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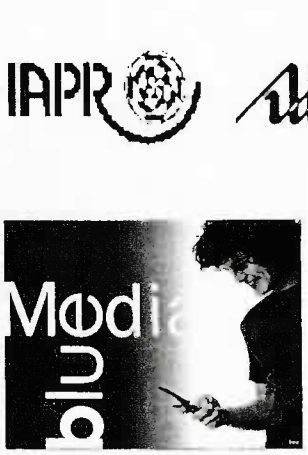

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The method of decision-making support for employment of IT-specialty personnel considering the requirements of employers

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Abstract: *The properties of the task of employment for IT field are given, then problem is reduced to multicriteria task of decision making, functioning in a fuzzy environment. Criteria estimation method allowing regulation and selection of the best alternative according to the scenario appropriate to the requirements of the decision making person has been proposed. Methods for initial data processing for this task realization were set forth. Algorithm for the solution of employment task of IT-specialty personnel were described according to the suggested methodology.*

Keywords: personnel employment task, membership function, criteria fuzzyfication, importance factor of the criteria.

1. INTRODUCTION

Dynamics of expansion of ICT sector, state policy and strategic documents in this area, oriented to integration of the country into global information space, Azerbaijan IT-industry growth rates have caused sharply increased demand for IT-experts. According to the results of monitoring of a supply and demand in the market of the IT-experts, carried out by Institute of information technologies, for today the ratio of demand for IT-experts exceeds corresponding offers approximately in 3 times, i.e. IT-experts in the market are required three times more, than train the high schools [1]. Moreover the diversification of Azerbaijan economy stipulates the further expansion and a deepening of IT applicable spheres and enables to assume, that there is no fear of the fall of demand for IT-experts nearest years.

Penetration IT into the diversified spheres of human activity promotes diversification of the IT-segment, that, on the one hand, causes the transformation of old IT-professions, on the other hand, stimulates occurrence in the market the new ones.

Within the framework of "Monitoring of supply and demand in IT labor market of Azerbaijan", the list of IT professions and their ranking based on evaluation of demand of IT professions was determined [1, 2].

Current article reviews the solution of issues related to recruitment based on evaluation of demand set forth to IT specialists.

2. CHARACTERISTIC ASPECTS AND CONCEPTUAL MODEL OF RECRUITMENT ISSUES RELATED TO IT PROFESSIONS

The list of criteria for recruitment as an IT professional, set forth by the employers for those wishing to be employed have been determined. Criteria are presented in 6 groups: criteria are presented as following, K_1 – age, K_2 – gender, K_3– education, K_4 – personal qualities, K_5 – professional requirements in IT specialization, K_6 – additional capabilities. Each of these criteria is defined by multiple indicators that characterize them [3].

One of the complication problems during the solution of this issue, is determination of knowledge and capabilities of the job applicant in accordance with professional requirements and determination of his/her suitability level to requirements set forth to occupy this position. I.e. above listed are determined through multiple indicators with different importance levels. For instance, it is necessary to determine the level of personal qualities of the job applicant for IT position, such as performance discipline, initiative at work, capability to pass on experience, team work (communication) capability and analytical thinking, and find their importance coefficient with regard to each other; which requires attraction of experts to the process.

As a result of conducted researches, points reflecting the personal approach to recruitment of IT professionals emerged, which demonstrate themselves in different approaches to requirements set forth by the employer to the job applicant applying for the same position depending on the profile, activity direction, property type (government or non-government, joint etc) of the organization.

This point emerges when a requirement indicated as obligatory by one employer for a specific position, can be evaluated as desired or even unimportant by another employer. Naturally, if a job applicant doesn't meet at least one indicator listed as obligatory for this specialty by the employer, his chances of getting accepted to the relevant position equals to zero.

Statistical results of the approach of 72 employers regarding meeting the indicators characterizing education and personal qualities for the specialty of programmer-engineer are presented in Table 1 [1].

Thus, it has been determined that the recruitment issue in IT specialties is:

- Multi-criteria issue;
- criteria are defined by multiple indicators, i.e. they are hierarchic;
- criteria have quantity and quality related characteristics;
- general criteria for occupation of a specific vacancy can be evaluated as desirable, mandatory and unimportant based on the requirements the employer, i.e. contents and characteristics of general criteria can change based on specific situations;

Above listed characteristics of the issue defines the fuzziness of entry information, "loads" the issue to a fuzzy environment and this requires selection of an adequate formalism that considers the uncertainty of

linguistic nature related to formalization of fuzziness of indicators and expert knowledge for modeling of the issue and evaluation of the alternatives. From this point of view, necessity for the use of fuzzy mathematical apparatus has emerged for solution of the recruitment issue.

