Smart Human Resource Management System

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***Abstract*—Nowadays companies are dynamic environments always changing and adapting to evolving needs. Every single day, companies manage people facing multiple issues: (a) the hiring process; (b) the onboarding process; (c) managing people on projects; (d) losing skilled workers and onboarding new ones over time; (e) determining learning paths for all employees to target emerging needs before demand becomes high. Allocating people across multiple projects while considering skill matching for tasks, different project requirements, the substitution of people on tasks, learning paths, employee satisfaction, and the timelines for tasks and projects is a very complex problem. Our company's business is consultancy and we decided to build this tool to support human resource decisions in our ecosystem, where projects often have strict, short timelines, time-to-market is generally brief and the rate of employee turnover is high.**

The development of our system starts with the analysis of the existing workflow for hiring and management. In order to reduce the churn score, we decided to ingest additional metadata into the system, such as the organizational graph and the feedback from retrospective sessions (scheduled at fixed intervals and in our standardized format). These are used in the system as an attention mechanism.

Our product is born as a system to assist with hiring and highlight internal competencies, aiming to improve employee reliability. It analyzes the organizational structure of companies and the lower levels of teams to increase group cohesion and reduce employee turnover. It provides behavior suggestions to boost internal rewards and helps guide appropriate investments in training and development.

The concept developed within our system is derived from sociological science, focusing on best practices for reducing employee turnover and improving worker well-being. Losing a person after forming him is a very high cost; often, it may be better to lose a project of three months than a resource.

Our product offers an effective system for providing information to newly onboarded employees, reducing uncertainty about company practices. It could help understand why an employee is leaving, in order to allow us to take action to retain them. Having a straightforward system to identify emerging technology boosts employer satisfaction and shortens our company's time to market.

***Index Terms*—Artificial intelligence, Human resource management, Knowledge graphs, Data mining, Recommendation system, LLM, Feature extraction mechanism, Enterprise social networking, Task management**

I. Introduction

Human Resource Management is constantly evolving with the advent of Big Data. Online databases of resumes, social media profiles, and employment histories allow companies to pinpoint the right person for the right job while ensuring equal employment opportunities. In this perspective, HR tasks have become more evidence-based and are now a true strategic business partner to companies. Companies are impacted by both external and internal factors and human resource administration plays a critical role in shaping strategies that gauge the future demand for human resources. [2]

HR tasks are selection and recruitment. Selection refers to picking the most suitable individual for the job, while recruitment involves creating a pool of potential candidates who might apply to an organization. [3]

Human resource management is portrayed as a powerful and proficient supervision of representatives of an organization to finish the required focused objectives. [4]

Every company has to allocate workers for realizing projects, hiring, and managing the loss of workers. What are the major actions that companies have to perform when managing workers? Firstly they need to allocate people to different projects; secondly, they need to invest in training workers; thirdly they need to create groups of people with similar working targets. Our work is born from analyzing the existing hiring workflow, leveraging the intrinsic social networks among employees and teams. Our approach aims to provide a novel solution that helps our industrial partner manage teams from all angles, reducing employee turnover and associated costs.

In [5] a process mining approach was introduced to minimize process execution time, considering three constraints: total cost, resource availability, and resource preference. In [6] an approach is illustrated to support decision-making on human resource allocation in an organization, based on a human-centric network discovered from the event log. From this perspective, industrial research is increasingly focusing on the use the Large Language Models (LLMs). The survey [7] shows that LLMs have recently demonstrated remarkable capabilities

in natural language processing tasks and beyond. Some works encompass diverse topics such as architectural innovations, improved training strategies, extended context length, fine-tuning, and multi-modal LLMs. Actually, the Large Language Models are used in many domains. The study in [8] deals with a model that uses domain-specific data from real-world legal cases, suggesting that fine-tuning can improve the performance of LLM-based text classifiers. In [9], LLM4S EC HW, a novel framework for hardware debugging is illustrated, which leverages a domain-specific Large Language Model (LLM). Authors in [10] discuss the usage of LLMs in the industrial field highlighting their potential for improving the efficiency, effectiveness, and quality of Industrial equipment operations and maintenance. In [11], LLMs are used for realizing a framework for automation and semi-automation autonomous driving. Finally, [12] presents an application designed to analyze control logic generation for PLCs and DCS from natural language inputs. It has generated syntactically correct IEC 61131-3 structured text code, which has increased electronic device productivity.

