A Web based Evaluation Support System by Integral Performance Appraisal

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***Abstract*—Performance appraisal is a process used by companies, in order to evaluate the employees' efficiency and productivity, for planning their Human Resource policies. This process can be carried out in different ways either just for employees' supervisors or by different collectives related to the evaluated employee. In the latter case, 360-degree performance appraisal or integral performance appraisal, the different types of appraisers have different degree of knowledge about the employee. Furthermore, such knowledge is usually vague and subjective. Due to these facts, in the literature exists some performance appraisal models [1], [2] that flexible and improve the evaluation process. In this contribution is presented and developed a Web based evaluation system that support integral performance appraisal according to the previous models.**

I. Introduction

A main goal of the Human Resources Department is the administration of the human capital by means of measuring the relationships between the company's human capital and the financial results obtained by the company [10].

Performance appraisal is a common activity in companies whose aim is to evaluate and analyze employees' capacity to accomplish their work [3], [10]. In the specialized literature it can be checked that several trends corroborate that human behavior measurement improves companies productivity [3], [6], [10], [16] and plays a key role in companies competitiveness.

The evaluated indicators involved in a performance appraisal are usually subjective and vague, therefore difficult to assess quantitatively in a precise way, but it is more adequate to express the assessments in a qualitative way by means of linguistic terms [24]. The use of fuzzy linguistic approach [25] for managing such uncertainty has obtained good results in different disciplines, among them "information retrieval" [4], "marketing" [23], "recommender systems" [19], [21], "education" [9], and "sensory evaluation" [18], [20].

Former models evaluate employees according to just their supervisors' opinions, however recently integral or 360-degree performance appraisal models are used where different types of appraisers such as supervisors, collaborators, customers, colleagues and employee himself. This type of models obtain a more general, objective and better assessment about the evaluated employee [7], [10], [17].

Commonly different groups of appraisers might have different degree of knowledge about the employee. Hence and due to the suitability of the linguistic information in the these problems, recently new models for performance appraisal have been presented that offer a linguistic multiscale framework to the appraisers to facilitate the elicitation of the subjective information about the evaluated employees [1], [2].

The utility of theses models has been theoretically argued, in this contribution a Web based evaluation systems that implements the 360-degree performance appraisal model introduced in [1] is implemented to show its real applicability in companies that accomplish these processes.

The rest of the contribution is set out as follows: Section 2 introduces some preliminaries regarding for performance appraisal with multiple linguistic scales. Section 3 reviews linguistic 360-degree performance appraisal model. Section 4 presents a Web based evaluation system to support performance appraisal. Finally, in Section 5, conclusions are drawn.

II. Linguistic Background

In this section is revised some necessary concepts related to linguistic information in order to understand the model that implemented our proposal.

A. Fuzzy Linguistic Approach

Many aspects of different activities in the real world cannot be assessed in a quantitative form, but rather in a qualitative one, i.e., with vague or imprecise knowledge. In that case, a better approach may be to use linguistic assessments instead of numerical values. The fuzzy linguistic approach represents qualitative aspects as linguistic values by means of linguistic variables [24].

In this approach, it is necessary to choose the appropriate linguistic descriptors for the term set and their semantics, there exist different possibilities (further description see [11]). One possibility of generating the linguistic term set consists of directly supplying the term set by considering all terms distributed on a linguistic term set on which a total order is

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defined [22]. For example, a seven-term set S, could be:

$$s_0 = None\ (N) \qquad s_1 = Very\_Low\ (VL)$$
$$s_2 = Low\ (L) \qquad s_3 = Medium\ (M)$$
$$s_4 = High\ (H) \qquad s_5 = Very\_High\ (VH)$$
$$s_6 = Perfect\ (P)$$

Usually, in these cases, it is required that in the linguistic term set there exist:

1) A negation operator: $Neg(s_i) = s_j$ such that $j = g - i$ ($g + 1$ is the cardinality).
2) An order: $s_i \leq s_j \iff i \leq j$. Therefore, there exists a $\min$ and a $\max$ operator.

The semantics of the terms are given by fuzzy numbers defined in the [0,1] interval, which are usually described by membership functions.

B. 2-Tuple Linguistic Representation Model

The use of linguistic information implies processes of computing with words (CW), there are different linguistic computing models. In [1] was chosen the linguistic 2-tuple model that improves the accuracy of the processes of CW and facilitates the managing of multiple linguistic scales through the use of Extended Linguistic Hierarchies (ELH).

The linguistic 2-tuple model [12], [14] is based on symbolic methods and takes as the base of its representation the concept of Symbolic Translation.