Table 1. Results of employers' requirements according to educational and personal qualities criteria for programmer-engineer specialty.

Character of employers' requirements / Indicators characterizing the employed person	obligatory (%)	desirable (%)	not required (%)
Education:			
Higher education diploma	68,11	25,02	6,87
Higher IT education diploma	30,58	51,43	17,99
Course certificates	5,64	31,97	62,39
Personal qualities			
Performance discipline	75,06	18,07	6,95
Initiative at work	23,63	55,52	20,85
Capability to pass on experience	13,9	56,91	29,19
Team work capability	34,67	29,19	36,14
Analytical thinking	17,99	50,04	31,97

3. TASK DESCRIPTION

Current article proposes an approaching that enables to consider the individual requirements of the employers. Thus, we are proposing the approach that enables the selection of the best job applicant among all job applicants considering the individual requirement of the employer regarding meeting the general criteria indicators in order to be hired for specific IT specialties.

Thus, let's consider that $X=\{x_1, x_2, \ldots, x_n\}=\{x_i, i=\overline{1,n}\}$ - is a set of job applicants – alternatives the best of which must be selected; $K=\{K_1, K_2, \ldots, K_m\}=\{K_j, j=\overline{1,m}\}$ – is a set of criteria inherent to alternatives and the set is defined by knowledge, capability and personal qualities of job applicants. In this case, suitability of alternatives to criteria can be shown in two-dimensional matrix, whereas element of the matrix will be defined by membership functions reflecting the suitability level of x_i alternative to K_j criteria: $\varphi_{K_j}(x_i): X\times K\to[0,1]$. Here, $\varphi_{K_j}(x_i)$ – reflects the suitability level of x_i alternative to K_j criteria. But these criteria are defined based on multiple indicators of different significance.

I.e. $K_j=\{k_{j1}, k_{j2}, \ldots, k_{jT}\}=\{k_{jt}, t=\overline{1,s}\}$.

Let's suppose,

1) $\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\}$ membership function $\{\varphi_{k_{j1}}(x_i), \varphi_{k_{j2}}(x_i), \ldots, \varphi_{k_{js}}(x_i)\}=\{\varphi_{k_{jt}}(x_i), t=\overline{1,s}, j=\overline{1,m}\}$ of $\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\}$ alternatives to criteria indicators is known (supply base);

2) Evaluation of the decision making person (DMP) regarding obligation (O), desirability (D) and unimportance (U) of meeting $\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\}$ criteria indicators for occupation of a specific position is known (requirement base).

Objective of the issue is to select the best alternative from the supply basis in accordance with demand basis for occupation of a specific vacancy or make a ranked list of alternatives from best to worst : $X: K^*\to X^*$. Hereby, X – is the set of primary alternatives, K^* – is the set of indicators marked with obligation (O), desirability (D) and unimportance (U), X^* – is the ranked list of selected alternatives in accordance with demand.

4. ISSUE SOLUTION

4.1. MODELING OF THE DEMAND BASIS

Employer's criteria indicators $\{k_{jt}, t=\overline{1,T}, j=\overline{1,m}\}$ for occupation of a specific vacancy are divided into three groups as obligatory (O), desirable (D) and unimportant (U) and form relevant sets: {O}, {D}, {U}.

Let's note that,

$$\{O\}\cap\{D\}\cap\{U\}=\text{Ш}$$

and

$$\{O\}\cup\{D\}\cup\{U\}=\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\},$$

i.e. these sets do not have a common element, any $k_{jt}\in K_j\in K$ element can belong to only one of these sets. Following possible situations – scenarios can happen depending on distribution of $\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\}$ criteria indicators among {O}, {D}, {U} sets.

Scenario 1. All indicators defining K_j criteria are obligatory: $k_{jt}\in\{O\}, t=\overline{1,s}$;

Scenario 2. A part of indicators defining K_j criteria are obligatory, another part is unimportant: $k_{jt}\in\{O\}\cup\{U\}, t=\overline{1,s}$;

Scenario 3. All indicators defining K_j criteria are desirable: $k_{jt}\in\{D\}, t=\overline{1,s}$;

Scenario 4. A part of indicators defining K_j criteria are desirable, another part is unimportant: $k_{jt}\in\{D\}\cup\{U\}, t=\overline{1,s}$;

Scenario 5. A part of indicators defining K_j criteria are obligatory, another part is desirable: $k_{jt}\in\{O\}\cup\{D\}, t=\overline{1,s}$;

Scenario 6. A part of indicators defining K_j criteria are obligatory, another part is desirable and a third part is unimportant: $k_{jt}\in\{O\}\cup\{D\}\cup\{U\}, t=\overline{1,s}$;

Scenario 7. All indicators defining K_j criteria are unimportant: $k_{jt}\in\{U\}, t=\overline{1,s}$.