As shown in the reference, in our system, we leverage the power of LLMs to support HR processes. The usage of LLMs can be combined with techniques like the attention mechanism. In [13] a method is illustrated that uses multiple word embeddings to extract domain-specific aspects from various contexts. These aspects are then used as labeled data to train an attention-based cross-domain model for improved prediction. In [14] an algorithm is presented to identify target areas on the human body and submit the detection results to a feature extraction module based on the attention mechanism. [15] Illustrates CWDNet, a text detection network that combines attention mechanisms and weighted branches. The Coordinate Attention (CA) mechanism is first introduced into the residual blocks of the ResNet network to enhance feature extraction. Then, a weighted branch fusion module is proposed to dynamically adjust the features' relevance at different scales.

For our aims, we focused on leveraging metadata to improve the search through an attention mechanism. Our core idea is to enhance internal incentives and leverage insights from sociology to suggest optimal operations through LLM's ecosystem usage. Our product analyzes the graphical composition of companies and project needs to allocate workers in a way that increases group cohesion, reduces turnover, and maximizes performance. Our system is designed to be highly scalable and is composed of microservices to solve atomic issues, allowing for customization based on clients' specific needs.

In this paper, we will illustrate some features of our system in some use cases of our internal company.

II. Preliminaries notations

We introduce the structured space we realized to mathematically describe a company and its workload requirements, providing the reader with an understanding of how the allocation process is designed.

Definition II.1 (Company)**.** A company is an environment characterized by:

- a group of workers with various features that can be segmented into subclusters based on knowledge in Geo-Data, preferences, skills, and experiences. These are further enriched with additional metadata, derived from retrospective analysis and skill gap assessments, which provide insights such as:
  - federalization, a measure of how well the worker integrates with the team;
  - client-worker project feedback, the feedback from the client regarding the worker's performance on the project;
  - worker-client project feedback, the feedback from the worker regarding their experience with the client during the project;
  - experience gap, a measure of the worker's readiness for additional responsibilities (if the skill package is in place);
- a workload, consisting of a set of projects and tasks, each with specific timeframes, required skills, experience levels, and geo-referencing details;
- a collection of data and metadata, including a graph that depicts the company's structure, specialized knowledge silos, and team composition. The graph's edge can be updated when the system is integrated with the retrospective package.

Let's consider a company that manages multiple projects. We'll define the plan as the workload of the company.

Definition II.2 (Workload)**.** The workload of a company consists of a set of projects P allocated across a timeline T. Each project has a project timeline pt defined by a start time pt_s and an end time pt_e, such that each pt is within the workload timeframe WLT ($pt \in WLT$).

Let us consider a group of people in a federated company that has to manage people on a single project. Let us define a project p.

Definition II.3 (Project)**.** A project $\mathrm{p} \in P(\mathrm{p}_i)$ is defined as a set of tasks: p = (t_i) over time $T_p \in (t_s, t_e)$.

Definition II.4 (Task)**.** A task t is a structure composed of multiple attributes:

- a set of properties, i.e., the skills required for the workload;
- a range of dates during which the specific skills are needed.

Based on this, we can define a task as a set of skills $s_i \in S$, where $s_i = (1 \iff \mathrm{s}_i \; is \; required \; at \; t_i \in T$, otherwise 0).

Let's consider a worker and define a worker as a structure with some attributes.

Definition II.5 (worker)**.** A worker is an abstract identity composed by:

- metadata, including location, propensity to move, and relationships within the company;
- a set of features describing skills and attitudes.

The final definition we need to introduce before we begin considering our problem domain is about company organization.

Definition II.6 (Company organization)**.** The company organization is a graph where people are subdivided into non-isolated groups and connections between users are based on the correlation of skills.

Finally, after introducing the main concept, we are going to define the problems we are addressing with our framework by listing the use cases:

- finding the optimal allocation of the workers on projects to maximize the probability of Considering full placement and achieving the best worker performance;
- Considering the workload timeline, which consists of a series of sub-tasks following a predefined plan, it is possible to understand what skills are required, in what quantity, and at which times. According to this information, our system aims to drive the management to make the right decisions regarding training and hiring processes;
- facilitating the assessment of new resource needs through automated responses to HR questions;
- reducing employee turnover through continuous feedback derived from worker retrospectives.

User presence and documentation are standard features in every HR system, so we don't cover them in this paper. However, they are included and serve as the main source for our input data.