Definition 1. *The Symbolic Translation of a linguistic term* $s_i \in S = \{s_0, ..., s_g\}$ *is a numerical value assessed in* $[-.5, .5)$ *that supports the "difference of information" between an amount of information* $\beta \in [0, g]$ *and the closest value in* $\{0, ..., g\}$ *that indicates the index of the closest linguistic term* $s_i \in S$*, being [0,g] the interval of granularity of* S.

From this concept the linguistic information is represented by means of 2-tuple (s_i, α_i), $s_i \in S$ and $\alpha_i \in [-.5, .5)$.

This model defines a set of functions between linguistic 2-tuples and numerical values.

Definition 2. *Let* $S = \{s_0, \ldots, s_g\}$ *be a set of linguistic terms. The* 2-tuple set associated with S *is defined as* $\langle S \rangle = S \times [-0.5, 0.5)$. *We define the function* $\Delta : [0, g] \longrightarrow \langle S \rangle$ *given by,*

$$\Delta(\beta) = (s_i, \alpha), \quad with \quad \begin{cases} i = round\,(\beta), \\ \alpha = \beta - i, \end{cases}$$

where "round" assigns to β *the integer number* $i \in \{0, 1, \ldots, g\}$ *closest to* β.

We note that Δ is bijective [12] and $\Delta^{-1} : \langle S \rangle \longrightarrow [0, g]$ is defined by $\Delta^{-1}(s_i, \alpha) = i + \alpha$. In this way, the 2-tuple of $\langle S \rangle$ will be identified with the numerical values in the interval $[0, g]$. This representation model has associated a computational model that was presented in [12].

C. Dealing with Multiple Linguistic Scales. Extended Linguistic Hierarchies

The Web based system implemented in this contribution is based on [1] that deals with ELH to manage multiple linguistic scales. Here, we review in short basic concepts of ELH to understand the working of the system.

1) Building Extended Linguistic Hierarchies: An ELH is a set of linguistic terms sets, where each level is a linguistic term set with different granularity from the remaining levels of the ELH. Each level belongs to an ELH is denoted as $\mathbf{l}(\mathbf{t}, \mathbf{n}(\mathbf{t}))$, being t the level of the ELH and $n(t)$ the granularity of the linguistic term set of the level t.

In order to build an ELH it is necessary to follow the *extended hierarchical rules* [8]. Following these rules, an ELH is built as:

- *Extended Rule 1:* a finite number of the levels $l(t, n(t))$ with $t = 1, ..., m$, that defines the multi-granular linguistic context,
- *Extended Rule 2:* a final level $l(t', n(t'))$, $t' = m+1$ and with the following granularity is added:

$$n(t') = \big(L.C.M(n(1) - 1, ..., n(m) - 1)\big) + 1 \qquad (1)$$

being $L.C.M$ the *Least Common Multiple*.

In this way, given an ELH, $S^{n(t)}$ denotes the linguistic term set of ELH corresponding to the level t of ELH with a granularity of uncertainty of $n(t)$

$$S^{n(t)} = \{s_0^{n(t)}, ..., s_{n(t)-1}^{n(t)}\}.$$

2) Computational Model: Obviously, the use of linguistic information implies processes of "*computing with words*" (CW). In order to accomplish such processes when we are dealing with multiple linguistic scales, in [8] was proposed a computational model based on linguistic 2-tuples [13] to accomplish the proceses of CW in a precise way in this context. Such a model consists of a three-step process showed in Figure 1;

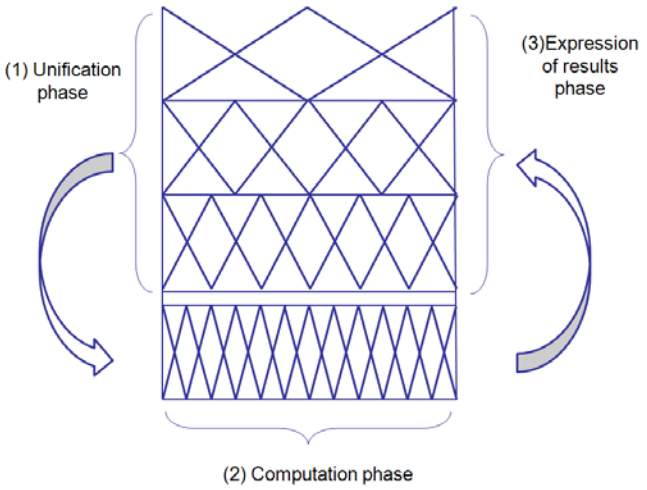

Fig. 1. Computational Model

- Unification phase. The linguistic information is expressed in only one linguistic term set that for ELH is always $S^{n(t')}$ (for further details see [8]). The information is unified into the level $l(t', n(t'))$ of the ELH, using the transformation function, $TF_{t'}^{t}$ proposed in [15]:

$$TF_t^{t'} : l(t, n(t)) \longrightarrow l(t', n(t')).$$

$$TF_t^{t'}(s_i^{n(t)}, \alpha^{n(t)}) = \Delta\left(\frac{\Delta^{-1}(s_i^{n(t)}, \alpha^{n(t)}) \cdot (n(t') - 1)}{n(t) - 1}\right). \quad (2)$$

- Computation phase. Once the information is expressed in only one expression domain $S^{n(t')}$, the computations are carried out by using the linguistic 2-tuple model [13]. The results are expressed by means of linguistic 2-tuples assessed in the same level, $l(t', n(t'))$.
- Expression of results phase. In this step the results can be transformed into any level of the ELH in a precise way to improve the understanding of the results by means of the transformation:

$$TF_{t'}^{t} : l(t', n(t')) \longrightarrow l(t, n(t)).$$

III. Linguistic 360-degree performance appraisal model based on ELH

In this section, we focus our attention into the model of the performance appraisal proposed in [1], which will be implemented for our system. To do so, we begin with a short explanation of the model followed by the steps of the model.

In [1] was presented linguistic 360-degree performance appraisal model where appraisers can express their assessments in multiple linguistic scales according to their knowledge. In order to operate with this assessments, the authors proposed the use of the extended linguistic hierarchies approach, so the model offers flexibility, an accurate computational model and the results are expressed in the initial scales.

The model is based on the decision analysis scheme [5] that consists of the following phases showed in the Figure 2.

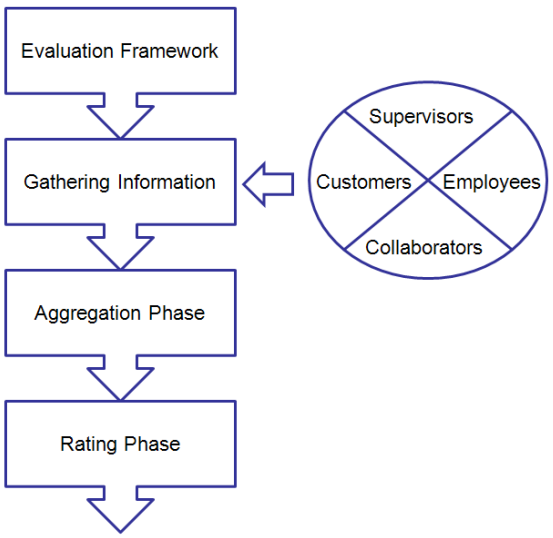

Fig. 2. Evaluation process

1) Evaluation Framework: This phase defines the evaluation framework, such that, the problem structure is defined and the linguistic descriptors, and semantics that will be used by the appraisers to express their assessments about the evaluated employees. In this phase, the ELH that manages the information is built.
2) Gathering Information: In this phase, the appraisers of the different collectives will provide their opinions regarding the employees by means of vectors of linguistic assessments assessed in the different scales of the ELH.
3) Aggregation Phase: The aim of this phase is to obtain an global values about performance of the evaluated employees according to the different criteria and reviewers' collectives. To compute such a global values, this phase follows the computational scheme of the ELH, revised in the section II-C2.
4) Rating Phase: Finally, in order to obtain the final ranking of the employees, the global values are used for sorting and ranking employees according to the human resources department policy.

IV. A Web based evaluation system supporting integral performance appraisal

In this section, we present a Web based evaluation system supporting performance appraisal (WSSPA) that develops the linguistic 360-degree performance appraisal model based on ELH, reviewed in the previous section. To do so, we pay attention to the architecture of the system and its functionality.

The proposed system is located at the following URL: *http://sinbad2.ujaen.es:8080/edumel*. The homepage of the system is shown in Figure 3.