(Let's note that, scenario 1 and 3 did not emerge during research and scenario 6 was the most common scenario.).

4.2. FORMATION OF THE SUPPLY BASIS

Mathematical formalization of criteria must be carried out in order to find the membership function of

$\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\}$ criteria indicators to alternatives.

K_1, K_2, K_3 are exact criteria and relevance of the job applicant to these criteria is determined in a formal order, based on the documentation submitted by the applicant.

An Indistinctness and quality characteristic, and support of expert knowledge during the definition of K4, K5, K6 criteria, make it necessary to use fuzzy mathematical logic methods that enable to form the linguistic phrases of the natural language [4]. To that effect, it is necessary to develop mathematical formalization of criteria for realization of supply base, and the mechanism of turning the linguistic phrases regarding the level of satisfaction of criteria into a fuzzy value defined in the — [0,1] interval.

Mathematical formalization of criteria

A criteria indicators scale is selected in order to determine the membership function – fuzzy value of the alternative criteria indicators, i.e. each criteria indicator is divided into rating levels in accordance with quality levels (excellent, good, acceptable, poor etc) of the relevant linguistic phrases of the natural language.

After performing of each criteria factor, appropriation of a fuzzy value from the fuzzy set to a linguistic rating level selected for it must be performed (Table 2).

Table 2. Mathematical formalization of "Work experience in specialty"

Quality rating of "Work experience in specialty" indicator	Linguistic rating	fuzzy subset, set in [0, 1] interval
1) Has three or more years work experience in specialty	excellent	[0,98-1]
2) Has 1 to 3 years work experience in specialty	good	[0,8-0,97]
3) Has 6 months to 1 year work experience in specialty	acceptable	[0,5-0,79]
4) Has less than half a year work experience in specialty	poor	[0,1-0,49]

With this objective, members of the expert team determines an individual fuzzy value from the relevant value set defined in [0,1] for each rating level. As a result of unification of individual value as a common, collective value, the final fuzzy value of the rating level is determined.

Final – collective fuzzy value determined by the experts based on individual fuzzy values can be defined in following ways: 1) by intersection of fuzzy sets; 2) by connection of fuzzy sets; 3) by making an agreed selection on fuzzy sets. Based on the last approach, individual evaluation of the "superior" expert with special creativity is considered as the collective value. Such expert must choose such a membership value out of all individual membership values defined by experts as a collective membership value at each point of the possible alternatives space, that in general situation, it must differ from remote values in collective and hold a determined "middle" position

Thus, a "supply basis" is formed by finding a $\{\varphi_{k_{j1}}(x_i), \varphi_{k_{j2}}(x_i), \dots, \varphi_{k_{js}}(x_i)\} = \{\varphi_{k_{jt}}(x_i), t=\overline{1,s}, j=\overline{1,m}\}$ membership function based on how alternatives meet $\{k_{jt}, t=\overline{1,s}, j=\overline{1,m}\}$ criteria indicators of alternatives.

5. EVALUATION OF ALTERNATIVES

Evaluation of alternatives based on proposed indicators is carried out in three stages.

In the first stage, suitability of the job applicant to relevant requirements of the employer on indicators of K_1, K_2, K_3 criteria determined based on documents submitted by the job applicant.

In the second stage, evaluation of alternative based on K_4, K_5, K_6 criteria is carried out. Definition of membership function of the alternative to these criteria is realized through a scenario relevant to evaluation of these criteria in the supply basis.

Claim 1. If a part of indicators defining $K_j = \{k_{jt}, t=\overline{1,s}\}$ (here $j=\overline{4,6}$) criteria (scenario 1,2,5,6) is obligatory and the value of membership function of alternative to at least one of these indicators equals to 0, then the membership function of the alternative to the relevant criteria will also equal to 0.

Claim 2. $K_j = \{k_{jt}, t=\overline{1,s}\}$ (here $j=\overline{4,6}$) is only defined by desirable (or partly unimportant – scenario) indicators and the value of membership function of alternative to at least one of desirable indicators differs from 0, then the membership function of the alternative to the relevant criteria will also be different from 0.

Thus, membership function $K_j, j=\overline{4,6}$ of the alternative, depends on distribution of indicators characterizing it among {O}, {D}, {U} sets, scenarios.