VT HR Management teams system is a tool with multiple features, designed to be easy to extend and tuned to each company's unique needs for managing both the workload and the people within the organization from every angle. Our system, by facilitating team collaboration and creation and by offering fuzzy users, is an ideal solution for any company. It can also support project management for consulting firms that aim to offer a comprehensive service and support to customers, moving beyond the traditional, simple body rental approach.

III. Smart HR Management system

Figure 1 illustrates the high-level design of the proposed system for managing and allocating workers to projects that dynamically arrive and are scheduled. The system is designed by combining various features to address key aspects of the HR and project workflow within a company.

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Optimization Problem: Worker Allocation

Let $\mathcal{G} = (\mathcal{V}, \mathcal{E})$ be a relational graph, where $\mathcal{V}$ is the set of workers and $\mathcal{E}$ is the set of edges representing the relationships between workers. Each worker $v \in \mathcal{V}$ has a set of technical skills $\mathcal{T}_v$ and soft skills $\mathcal{S}_v$.

We are given a set of projects $\mathcal{P} = \{p_1, p_2, \ldots, p_m\}$, where each project p_i is composed of a set of tasks $\mathcal{T}_{p_i} = \{t_{p_i,1}, t_{p_i,2}, \ldots, t_{p_i,n_i}\}$. Each task $t_{p_i,j}$ has a set of requirements $\mathcal{R}_{t_{p_i,j}}$, a time start $\mathcal{T}^s_{t_{p_i,j}}$, a time end $\mathcal{T}^e_{t_{p_i,j}}$, and a set of skills $\mathcal{S}_{t_{p_i,j}}$ required to complete the task.

The goal is to optimize the allocation of workers to tasks, subject to the following constraints: 1. Each worker can be assigned at most one task at a time. 2. Each task can be assigned to at most one worker at a time. 3. Each worker's technical and soft skills must match the task's requirements. 4. The start and end times of each task must be respected. 5. For each project, we want to assign workers who like to work together, i.e., workers are connected by an edge in the relational graph. Let $x_{v,t_{p_i,j}} \in \{0,1\}$ be a binary variable indicating whether worker v is assigned to task $t_{p_i,j}$. Let $s_{v,t_{p_i,j}} \in [0,1]$ be a score indicating the match between worker v and task $t_{p_i,j}$. Let $y_{v,w,p_i} \in [0,1]$ be a score indicating the likelihood of workers v and w to work together. The optimization problem can be formulated as:

$$\max \sum_{p_i \in \mathcal{P}} \sum_{t_{p_i,j} \in \mathcal{T}_{p_i}} \sum_{v \in \mathcal{V}} s_{v,t_{p_i,j}} x_{v,t_{p_i,j}} + \sum_{p_i \in \mathcal{P}} \sum_{v,w \in \mathcal{V}} y_{v,w,p_i} x_{v,t_{p_i,j}} x_{w,t_{p_i,j}}$$

subject to:

$$\sum_{t_{p_i,j} \in \mathcal{T}_{p_i}} x_{v,t_{p_i,j}} \leq 1 \quad \forall v \in \mathcal{V}, p_i \in \mathcal{P}$$

$$\sum_{v \in \mathcal{V}} x_{v,t_{p_i,j}} \leq 1 \quad \forall t_{p_i,j} \in \mathcal{T}_{p_i}, p_i \in \mathcal{P}$$

$$\mathcal{T}^s_{t_{p_i,j}} \leq \sum_{v \in \mathcal{V}} x_{v,t_{p_i,j}} \quad \forall t_{p_i,j} \in \mathcal{T}_{p_i}, p_i \in \mathcal{P}$$

$$\mathcal{T}^e_{t_{p_i,j}} \geq \sum_{v \in \mathcal{V}} x_{v,t_{p_i,j}} \quad \forall t_{p_i,j} \in \mathcal{T}_{p_i}, p_i \in \mathcal{P}$$

$$\mathcal{R}_{t_{p_i,j}} \cap \mathcal{T}_v \neq \emptyset \Rightarrow x_{v,t_{p_i,j}} = 1 \quad \forall v \in \mathcal{V}, t_{p_i,j} \in \mathcal{T}_{p_i}$$

$$\mathcal{S}_{t_{p_i,j}} \cap \mathcal{S}_v \neq \emptyset \Rightarrow x_{v,t_{p_i,j}} = 1 \quad \forall v \in \mathcal{V}, t_{p_i,j} \in \mathcal{T}_{p_i}$$

$$y_{v,w,p_i} = 1 \Rightarrow (v,w) \in \mathcal{E} \quad \forall v,w \in \mathcal{V}, p_i \in \mathcal{P}$$

$$\sum_{v \in \mathcal{V}} y_{v,w,p_i} \leq 1 \quad \forall w \in \mathcal{V}, p_i \in \mathcal{P}$$

The objective function maximizes the total score of the allocation, which is a combination of the match between employer and task and the likelihood of workers working together.

