PERSONNEL RECRUITMENT METHODOLOGY FOR ENERGY EQUIPMENT SERVICES DEPARTMENTS WITH EMPHASIS ON SYSTEM RELIABILITY

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Abstract. Recruitment at the field of energetics is the primary factor for the reliability of a complex system. Clearly, that the personnel must be recruited according to the system complexity and reliability, so we must have a method for personnel recruitment. Here we have shown a method for the scoring system that can be used in this task.

Keywords: human reliability, scoring, fuzzy sets.

Introduction

Personnel recruitment on the workplaces connected with electromechanical systems service is one of the problems the decision of which has a priority character. There are two components which define the necessity of innovative technologies application by working out of the personnel recruitment procedure: minimization of the risks connected with the human factor, energy effectiveness and energy saving.

The economic profit of carrying out the recruitment, considering the served system characteristics, and also the features of applicants can be defined only approximately; however, by estimations of experts regarding the use of energy from 30 % to 80 % of economy is reached at the expense of leveling of the "the human factor". By the words of S.E. Magid, the chief of the "Technical educational systems in energy technologies" UNESCO department: "The number of compelled faults of domestic power units because of equipment refusals on heat power stations is 30 %. The share of operational personnel fault in these infringements makes a considerable size (to 15 %). As a whole in the Russian Open Society "United Power Systems" the infringements percentage because of the personnel from infringements in total makes 2 %. At the same time, on power stations this quantity makes 18 %. In the power supply systems of Siberia the relative quantity of infringements because of the personnel reaches 50 %." [1].

For the solution of the personnel recruitment problem on the specified above positions it is offered to construct a scoring system which would allow estimating the personnel reliability on the basis of the maximum general characteristics of the served equipment, and also the data on the applicant. Here under scoring we understand a model of the applicant classification for various groups if the characteristic which divides these groups is unknown, but other factors connected with the characteristic interesting us, under human reliability – probability of knowing that (1) it carries out correctly some, demanded by system, action for demanded time and (2) does not carry out the superfluous actions, capable to lead to decrease in reliability of the served system.

Materials and methods

First, we have performed an expert survey in 2009 – 2010 where energy department managers have been asked for feedback form completion. For an estimation of the human error possibility in the set conditions we have offered the approach consisting in paired comparison by the experts of importance of negatively influencing factors for revealing of their relative scales [2]. In total it was offered to use 29 performance shaping factors (PSFs) effect on the personnel serving the power equipment, that concern six groups: psychological, social, external industrial, physiological, equipment condition, qualification.

We represented questions as scales, where the center is an equal influence degree of two PSF's on a worker, and the ends – maximal degree of influence by near written to the mark of the expert PSF under the second.

So, we received 29 values from each expert and could evaluate the aggregate values. For processing of the survey results we used the SAM method [3], where the distance between the triangular fuzzy numbers, calculated under formulas (1 – 3).

$$S\left(\tilde{R}_i, \tilde{R}_j\right) = \frac{\tilde{R}_i}{\tilde{R}_j}, \tag{1}$$

$$Val(S) = \frac{\left(\overline{S} + 4 \cdot \dot{S} + \underline{S}\right)}{6}, \tag{2}$$

$$D = \begin{cases} Val(S), Val(S) \le 1 \\ \dfrac{1}{Val(S)}, Val(S) > 1 \end{cases}, \tag{3}$$

where $\tilde{R}$ – the fuzzy number corresponding to an expert estimation of the superiority of one factor over another,

S — measure of the same factor estimation by different experts;

D — defuzzifying distance, degree of distinction of the expert estimations.

It has been revealed that the greatest scales groups of PSF possess: qualifying, psychological and equipment condition.

The direct and indirect estimation of scales spent for the purpose of data verification, given by the experts, has revealed only small deviations in relative scales at preservation of the general qualitative picture: the groups are stratified in two parts, the first of them includes the qualification factors, psychology and the equipment condition, into the second — social, physiological and reflecting influence of external factors of manufacture (noise, bad illumination etc.).

According to the received results it is possible to draw a conclusion on internal consistency of the collected data and the possibility of further operating by them within the limits of construction of own model of reliability of the person.

After ranking and quartiles calculation it has appeared that to top quartiles of PSF there are exclusively representatives of two groups: psychological and qualifying (Table 1). These factors will have the greatest weight at construction of the model on the basis of the offered survey.

Table 1

Top quartile of PSFs and its groups

Group	PSF	Weight
Qualification	Little experience of work	3.00
Psychological	Carelessness	2.92
Qualification	Badly formed	2.86
Psychological	Unconscientiousness	2.84
Qualification	Absence of the admission	2.71
Psychological	Bad emotional condition	2.51
Psychological	Bad educability	2.32
Psychological	Improper temperament	2.30

First, for check of validity of the data collected during the expert poll (external consistency) the method of a triangulation of models, owing to inaccessibility of statistics by errors of the personnel and impossibility of carrying out of the experiment has been chosen. As a base model for comparison the model offered Pyy Pekka [4] has been chosen.