Calculation of membership function of the alternative $K_j = \{k_{jt}, t=\overline{1,s}\}$ to the criteria, is based on membership function of the indicators characterizing the criteria and its "curve" i.e. their aggregation based on principal of their importance factor depicted in thus [5], following are proposed for calculation of membership function of the alternative to $K_j = \{k_{jt}, t=\overline{1,s}\}$ criteria:

1. *Based on Scenario 1,* membership function of the alternative to criteria *Kj* is calculated using following equation.

$$\varphi_{K_j}(x_i) = \prod_{t=1}^{s} \left[\varphi_{k_{jt}}(x_i)\right]^{w_{jt}} \qquad (1)$$

Here $\varphi_{k_{jt}}(x_i)$ - is the membership function of the job application to k_{jt} indicator, w_{jt} – is the importance factor *of* k_{jt} indicator. Let's note that, $\sum_{t=1}^{s} w_{jt} = 1, \quad t=\overline{1,s}$ condition must be met for criteria indicators.

2. *Based on Scenario 2*: Suppose, g quantity of indicators defining K_j criteria have been evaluated as unimportant and naturally g<s. Then, the membership function formula of the alternative to K_j criteria (1) is defined based on s-g quantity of obligatory indicators.

3. *Based on Scenario 3:* Membership function of i^{th} alternative to K_j criteria is calculated using

$$\varphi_{K_j}(x_i) = \sum_{t=1}^{s} w_{jt}\, \varphi_{k_{jt}}(x_i) \qquad (2)$$

equation.

4. *Based on Scenario 4,* membership function of i^{th} alternative to K_j criteria is found only based on formula for indicators included in {D} set (2).

5. *Based on Scenario 5,* in order to find the , membership function of i^{th} alternative to K_j criteria, firstly the difference of membership function of its obligatory indicators from 0 is checked and if one of them equals to zero, then $\varphi_{K_j}(x_i)=0$ is accepted, otherwise in accordance with formula (2), the value of membership function to K_j criteria is calculated. i.e.:

$$\varphi_{k_j}(x_i) = \begin{cases} 0, & if \quad \prod_{d=1}^{g} \varphi_{k_{jd}}(x_i) = 0 \\ \sum_{t=1}^{s} w_{jt}\, \varphi_{k_{jt}}(x_i) & if \quad \prod_{d=1}^{g} \varphi_{k_{jd}}(x_i) \neq 0. \end{cases} \qquad (3)$$

Here, $k_{jd} \in \{M\}, d = \overline{1,g}$ — K_j is the obligatory indicators characterizing K_j criteria and naturally in this case $g<s$.

6. During the solution of the problem based on *Scenario 6,* if S quantity of indicators of K_j is evaluated as unimportant, then it is possible to find the membership function of the alternative to this criterion by carrying out the operational sequence relevant with formula (3) in accordance with *s-g* quantity of indicators.

7. During the solution of the problem based on *Scenario 7,* during the definiton of membership function of the alternative to K, (i.e. the value of the job applicant's chance to get the job), its membership function to K_j is not taken into consideration.

In the **Third stage,** the value of the job applicant's chance to get the job, i.e. $\varphi_K(x_i), i = \overline{1,n}$ must be defined. The value of membership function of alternative to K, is based on aggregation of its $\{\varphi_{K_j}(x_i),\ j = \overline{4,6}\}$ membership function to $K_j, j = \overline{4,6}$ criteria [5]. i.e. the evaluation of the alternative's chance to get the job is defined based on $\varphi_K(x_i) = \sum_{j=4}^{6} w_j\, \varphi_{K_j}(x_i)$ formula.

6. USE OF INFORMATION ABOUT IMPORTANCE OF THE CRITERIA

On the basis of the obtained information for today preparation of methods for determining of criteria importance factors is one of the points the attention is attracted to in the sphere of multicriterion problems solution.

Information about mutual importance, significance of the criteria can be referred by the experts can be:

— expressed by the linguistic expressions representing mutual relative advantage (or weak points) and their pair comparison;

— referred to the establishing of appropriate grade to reflect assessment value of the considered criterion against the background of criteria defining any global factor.

In first case to display mutual relative advantage of the criteria the linguistic expressions of the type given below are used:

- criterion K_1 has a weak advantage over criterion K_2
- criterion K_2 has rather more advantage over criterion K_1 and etc.

Such linguistic expressions for degree of mutual relative advantage of compared criteria are estimated by 9-point Saati's table [6].

In the second case information about the importance, significance against the background of common criteria reflects value of any criterion.

In such case it is more advantageous to use method of importance factor on the basis of 10-point system of expert estimation of the criteria [7].

7. RESULT

A system supporting the decision making system is used in ANAS Institute of Information Technology during the recruitment of IT specialized staff. The results of the survey with 101 specialist-experts specialized in IT field are used for the formation of the information base of the system. It is considered to use the results obtained from the realization of the system for decision making during regulation and administration of supply and demand in IT labor market.

Proposed solution method of the issue of recruitment of IT specialized staff is realized in Delphi 2009 programming system.

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