The first two constraints ensure that each worker is assigned to at most one task and each task is assigned to at most one worker. The third and fourth constraints ensure that the time start and end of each task are respected. The fifth and sixth constraints ensure that each worker's technical skills and soft skills match the requirements of the task they are assigned to. The seventh constraint ensures that workers who like to work together are assigned to the same project.

This optimization problem can be solved using various optimization techniques, such as linear programming or integer programming. —

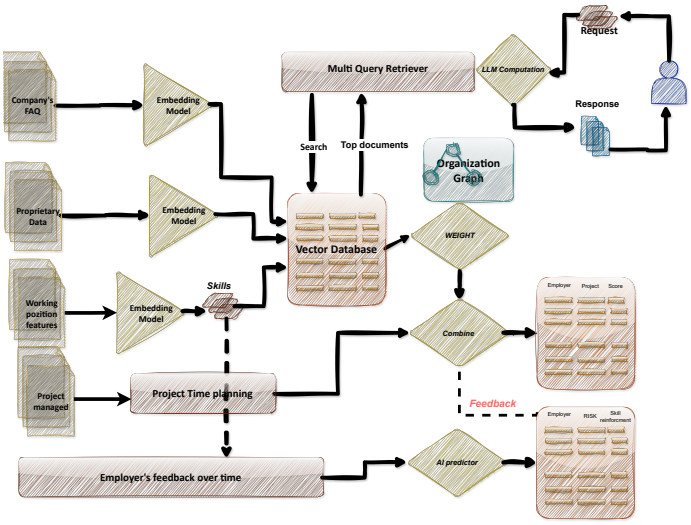

Fig. 1. high level of VT-SHR System

The system offers the features below:

- manages knowledge needs from employers, reducing information mismatches within the company and simplifying the work of the HR department;
- supports HR in finding employees for eventual emergency needs;
- supports the allocation of employees to projects by easing information sharing across all company levels. This is achieved through task planning to understand needs and eliminate bottlenecks associated with centralizing project-related tasks with individual workers;
- increases employee loyalty to their teams by leveraging social connections within team composition, leading to reduced employee turnover [1];
- provides clear insights into hiring needs and skill gaps based on employee knowledge and job market trends, enabling easy and effective training paths;
- ensures a clear, efficient employer's career path to increase worker satisfaction.

We created this system to address our internal company needs. We started by asking all our employees a simple question: what do you think we should improve in team management? We collected responses and defined a model of the company from an engineering perspective, as described in section II.

After each step of refining the system, we evaluated it by asking another simple question: would you like to work for a company that follows these procedures in an automated, clean, and clear way?

At the end of the development, the company's response was a straightforward assessment: our company has a low employee turnover rate [1].

IV. Use Cases

In this work, we illustrate a few simple use cases to demonstrate the potential of our system. Our discussion does not encompass all the system features but rather focuses on the more interesting aspects of our framework, discussing others only at a high level for copyright reasons.

Figure 2, provides a high-level overview of how our system assists HR in finding people to hire or allocate to a project based on emerging needs. Assuming we are looking for two

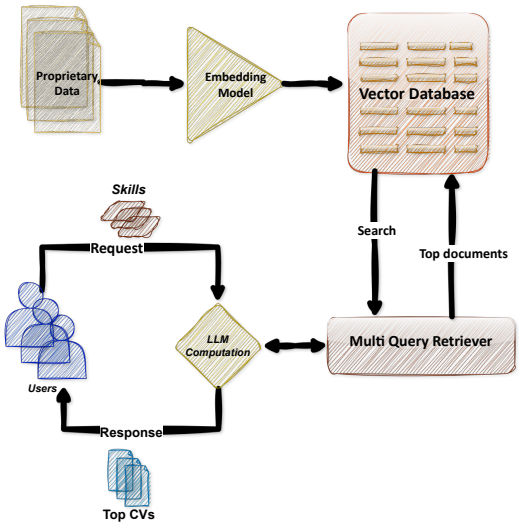

Fig. 2. HR is searching across all internal employees and external Resumes to find workers to hire or to allocate to a project

DevOps for a project, our system will search through the profiles of internal employees, freelancers, and potential new hires to find the best match. It will display a set of top matches selected from both internal and external sources and also indicate when each candidate might be available for allocation.