As a result of triangulation it is possible to conclude that the model constructed on the basis of logistical function with parameters can be applied to estimation of probability of an error of attendants:

w_1 – expressiveness of sluggishness;

w_3 – skill level of the personnel;

w_4 – estimation of complexity of the equipment;

w_5 – estimation of the condition of the equipment;

w_6 – degree of expressiveness of negative psychological factors.

$$p = \frac{e^{2.67-0.29\cdot w_1-0.48\cdot w_3-0.33\cdot w_4-0.38\cdot e_5-0.40\cdot w6}}{1+e^{2.67-0.29\cdot w_1-0.48\cdot w_3-0.33\cdot w_4-0.38\cdot e_5-0.40\cdot w6}} \quad (4)$$

We found the model to be simple, and it can be used for our purposes. Second, the lower bound of distributed electromechanical system reliability, representable in a kind of the count with unreliable nodes, probably to estimate proceeding from the following, there are enough general parameters: vertex connectivity, node reliability, maximum degree of node and node number [5]. Suppose, that human reliability is lower than the node reliability and equal on all nodes of the graph that represent the electromechanical system. In this case we can use this algorithm for personnel scoring.

$$R(G)_l = \sum_{i=2}^{r}(r-i+1)\cdot\left(q^k\right)^{(r-i)}\cdot\left(1-q^k\right)^i, \quad (5)$$

where

$$r = \left(\left(n-\Delta\right)\cdot\left(\frac{n\cdot(k-1)}{k}+1\right)\right)+2^{\left[\frac{1}{k}\right]+\left[\frac{3}{\Delta+k}\right]-\left[\frac{\Delta}{n-1}\right]}+1 \quad (6)$$

$q = 1 - p$;
k – vertex connectivity;
Δ – maximum degree of node;
n – node number.

$R(G)_l$ can be used as the worker's score, showing how this person can work with the enterprise systems. For the data storage purposes we need to create DB with fuzzy numbers storage possibility, so we offer an E-R model that can be doing this (Fig. 1). Here we present only a general model, because the full model is very complex.

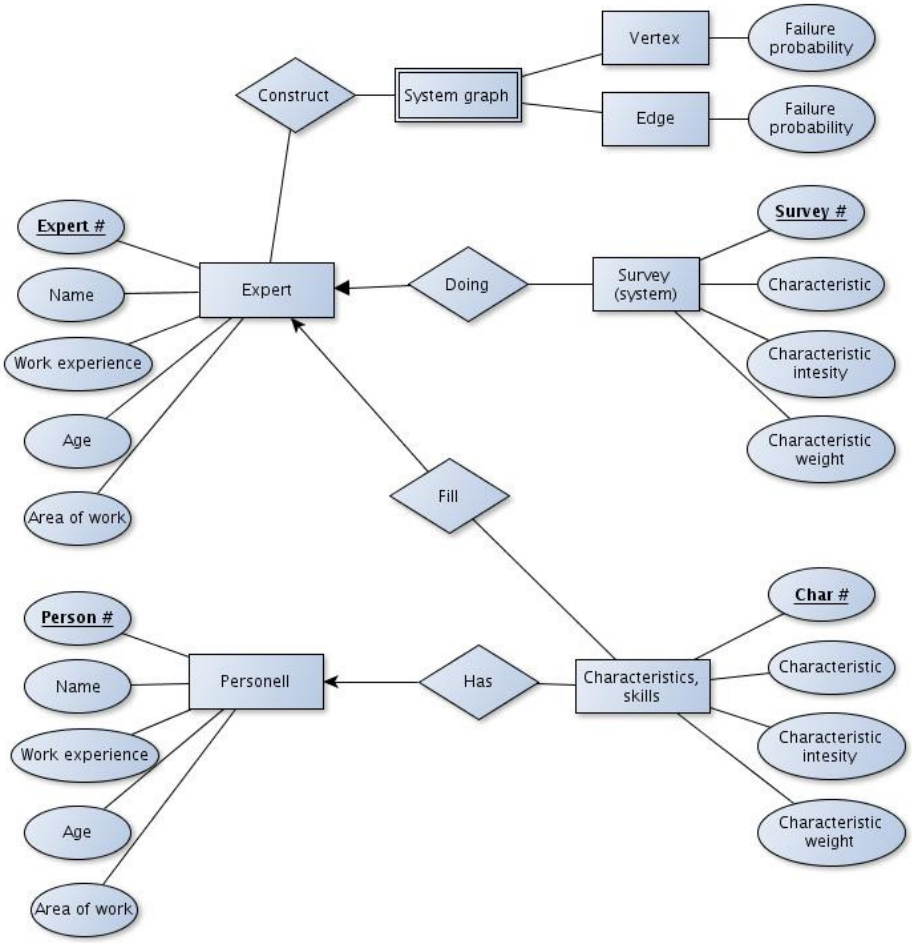

Fig. 1. **E-R model for DB**

So, we can realize this schema with any client-server RDBMS, such as postgreSQL or MySQL, depending on the enterprise or department size.

Results and discussion

Our experts chose only some PSF as the main. As we see, the qualification, psychological factors are the main at the PSF structure. So, the skills and characteristics, mentioned above (Table 1) must be corrected first at the departments. Using this set of characteristics we can calculate the human reliability with the characteristics of the system, or subsystem, where the worker operates.

Conclusions

Now we are working at a more complex dynamical model and multiagent simulation, where the time-factor can be allowed. More, we try to use more complex models for error possibility that can use information of one factor intensity strengthening depending on the others.

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