Digitalization of HR-Management Processes of Project-Oriented Organizations in the Field of Safety

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Abstract

The article presents the results of research on HR-processes. The necessity of automation of HR-processes is substantiated. The main tasks to be solved by HR-automation are identified. Particular attention is paid to the issue of automation of personnel management. The significance of the obtained results lies in the possibility of increasing the efficiency of the enterprise with HR automation. The main stages of building an incremental life cycle model for the development of an intelligent decision-making information system (HRIS) with a set of mathematical methods for decision-making. Creating an effective system for data analysis and selection of candidates is one of the most important tasks of a modern personnel management system (PM). Computerization of personnel records management is one of the main conditions for the rational organization of record-keeping processes in the organization, a means of improving the efficiency of personnel services, a factor in increasing productivity and efficiency of managers. Tasks that are solved in the process of staffing belong to the class of tasks of complex decisions in conditions of uncertainty. From this point of view, scientific and methodological tools were analyzed, acceptable and selected expert method. An information-analytical system has been developed for the formation of project teams of higher education seekers in higher education institutions of the civil protection system and to improve the quality of personnel decision-making through an organized relational database and knowledge.

Keywords 1

Information system, project team, database, digitalization, HR process

1. Introduction

Projects of digitalization and digitalization of personnel management and formation of project teams are developing rapidly. The transformation of HR-technologies under the influence of digitalization of business processes has led to the development of innovative human resource management systems (HRM systems). An important factor for higher education institutions in the civil protection system at the stage of initiating the development of a new information analytical system of personnel management (HRIS) are resource constraints, which determine the choice of flexible Lean project management methodology (careful use and allocation of resources).

2. Analysis of recent research and publications

Domestic and foreign scientists, such as Bushuyev S.D. [1-3], Chumachenko I.V. [5], Kononenko I.V. [4] and others, deal with the issues of effective human resources management.

The development of modern science and computer technology poses a number of new challenges

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for scientists and researchers, such as optimizing the recruitment process and reducing the processing time of relevant data of project team members.

According to research by Bersin & Associates, organizations with a formalized strategy in the field of HR are 26% more effective than their competitors. HR managers of innovation organizations use an approach based on data analysis by statistical methods and analytical complex. Due to this, the manager chooses the optimal solution. According to a survey conducted by KPMG International Cooperative, only 17% of managers believe that HR analysis in their organizations is focused on solving rational personnel tasks. The key trends in HR transformation are HR analytics, optimization of the use of resources for personnel and strategic planning of human resources. HR analytics allows you to use different types of data to predict effective models and improve processes. Cost optimization based on data analysis helps to increase the efficiency of human resource management and identify new opportunities to achieve the goals of the organization. Through analytical processing of information, managers can effectively plan the need for human resources, anticipate the number of staff in the future, assess the staffing or overstaffing, as well as recommendations for specific proposals to support management decisions.

Based on analytics data to manage project team members, you can optimize talent selection and increase their involvement. And given the percentage of voluntary redundancies, the task of retaining employees becomes key for HR teams. The greatest investment in HR analytics and data-based decision support systems requires integration with databases to provide an integrated approach to analyzing team members' personal data. According to Gartner, by 2025, an average of 60% of organizations in the world will invest in automation of HR processes.

A simple and fast method of consolidating and comparing BIO HR data (benchmarking, insights, opportunities) allows to analyze eNPS (staff loyalty), assess competencies, performance of team members on "reference" parameters and identify "hidden" knowledge and patterns that correlate with the results of the organization.

Deloitte found that the income of companies that use HR analytics is 82% higher than those who do not use this approach.

To support decision-making, effective information support HR managers need to use databases and knowledge bases, the optimal application of methods and rules of forming a system of criteria, ranking candidates, selection and analysis of candidates will intellectualize the personnel decision-making process.

In [18] the scientific and methodological apparatus of personnel selection for the internal troops of the Ministry of Internal Affairs of Ukraine is considered, which uses the theory of fuzzy sets to describe four-point scales used in expert assessment of candidates. This has significantly simplified the procedure for processing evaluation results, formalized them and developed a software product that implements information and analytical technology of professional selection.

Fuzzy cognitive maps (FCMs) were proposed by B. Cosco [16] and are used to model the causal relationships found between the concepts of a particular field. Unlike simple cognitive maps, FCMs are a fuzzy oriented feedback graph whose nodes are fuzzy sets. Thus, FCM combines the properties of fuzzy systems and neural networks. The active use of fuzzy cognitive maps as a means of modeling systems is due to the possibility of visual representation of the analyzed system and the ease of interpretation of causal relationships between concepts.

In [15] as a prototype was selected developed at the department software product "Selection", used to solve problems of decision support for the selection of personnel to replace certain categories of servicemen of the Ministry of Internal Affairs of Ukraine. To create an intelligent system, it is advisable to use the concept of "rapid prototype", the essence of which is that at the initial stage a version of the IS is developed, which must meet two conflicting requirements: solve typical problems and labor costs should be minimal.