Figure 3 shows a design workflow for the planning function. Our system supports companies in managing the allocation of

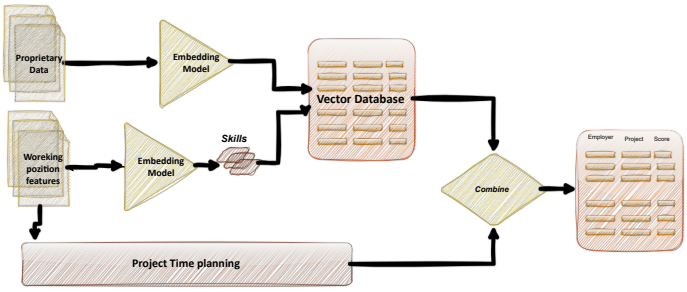

Fig. 3. Use case plan: allocating resources to projects over time

workers across multiple projects. It combines various features, such as project tasks and worker skills, along with feedback, to calculate a success score. This score is used to optimize the allocation process by maximizing these scores.

Figure 4 illustrates a job web crawler process that a company might implement using our application.

V. Demo

In this section, we will show some use cases realized with our system. In figure 5 we show how our assistant

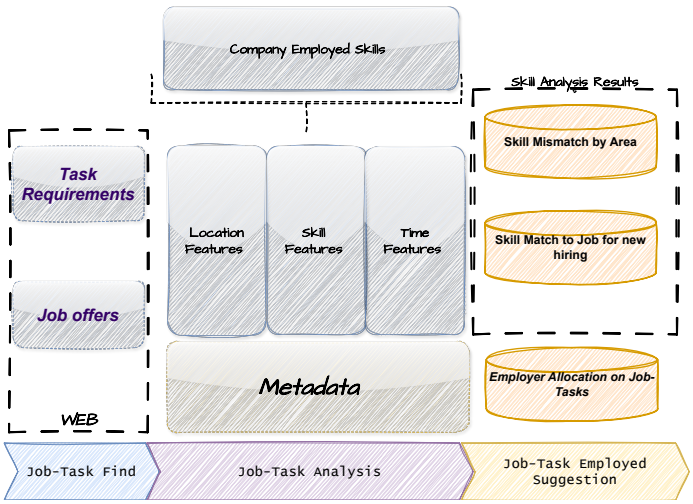

Fig. 4. Use case plan: logical task flow

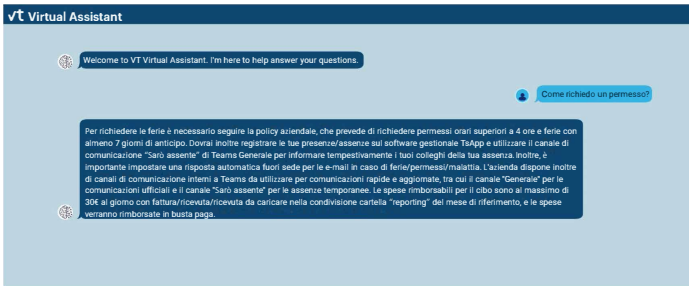

Fig. 5. HR Virtual Assistant: an example of a rule request

can extract information from text files and answer specific questions within a defined context. Specifically, it simplifies the consultant of HR-related information, improving efficiency and making it easier for employees to make requests.

In figure 6 we demonstrate how our assistant can return the profile of a job candidate who meets a set of desired skills.

VI. Conclusion

In this paper, we presented an architecture that we used to create our Human Resource Management System. It addresses the challenge of sharing information, reduces the workload of the HR department, facilitates company management, promotes team growth, and decreases the likelihood of employee turnover.

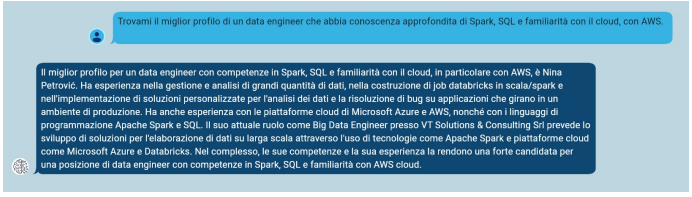

Fig. 6. HR Virtual Assistant: an example of retrieving suitable profiles from resumes/Cvs

At VT research lab we are developing an algorithm for managing the allocation of workers over projects by evaluating the use of greedy algorithms and knapsack models in combination with temporal features.

Acknowledgment

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