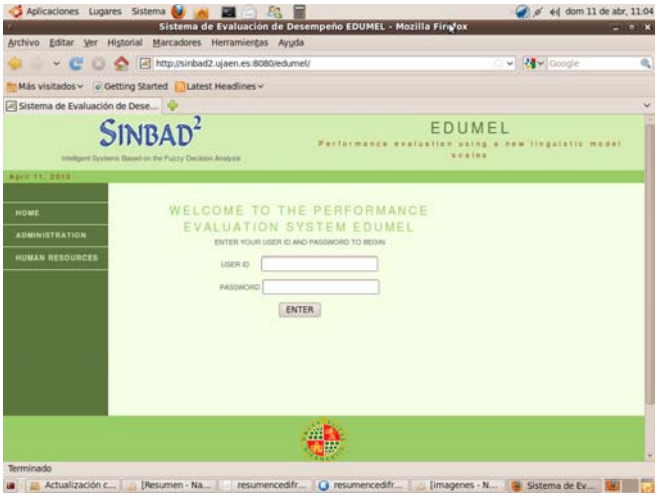

Fig. 3. Homepage of the system

A. System architecture

Here, we briefly describe the main elements of the system as well as the Web technologies used to design and implement the system.

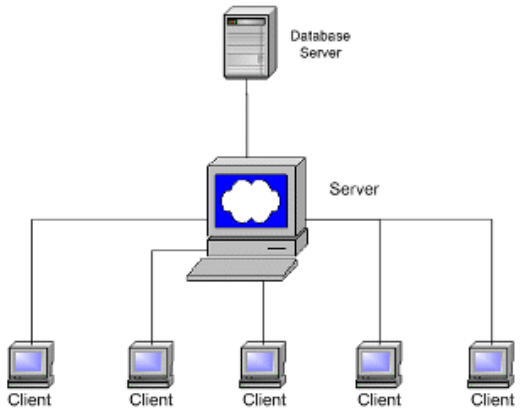

Fig. 4. Client-server architecture

As it is depicted in the Fig. 4, the system has been developed following a client-server architecture. So, the system is hosted in a computer which makes the role of internet server. Remote clients can connect with this server through a Web browser. The users then send requests that are parsed on the server and consistent answers are sent back to client. This architecture avoids that the end user installs the application on his/her computer. Moreover, this architecture is highly scalable and extensible to add new clients and servers. Note also that a database system is used to store all the information related with the process, that is, information about the problems, experts, preferences given in every round, etc.

Regarding Web technologies and language programming, we have used the Java language, particulary JavaServer Pages (JSP) because allow to generate dynamic web pages by using HTML and XML documents. JSP generate pages that are compiled and executed on the server to deliver an HTML or XML document. The compiled pages and any dependent Java libraries use Java bytecode rather than a native software format. This allows that the application can be executed within the Java Virtual Machine on any computer and operating system.

B. Web System Functionality

At this point, we present the functionality of the system based on the phases of the implemented model. The functionality is shown from the point of view of the role that performs it. There are 3 types of roles in the system: *administrator*, *appraisers* and *human resources*.

1) Evaluation Framework: The *administrator* defines the evaluation framework, such that, the structure is defined and the linguistic descriptors and its semantics that will be used by the appraisers to express their opinion about criteria of the evaluated employee.

In general, the administrator can manage users, departments, assessing indicators, surveys and assessments.

The *administrator* defines diverse indicators and the linguistic scales to assess each indicator. In addition, design surveys that include appropriate indicators, depending on the type of evaluation.

The first step in order to create an evaluation is that the administrator selects the type. There are two types of evaluation: regular assessment and evaluation for promotion. The regular assessment evaluates employee performance, evaluation for promotion aims to get an assessment to promote to a specific position. The system automatically selects the set of appraisers that evaluate the employees, according to the type of evaluation and the evaluated employee. Furthermore, the system allows manually add or remove any evaluator of the set.

The last step is to associate the survey, previously designed, to gather assessments of the evaluators. In the Figure 5 shows a design example of an assessment.

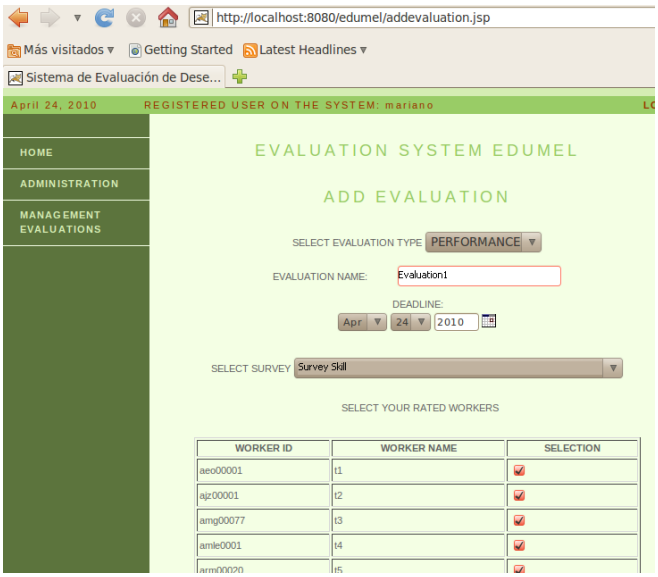

Fig. 5. Creating an assessment

2) Gathering Information: After the framework has been defined in order to evaluate the different evaluated employee, the evaluation process must obtain the opinions from the appraisers. To do so, in the system defines the role *appraiser*.