In [14] the possibility of applying the concordance coefficient W, Spearman's rank correlation coefficients WS and Fechner sign correlation coefficients WF and modified concordance coefficient (MCC) Wm is considered to solve the problems of rating evaluation of some objects of comparison (OP) based on the results of examination with the use of four-point order scale. When solving professional selection problems, it is advisable to use the modified concordance coefficient in algorithms for constructing ranked lists of any comparison objects using a four-point order scale. This

ratio is also suitable for establishing the consistency of the results of expert evaluation, the level of preparedness of an individual specialist or production unit to perform tasks within the so-called team.

In [18] the analytical system for the admission committee of the university is investigated. The system (IAS) provides organization and support of the admissions committee at all stages, from the analysis of the recruitment plan to the formation of the student body. To implement the functions, an automated workplace was created with the help of WEB-technologies, the implementation of an interactive user mode with the implementation of the necessary checks directly in the process of entering data into the database. IS is a single WEB-interface for the operator, which allows you to serve the applicant. The operator carries out the registration of the entrant by filling in the personal data of the entrant. The recommendation for enrollment is made by creating a list of applicants using existing forms through a web-browser. The information is entered into the database.

Willingness to use HR analytics remains a serious problem. After several years of discussing this issue, only 8% of respondents said they had useful data; only 9% believe that they have a good understanding of what characteristics of employees lead to success in their organizations; and only 15% of all used HR systems and a set of talent indicators for line managers.

Analysis of information systems has shown that not one of them does not allow to effectively solving problems due to their low functionality. At the same time, the cost of these IAS was unacceptably high. As a result, it was decided to develop its own automated IAS, which would meet the requirements of higher education institutions of the civil protection system, would solve all current problems, and would be able to expand their functionality when changing the regulatory framework.

Despite a number of studies in this area, many issues related to the automation of the information system of the human resources department remain unresolved. Existing information systems in HR do not fully use analytical data processing and forecasting based on data. This reduces efficiency in human resource planning. The main difficulties arise when combining the organization's HR operations with personnel data, underdeveloped analytics and integration between different data sources, HR systems.

3. The bulk of research

In the current market of IT products, the available automated personnel management systems can be divided into those based on the concept of ERP, CRM-systems (customer relationship management), financial and analytical systems, reference systems, information security systems, design systems CASE means.

ERP (Enterprise Resource Planning) - an organizational strategy for integrating production and operations, human resource management, financial management and asset management, focused on continuous balancing and optimization of enterprise resources with a specialized integrated application software package that provides a common data model and processes for all areas of activity. ERP is primarily an information system that allows you to store and process most of the critical data for the company's work - the role of analytics.

HRIS software often contains a number of interconnected databases. HRMS (Human Resource Management Software) is a more complete human resource management tool that offers several functions of human resource management, such as payroll, payroll administration, performance analysis and review, and recruitment and training. Personnel management system is a multifunctional software. Therefore, you should be extremely careful before choosing one for your company; HRIS should be mobile and user-friendly. In the Ukrainian markets, mainly such products of Western companies as «SAP», «Oracle», «BAAN», «PeopleSoft» and «Platinum» represent this type of system.

To automate the activities of the personnel department, as for any other department of the enterprise, a number of software products have been developed. The choice of automated information system (IAS) depends on its functional features, the scale of the enterprise and so on. The list of software products developed for human resources is quite large and constantly updated. However, not all companies can afford quite expensive software products, and some organizations still keep all records in paper form.

For successful management of organizations it is necessary to be able to properly make various management decisions and choose methods of making them. The article considers the peculiarities of the application of the method of expert assessments for decision-making in the functioning of project institutions. The current objective methods of determining the optimal development of the organization in conditions of uncertainty are not able to accurately reflect in quantitative terms the qualitative content of HR processes and do not allow to determine a comprehensive assessment. Therefore, one of the alternatives is to use the method of expert assessments.

When solving expert evaluation tasks in the fields of qualimetry and professional selection using different scales, there is a need to identify the relationship between quantitative and qualitative indicators of some objects of comparison (OP), if they need or can be ranked. To do this, use the Pearson correlation coefficient for scales of relations, intervals and quantitative scales, Spearman or Kendall rank correlation and others - for the order scale.

In the practice of solving the problems of expert evaluation, the concordance coefficient is used as the opinions of experts agree [15].

$$W = \frac{\sum_{i=1}^{n} dj^2}{\frac{1}{12}[m^2(n^3-n)-m\sum_{i=1}^{m} Ti]}, \quad (1)$$

where n is the number of factors; m - number of experts; dj - deviation of the amount from the average amount; Ti - the results of intermediate calculations.

$$dj = \text{Sj-}\frac{\sum_{j=1}^{n} Sj}{n}, \quad (2)$$

where Sj is the sum of the ranks. The concordance coefficient takes values from 0 to 1. The greater the value of the concordance coefficient, the greater the degree of agreement of experts. At $W = 1$ there is a complete agreement of experts; if $W = 0$, then there is almost no consistency.

