential assignments is computed as opposite to the degree of satisfaction of the preferences of employees and HR managers. In this way, the optimal allocation is achieved by maximizing the global mutual satisfaction of employees and managers. To this aim, a fuzzy cost model has been defined to measure and evaluate the degree of satisfaction of HR managers and employees in potential employee-job assignments. The degree of mutual satisfaction of employees and HR managers depends on how and how well their expectations were met, so a metric for each particular type of preference is required.

In the following, the elements composing the proposed decision model are diffusely explained.

A. DATA MODEL

Figure 2 reports the data model specially designed to formally describe assignable employees and available jobs, and the preferences of HR managers and employees on assignments. It is important to note that, while the proposed decision model has general applicability, the kind of information considered and selected for describing jobs and employees has been impacted by the real case study analyzed and used for validating the model itself. Moreover, some taxonomies resulted very wide (e.g., all possible academic training and competencies, all possible languages, or all possible areas of activity) and are referred to Italy (e.g., possible Master Degree titles according to Italian legislation), and should be replaced in case of applications in other countries or in an international environment.

As a consequence, in order to simplify the fulfillment of jobs, employees, and the preferences of HR managers and employees on assignments, while the proposed decision model theoretically includes the whole taxonomies, some subsets were chosen, which are reported in the following. Domain experts individuated them by evaluating the requirements of the public sector related to the application, thus they should be replaced for different applications.

Furthermore, note that classes modelling a taxonomy of admitted values have not been represented in the class dia- grams, but, for brevity, they have been just reported in bold as allowed instances of some attributes. However, they are described and discussed in the following sections.

1) JOBS AND EMPLOYEES

According to domain experts, a complete description of peculiar aspects characterizing each job is not a simple task in

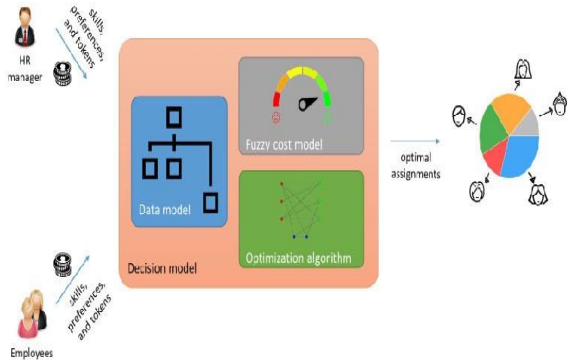

FIGURE 1. The proposed decision model to support HR allocation.

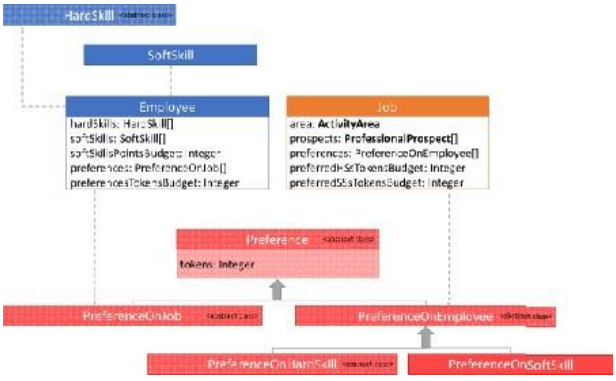

FIGURE 2. The data model underlying the proposed decision model.

public organizations, where the type of required working activity can be very heterogeneous. An employee is often asked to perform different tasks that fall into a general activity area, characterizing the office to which they are assigned.

As a consequence, to keep the proposed decision model generic and applicable in different public organizations, available jobs have been modeled through the class **Job** which is mainly characterized by two mandatory attributes

- *j.area* is used to link a job *j* **Job** to one instance belonging to the class **Activity Area** representing the main area of activity the job;

- *j.prospects* is used to link a job *j* **Job** to a list of instances belonging to the class **Professional Prospects** representing the professional prospects the job could allow to generate.

Each employee has been modeled through the class **Employee** which is mainly characterized by two attributes

- e.softSkills can be used to link an employee to a list of instances belonging to the

class SoftsSkill representing the socio-relational experiences the employee have manifested more in the past;

- e.hardSkills can be used to link an employee e

Employee to a list of instances belonging to the abstract class HardSkill representing easily assessable skills owned by the employee (e.g.: academic training, tech nical competencies, work experiences, and so on).

Moreover, both jobs and employees are characterized by an attribute preferences which can be used to link them to a list of instances belonging to the classes Preference On Employee and Preference OnJob, respectively. These abstract classes are specializations of the abstract class Preference, which is the upper class of a class hierarchy specially defined to model the different types of preferences of HR managers and employees on assignments. Note that, each element p Preference is characterized by a an attribute p. tokens representing the number of tokens an individual want to bet on that preference, whose use will be described later in the definition of the optimal assignment search algorithm.