When a user with the role *appraisers* is logged in the system, it shows the surveys that the user should complete. Automatically, the system offers the most appropriate scale, according to the user's knowledge about the evaluated employee. The state of a survey can be: open or finished. Following, we describe the meaning of each state:

- *Open*: While the survey is open, the appraisers can insert his/her assessments, or modify existing ones (see figure 6.
- *Finished*: When the survey is close by the user, the system shows only the assessments made, the user can not change his/her assessments.

The *administrator* may impose a deadline for gathering the information, ie, defines a date, in which the surveys will be closed and the appraisers may not add or edit his/her opinions.

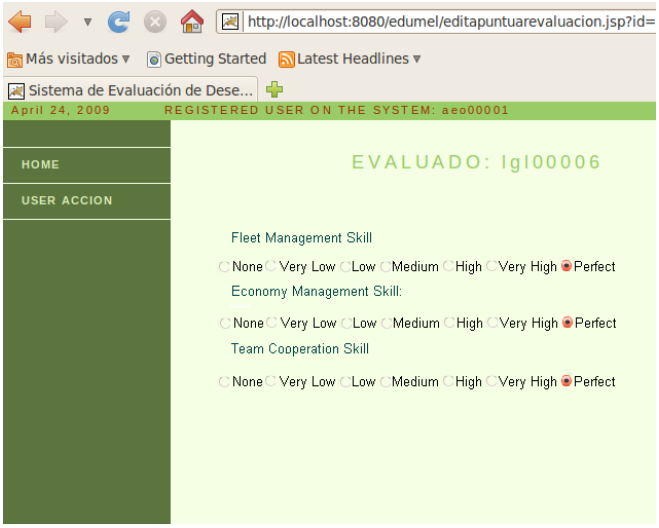

Fig. 6. Employee's assessments provided by a appraiser

Fig. 7. Aggregation Operators

3) Aggregation Phase: The system performs the computation processes according to type of aggregation operator selected, under supervision of a user with the role of *human resources*.

Currently, the system offers the following aggregation operators: maximum, minimum, arithmetic mean and median (see Figure 7). When the operator of aggregation is selected the computational processes are carried out to obtain global values about performance of the evaluated employees. The system allows to modify the type of operator and to re-calculate all global values.

4) Rating Phase: When the global assessment of every employee is calculated, the role of *human resources* can visualize the classification of the evaluated employees according to their global values. In addition, the system offers the possibility of establishing the partial classification according to an indicator.

The classification of the evaluated employees can be showed in any initial linguistic scale. As an added value, the WSSPA shows comparative graphs, allowing to identify easily employees with high and low performance (see Figure 8).

V. Conclusion

Performance appraisal is a process to determine efficiency and effectiveness of employees, playing a key role in companies competitiveness. In the last few years, the scientific

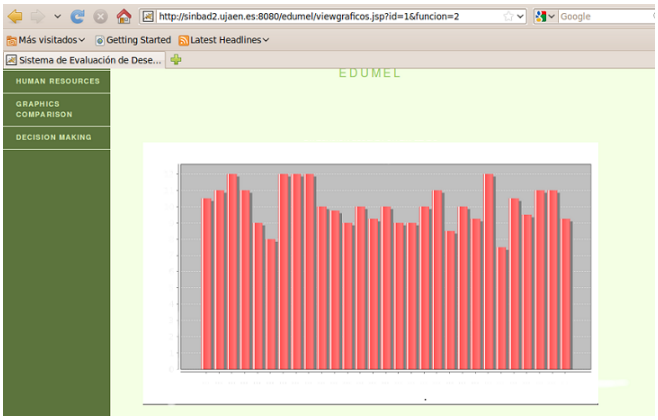

Fig. 8. Comparative graphs

community has developed new models to carry out better evaluation. In this contribution, we have implemented a Web based evaluation system that implements a linguistic 360-degree performance appraisal model based on ELH. This model offers flexibility, accuracy and provides results in any initial scales to facilitate their understanding. These features are wished by the companies in the process of performance appraisal. Furthermore, consequently, the system proposed offers companies a software tool for the performance appraisal in an automatic, easy, fast and distributed way.

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