When evaluating a comparison object by several parameters, the total evaluation of the object is as follows: experts make judgments about the weight of parameters (eg, criteria weights) and evaluate the object according to all parameters (eg, evaluation of alternatives by criteria). Analysts process the received estimates. Calculate the normalized weight of parameters (eg, criteria) according to the formulas of arithmetic mean, geometric mean or weighted average. Then comprehensive assessments are normalized. For the analysis of candidates, it is advisable to use the index method, which is based on the concept of "reference" candidate - a talent who has the necessary skills for the project. The suitability of the applicant is determined on the basis of the ratio of the deviation from the "ideal candidate" to the maximum deviation. If the deviation of the candidate is equal to the maximum, the coefficient of conformity will be equal to 0. If the candidate has all the necessary skills, it coincides with the "portrait of the ideal candidate" and the coefficient of conformity is 1. Deviation from the reference candidate is calculated as the distance between points. Since the number of requirements for inclusion in the team of a higher education institution of the civil protection system may vary due to the regulatory component, the following is proposed (formula 3):

$$\partial(Si, Si') = \sqrt{\sum_{i=0}^{n}(Si - Si')^2}, \quad (3)$$

where $\partial(Si, Si')$ – is the distance from the skill set of the candidate Si to the skill point Si',

n – is the number of skill requirements,

xi – is the coordinate of the point x on the i-th axis.

The calculation of the deviation fr

om the "reference" object of comparison for inclusion in the project with two requirements can be visualized in the form of a coordinate system, where the X and Y axes reflect the level of skills for training in ZVO TsZ (Figure 1).

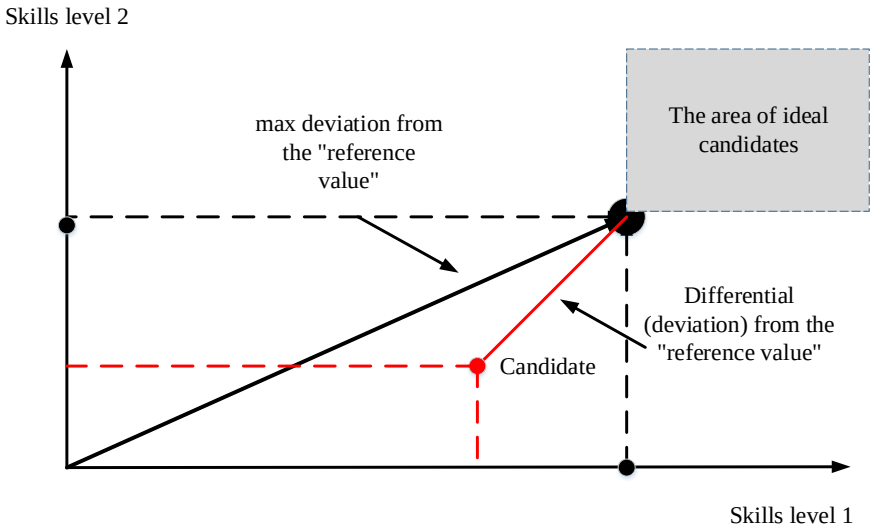

Figure 1: Area of the "ideal" candidate for inclusion in the team of higher education institutions of the civil protection system

If the candidate's level of all skills is equal to or greater than required, then he falls into the area of "ideal" applicant and the coefficient of compliance will be equal to 1 (Figure 1). The input index method receives candidate profile data and information on the requirements for inclusion in the project team. As a result, a list of profiles of candidates is generated, sorted in descending order of the applicant's compliance with the project for training in a higher education institution of the civil defense system. The most suitable candidates will be presented to decision makers from the first records of the received rating.

Information and analytical system of professional selection involves the implementation of such a sequence of procedures.

1. Expert assessment of candidates' compliance with a certain model.
2. Preliminary processing of evaluation results. Construction of visualized personograms of candidates. Calculation of the coefficients of conformity of each of the components of the professional profile for each of the candidates.
3. Calculation of generalized indicators and ratings of each of the candidates and compiling a ranking list.

A graphical representation of the incremental life cycle model is presented in Figure 2.

Incremental development is the process of partial implementation of the entire system and functionality. It operates on the principle of a cascading model with floors, so that the functional capabilities of the product, which are suitable for use, are formed earlier. Requires a complete pre-formed set of requirements, can begin with the formation of common goals, which are then clarified and implemented. The incremental model is an advanced cascade model. As a result of each increment, a functional product is obtained. The use of successive increments allows you to combine the results into a complex product, ie the ability to divide the problem into parts that can be effectively managed.

The composition of software and hardware depends on the specific conditions of the enterprise, namely the scale of production, staff, organizational structure of the management staff, the scale of document flow, the need for operational and retrospective information, the degree of centralization of documents and more.

HRIS is a set of intelligent information applications and tools used to manipulate data, analyze it and provide the results of such analysis to the end user. Modern DSS makes it possible to predict the degree of influence of decisions on the further development of the organization. By multidimensional analysis we mean the technique of presenting data from different points of view, or "measurements". Data is uploaded to the repository as facts, and "measurements" are indexes that provide easy and

quick access to these facts from different directions. The implementation of multidimensional analysis requires the support of a specialized multidimensional database.