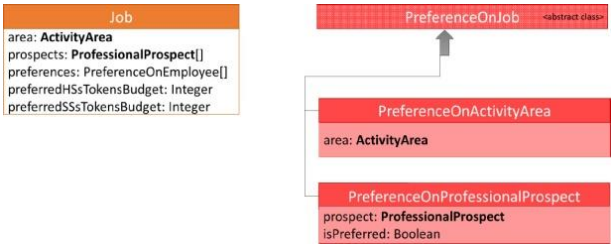

FIGURE 3. The classes defined for modelling jobs and employees preferences on them.

In the following, more details are given about the classes defined for modeling the different types of characteristics of jobs and employees, and preferences of employees and HR managers.

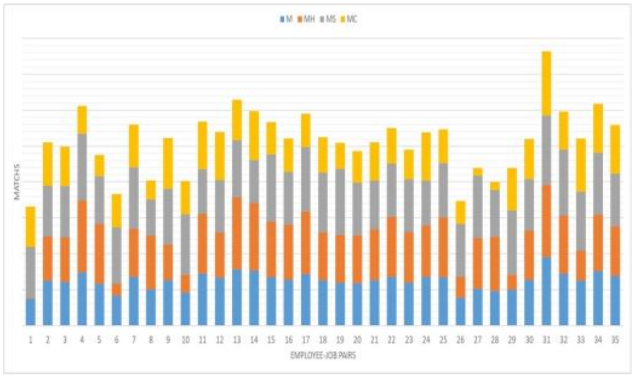

FIGURE 6. Global and partial degrees of satisfaction of assignments suggested by the proposed decision model.

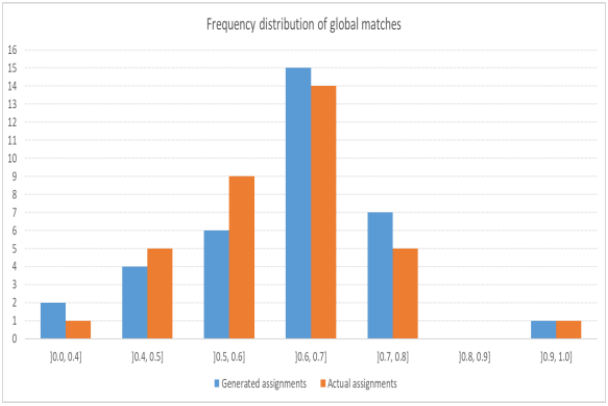

FIGURE 7. The comparison of frequency distribution of global matches for the generated (blue color) and actual (orange color) assignments.

A. ACTUAL ASSIGNMENTS

Results of the algorithm execution offered to HR managers a support for employees allocation. The decision was supported by assignment suggestions as well as all the other information acquired during the proof. 23 of 35 suggested assignments were accepted, thus about 66%.

However, the right to choose the actual allocation clearly remained to HR managers, who made 12 changes, with respect to the suggestions of the algorithm, associated with changes in terms of global matching (as calculated by the pro- posed decision model). Most of HR managers changes have been performed by manually choosing a different employeefor some jobs, selecting them among those with higherdegrees of mutual satisfaction with the jobs of interest,as computed by the decision models.

As a result, a decrease of 0.804 in the total matching degree can be calculated by comparing the choices of HR managers with respect to the suggested optimal allocation.

In detail, the actual allocation corresponds to a set of global degrees of satisfaction ranging from 0.246 to 0.952 (Mean 0.604, SD 0.127).

The resulting actual assignments with respective degrees of satisfaction is reported in Table 2, while the comparison of frequency distribution of global matches for the generated and actual assignments is shown in Figure 7. As a further measure of the method effectiveness, the Root Mean Squared Error of the set of global matches of the suggested alloca- tions, with respect to those obtained by decision-maker is RMSE ≈ 0.100.

B. DISCUSSION

The application of the proposed decision model produced valuable results.

First, the defined data model allowed inserting all descriptions, both at the employees and jobs sides, without any reported problem.

IV. CONCLUSION AND FUTURE WORK

This work aimed at supporting HR managers in the assignment of a number of newly hired employees to available job positions.

With this aim, a decision model was defined, which enables to analytically measure each employee-job pair goodness, based on weighted preferences of both employees and HR managers, and to apply AI to suggest the optimal allocation, made of the employee-job pairs gaining the maximum satisfaction of the whole department.

The case study, performed at the Italian Ministry of Economy and Finance, involved the customization of taxonomies used to insert useful information, the customization of weights, to tune the measure of goodness of employee- job pairs, and also presented privacy issues, simply solved by pseudonymization, and required to calculate anonymous statistics.

The experimental results proved the applicability of the proposed decision model, and its efficiency in suggesting the best allocation to HR managers, thus saving great human efforts.

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