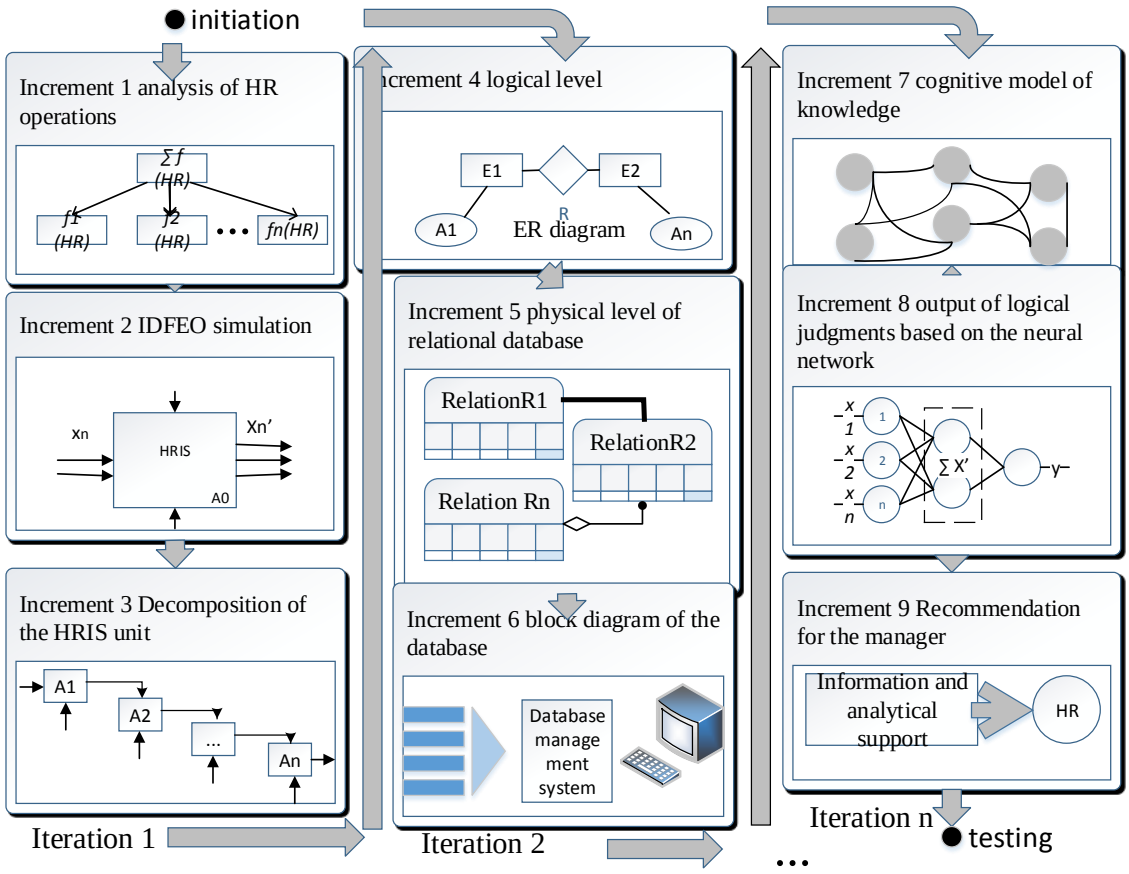

Figure 2: Incremental HRIS development lifecycle model for higher education institutions of the civil protection system

Multidimensional processing tools can be implemented within relational technology. In DSS operating on aggregate data, the traditional technology of preparing integrated information based on queries and reports has become ineffective due to a sharp increase in the amount and variety of source data. The solution was found and formulated in the form of the concept of data warehouse (Data Warehouse, DW) [18].

Using the client-server architecture maintains the maximum level of storage reliability, relevance and reliability of programs designed for many users of IS with a centralized database, independent of the hardware of the database server.

Features of the software solution are:

- its web-orientation;
- adaptability to the specifics of the activity;
- the ability to select candidates from the list, after entering the requirements for the candidate;
- support for an unlimited number of users working with databases;
- the ability to create reports and various documents of templates.

Therefore, the client-server concept was chosen for HRIS, the architecture of the system is shown in the Figure 3.

The use of the universal modeling language UML allows you to define, visualize and document object models of system software. In turn, this makes it possible to simplify the understanding of the structural organization of the software product and determined the specification of the tasks of implementation of the software complex of the HRIS information system.

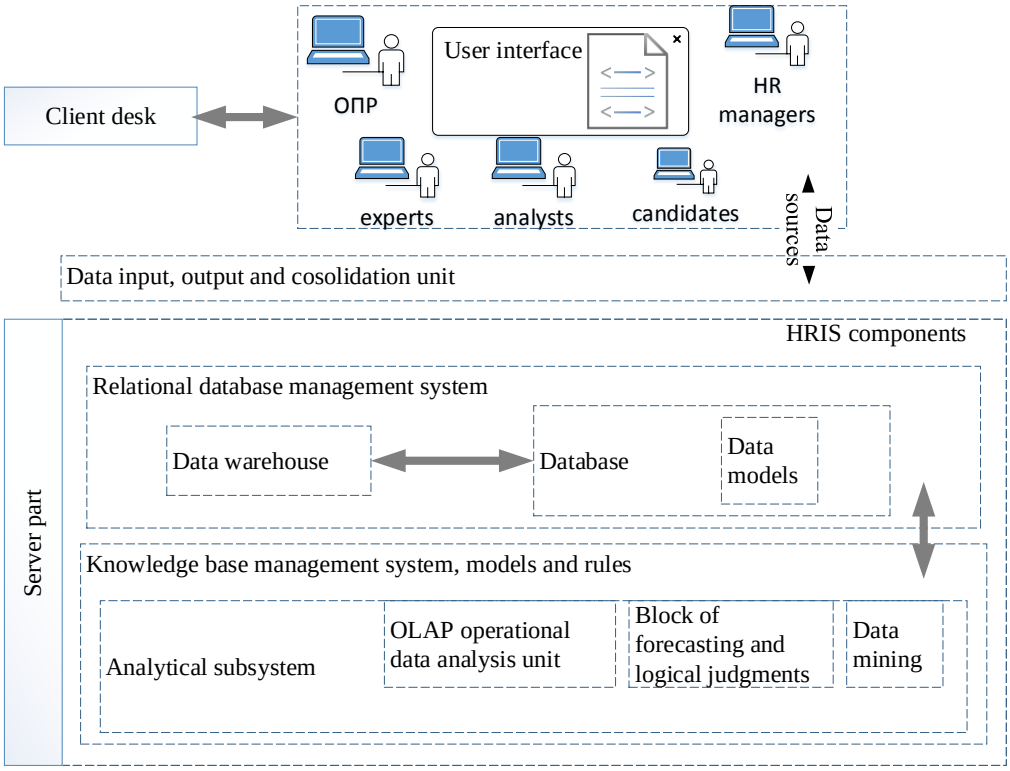

Figure 3: HRIS Architecture

For the design, construction and software implementation of the system requires its orientation to support decision-making within the subject area. The simulation phase builds regression and optimization of a subset of variables, decision-making based on neural network techniques, construction of classification trees for optimal set of variables and optimal partitioning of many objects, clustering and optimal grouping of objects. At the stage of data preparation access to any relational databases, text files is provided. Based on the prepared data, special procedures automatically build different models for further forecasting, classification of new situations, identification of analogies. The application data supports the construction of five different types of models - neural networks, classification and regression decision trees, Bayesian analysis and clustering (Figure 4).

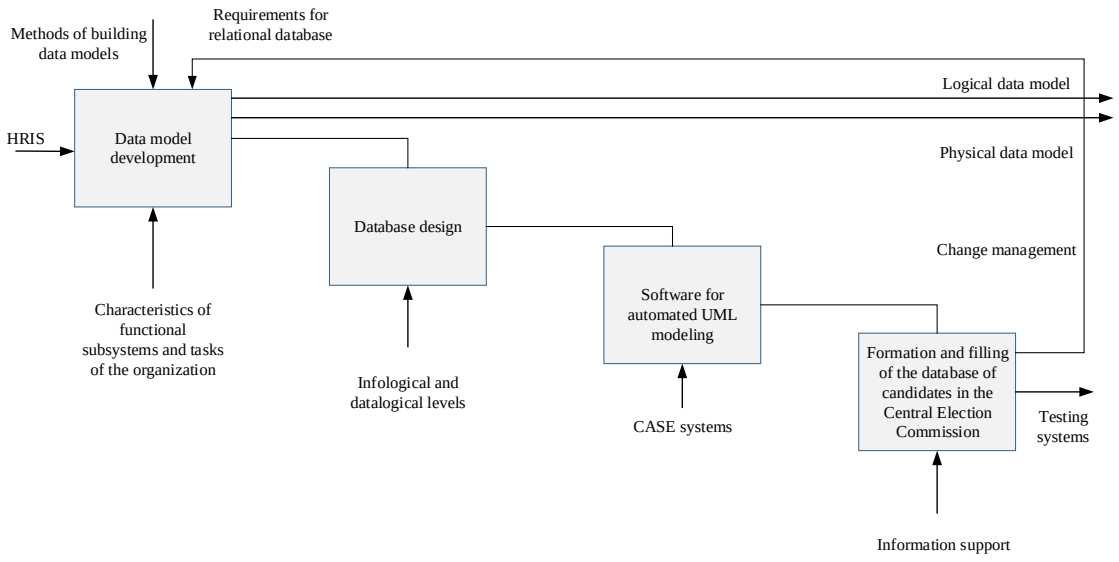

Figure 4: Contextual diagram of the decomposition of the process of creating a human resources

management database for higher education institutions of the civil protection system

Structural and functional modeling of IDEF0 for the HRIS project allows graphically describing processes and comprehensively studying the information system. Due to the methodology of functional modeling, the system can be seen as a set of interconnected functions (functional blocks). Therefore, the process of designing a web-system must begin with the development of a context diagram IDEF0.

The following entities have been identified for the database:

- users (decision makers, experts and other users) store information about users;
- candidates (applicants for inclusion in the project teams of higher education institutions of the civil protection system) store information about the candidates;
- resumes - stores information about personal data on the basis of which a personal file is formed;
- role - stores information about roles in projects.

The figure shows information about the attributes to the corresponding entities. Defining the essence and attributes of the information system was built ER-diagram, which is shown in the Figure 5. ER-diagram is a graphical representation (Figure 5) of entities and their relationships.

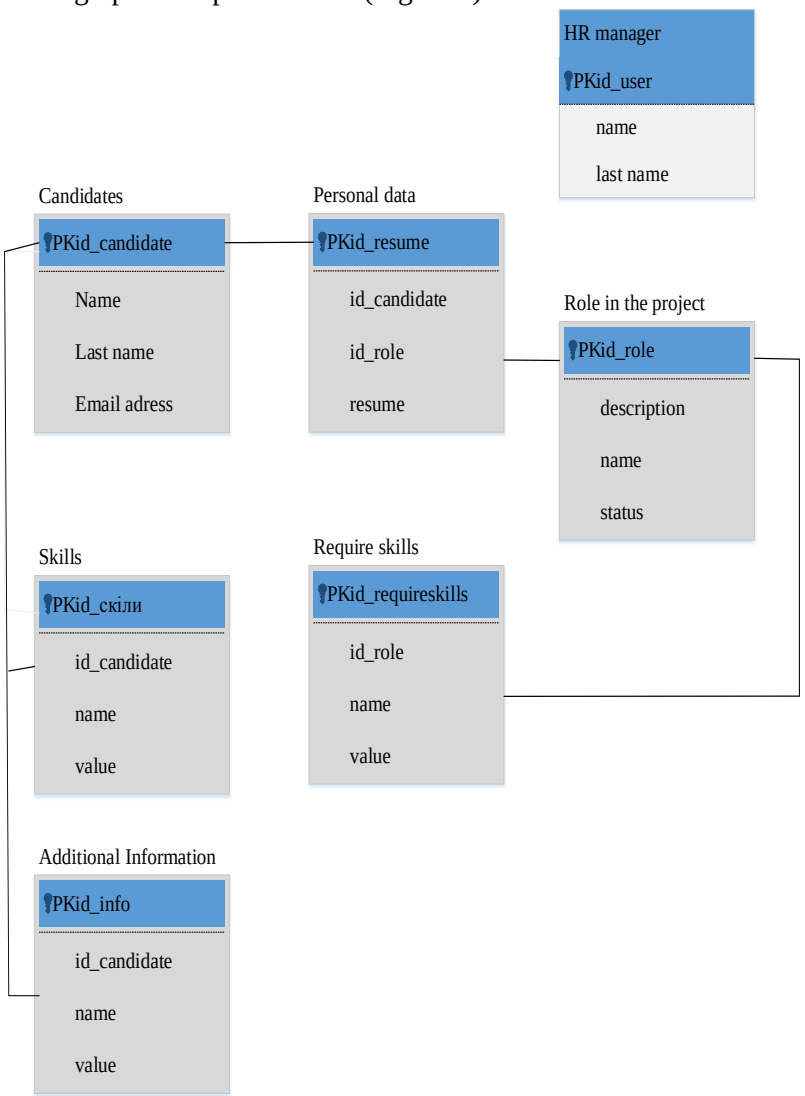

Figure 5: ER diagram of entities and their relationships

With the help of this chart you can see how the entities are interconnected in the information system. Candidates and resumes have connections "to each other", one candidate can send one resume, and one resume should refer to one candidate; roles and resumes have a one-to-many relationship, one resume can refer to one vacancy, one vacancy can have many resumes; role and

required skills have a one-to-many relationship, one skill can relate to one role, one role can have many skills candidates and skills have a many-to-many relationship, one skill can relate to many candidates, one the candidate must have at least one skill; candidates and additional info have a "many to many" link, one item can apply to many candidates, one candidate must have at least one parameter. The advantage of relational databases is obvious. Virtually all database management systems allow you to add new data to the table, modify, view and print them.

During the interaction of different functional units of higher education institutions, the civil protection system accumulates a lot of data on its activities, but these data still need to be structured into information for effective management decisions. Analytical methods allow decision makers to complete the entire cycle of work with larger volumes and unexplained statistical structure through Data Mining. It includes the following stages: sampling, research, modification, modeling, evaluation of results. The analytics and forecasting subsystem contains methods of statistical data processing, which can be divided into four interrelated sections:

- preliminary analysis of personnel statistics;
- identification of connections and regularities (linear and nonlinear regression analysis, correlation analysis);
- multidimensional statistical analysis (linear and nonlinear cluster analysis, component analysis, factor analysis);
- dynamic models and forecast based on time series [theory of decision support systems].

The analytical software package (ASP) includes a special set of software and tools for rating analysis, which allows you to study the data of comparison objects and form on the basis of their indicators different ratings for decision makers. Rating analysis allows you to assess both the current state of the set of objects, and their state in the past on the basis of time series. The comparison of the obtained result with the state of other similar objects of comparison is carried out.

The analytical software package implements a wide range of opportunities to view various charts and compile ratings-reports. Another tool for analyzing and presenting data is Web Intelligence, which has the means to build reports through a web browser.

To model the base of rules, it is advisable to use fuzzy cognitive maps, tasks of rules and functions of belonging to the thermal baths and derivation of the dynamics of system development under different input influences. Analysis of the developed cognitive map allows you to quickly obtain information about the behavior of the system and conduct experiments. Institution of higher education in the system of civil protection - a complex organizational and technical system, which consists of a train (formula 4):

$$< D(t), S(t), Y(t), E(t), t >, \qquad (4)$$

which takes into account the following parameters: *D* - actions of top management, resource allocation; *S* - environmental factors; *Y* - initial indicators of organization development; *E* - is a set of concepts connecting input and output variables; t is the time. The task of optimal management of this system and the study of its behavior in the process of human resource management on the basis of higher education institution in the system of civil protection and the environment is initiated. The system is characterized by a fuzzy logic of human factors. One of the approaches to the construction of a generalized fuzzy cognitive map is proposed, in which input and output variables are distinguished, and connections are described by fuzzy rules. In the set of concepts C of the fuzzy causal network G = (C, W) there are many input effects X = {x1, x2, ..., xn}, many output effects Y={y1, y2, ..., ym} and intermediate concepts E = {e1, e2, ..., ep}, set of connections between concepts, W $\in$[0; 1]. Each concept *ei, i=1,...P* is characterized by a term-plural of linguistic variables (formula 5)

$$Ti=\{T1,T2,...Tm\}, \qquad (5)$$

where mj - is the number of typical states of the concept. To describe each term Ti, a term set with membership function μ (x) is constructed. We present the model of a higher education institution in the civil protection system in the form of a generalized fuzzy cognitive map (Figure 6).

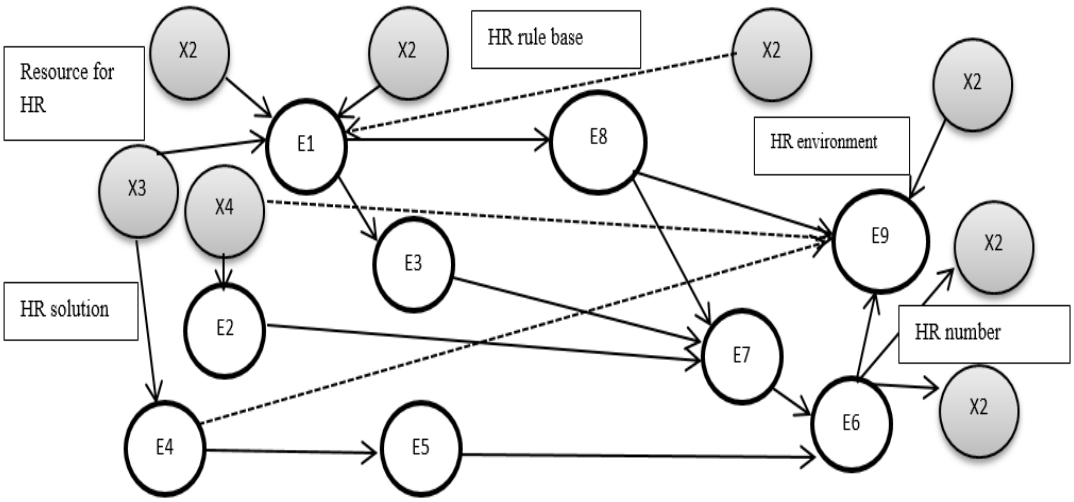

Figure 6: Model of the personnel department of the institution of higher education of the civil protection system in the form of a fuzzy cognitive map

Let's highlight the concepts:
E1 - Innovative projects of the HEICPS;
E2 - resource constraints of the HEICPS;
E3 - competence of team members;
E4 - advanced training;
E5 - management of selection and placement processes;
E6 - personnel needs planning;
E7 - development of project teams of he HEICPS;
E8 - human resource management;
E9 - scale and type of organization;

Developed fuzzy cognitive map, which simulates the behavior of ATS ZVO TsZ, covers its main operating elements:

- strategic management of the project management office (PMO) of the HEICPS;
- allocation of resources for the development of new projects (concepts X1,…, Xn);
- functioning of the HEICPS (concepts Ei, i = 1);
- factors that determine the activities of the organization (concepts E1, E2);
- characteristics of candidates (concepts E3, E7, E8, E9);

Fuzzy-cognitive approach to building simulation models of complex systems allows for optimal control of such systems without building an accurate mathematical model. .

As a function of belonging to the rules was chosen Gaussian type function, which has become widespread in fuzzy networks. It is described by the formula:

$$\mu(x) = \exp[-\left(\frac{x-c}{\delta}\right)^2] \qquad (6)$$

and operates with two parameters: δ and c. The parameter c means the center of the fuzzy set, and the parameter δ is responsible for the function. FCMapper software is used to calculate the parameters of fuzzy cognitive maps. The general sequence of steps for building scenarios based on the analysis of fuzzy cognitive maps is presented in Figure 7.

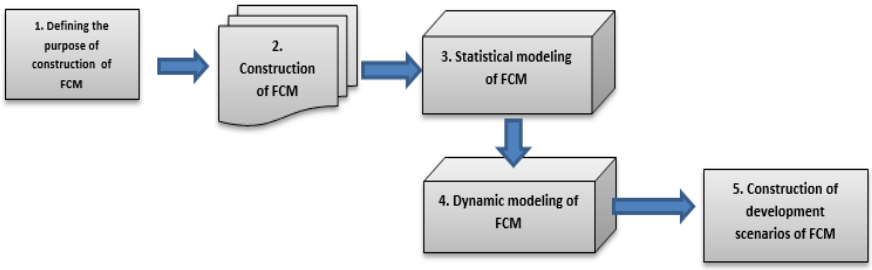

Figure 7: Generalized process of building rule base scenarios based on fuzzy cognitive maps

The function of belonging of an element to the set takes values in the interval [0, 1], and not only 0 or 1 (a characteristic feature of fuzzy logic). Thus, Cosco's cognitive maps allow us to indicate the "intensity" of the influence between factors. Such a mathematical structure allows to formalize the purely subjective opinion of the decision-maker, formed in the context of incomplete information about the membership of an element in a group. Figure 8 shows a neural network model of personnel selection for the team of a higher education institution in the civil protection system using the "black box" model (Figure 8).

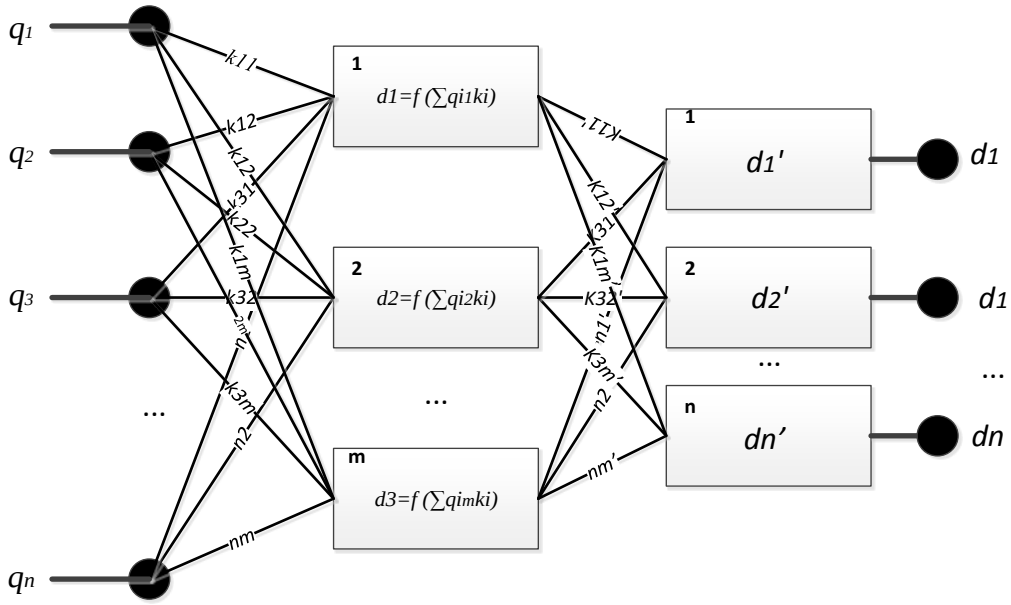

Figure 8: The scheme of the neural network of the formation of the project team of HEICPS

The basic component of the neural network is the data processing node. Each processing node sums the values of its inputs. Next, this amount passes through an arbitrary activation function to obtain the original value of the node. The state of the original neuron is determined according to formula 7:

$$d = \sum_{i=1}^{n} qiki\,, \qquad (7)$$

where $q\acute{i}$ - is the value of the i-th input of the neuron (initial data of the candidate);

ki - weight of the i-th synapse (candidate);

d - the value of the state of the neuron (inference of logical judgment-management decision).

Depending on the positive or negative answer, decisions will be made for decision makers. A genetic algorithm was chosen as the neural network self-learning algorithm. Genetic algorithm is an adaptive heuristic search method, which is a probabilistic search algorithm based on the mechanism of optimal selection and natural genetics. It is used to add hidden scales and source layers of the

neural network. This algorithm contains the following component procedures: formation of the initial population, crossover operator, mutations, assessment of the fitness of individuals, selection. The population contains many alternative solutions, presented in the form of population persons. The algorithm completes its work if the value of the recognition error of the best person of the population does not change n populations. The larger n, the fewer recognition errors and the more accurate the neural network. Recognition error is calculated by formula 8:

$$\varepsilon i = 1 - \frac{y}{y0} \quad (8)$$

where $y0$ – is the reference value of the output signal (portrait of the "ideal candidate");

y – the estimated value of the original when recognizing the defect of the printed circuit board from a self-learning sample with this set of weights.

The artificial neural network shown in Figure (7) is reformatted into a person's chromosome, filling it with weights (from top to bottom, left to right). Thus, the chromosome is a set of genes - weights of candidates for inclusion in the project team of HEICPS is described by formula 9.

$$C = (k11, k12, \ldots k1m, k21, k22, \ldots k2m, \ldots kn1, kn2, \ldots knm, k11, k12, \ldots k1m, k21, k22, \ldots, km, km2, \ldots kmn) \quad (9)$$

The only direct calculations of machine learning genetic algorithm is the movement of the neural network. Because of this, the system requirements are very flexible compared to in-depth neural network training); adaptability (various tests and ways of manipulating the flexible nature of genetic algorithms could be adapted and integrated).

4. Conclusions

Thus, information system has been developed to support personnel decision-making for higher education institutions as an expert system. The analytical subsystem will ensure the organization and support of the Admissions Committee at all stages, starting from the analysis of the recruitment plan for higher education institutions of the civil protection system. The practical significance of the obtained results is that the improved model and methods should be implemented in the form of a software module. This improves the quality of candidate selection. The created system will allow sorting, selecting the necessary information from the lists, performing arithmetic operations and performing many other functions that will automate the routine work of the HR specialist.

The developed models consider the use of databases and knowledge bases required for storage, monitoring and analysis of large amounts of information for the operation of an intelligent system focused on decision support for different classes of tasks. The availability of comprehensive decision support methods used at each stage of project team formation will significantly increase the number of functional tasks in human resource management.

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