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THE CONSTRUCTION PRINCIPLES AND ARCHHITECHTURE PECULIARITIES OF THE SYSTEM OF EARLY ECONOMIC NOTIFICATION AND REACTING

Abstract

The demands were formulated, the construction principles were suggested, the architecture of the early notification and reacting system was developed, its basic components function was examined and criteria for making the managerial decisions were selected.

Key words:

SENR, criteria of managerial decision making, tools of analytical data processing, intellectual data analysis, modeling of business's operation, forecasting.

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Introduction

The management of a modern industrial enterprise widely uses methods and means based on present-day informational technologies and artificial intelligence technologies. For the effective industrial production management information systems and the means for decision support are used at the all levels of its functioning. The variety of goals, tasks, complexity and time limits in management and potential risks that can affect the enterprise from outside and inside, need the informational support from management process. With the purpose of on time identification of factors, which signal about any tendency in development of the separate indexes of enterprise activity and taking the preventive measures in enterprise management it is reasonable to introduce the information system of early notification and reacting (SENR) [1–14]. Therefore, the development of information SENR is *an urgent task*, which is aimed at manager provision with the modern means of collecting, treatment and information analysis, decisions variants generating, their evaluation and the selection of the best variant.

Task assignment

The industrial enterprise adaptation to the crisis functioning conditions demands the wide use of present-day management methods and informational technologies. To form and make managerial antirecessionary decisions in information SENR the technologies of intellectual data analysis are used [12, 13]. The object of such information technologies study is an on time prediction of both outer (counterparties, competitors, state) and inner risks and threats. Intellectual data analysis provides the hidden rules and regularities finding that can be not found during the common data studying due to the complexity of links and the mass of data. The major component of the intellectual data analysis technology is Data Mining, which provide the new knowledge acquisition by means of complicated mathematical methods [13]. The key point here is that the main users of received information are people without the special mathematical degree. Therefore, received connections between the properties, forecasted characteristics or other features should be presented in a clear for a user way.

The main tasks solved by means of the intellectual data analysis technology include: classification, clustering, regression and prediction, association and consistent model and deviations analysis. The given technology help user to get free from the usage of statistic methods, but requires the understanding of the methods work and algorithms it is based on. Moreover, the technology of regularities search in the Database doesn't answer the unaddressed question. It

doesn't substitute analysts or managers, but gives them modern powerful tool for their work improvement.

Information SENR are mainly aimed at the action outcome identification of any factors, symptoms determination, and causes detection. The main tasks solved in our country are the indicators selection of an early notification and the determination of criteria of their interpretation. The main blocks of indicators of early notification include:

- general economic, which reveal the development tendencies of economic conditions;
- market, which reveal market tendencies, in which the enterprise is engaged;
- technological, which give information about the appearance of new products, methods and processes;
- social, which include the demographic situation in the country, cost of the workforce, level of the minimum salary;
- political, which have political nature, especially tendencies in political legislation;
- home ones, which are calculated on the basis of inner calculations and financial reporting [1–4].

Thus, *the aim of the work* is to set down the requirements, to select the construction principles and the development of architecture of the early notification and reacting system.

Main body

The development of architecture of the early notification and reacting system. We suggest developing informational SENR on the basis of integrated approach that is based on new information technologies and covers informational, organizational, technical, program and mathematical support. Developing informational SENR has to identify and analyze information about the hidden circumstances that can cause the bankruptcy or potential chances loss [3, 4]. To solve such problems informational SENR has to:

- collect, archive and pre-evaluate data;
- carry out electronic documentation;
- study data for its nature, character, relationship of cause and effect peculiarities, source of a restricted number of facts, processes and phenomena;

- analytically define economic process tendencies and their change in time perspectives, and their influence on adjacent spheres;
- solve tasks of economic analysis, modeling and forecasting, as well as different events planning.
- make automatic preparation, control and performing of the decision.

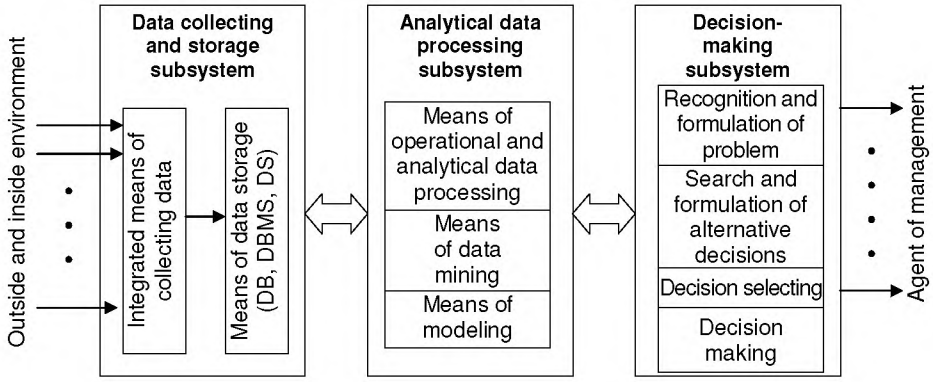
The following principles for the development of informational SENR are suggested [12, 13]:

- systemic – between the components of SENR are created such links, that provide entirety and interrelation with other systems.
- variable equipment content – requires the availability of the core of the SENR and variable program-hardware modules, with the help of which the core adjusts to the specific requirements;
- modularity – components SENR development, in functionally complete modules way, which have an access to the standard interface.
- openness – SENR is created with the possibility to enrich and renew, without its functioning disorders;
- compatibility – includes the use of informational-technological interfaces, due to which it SENR can cooperate with other systems;
- The complex of basic project decisions usage in SENR development.

The structure of suggested SENR in shown in picture 1 where DB – Database, DBMS – Database management system, DS – Data Storage.

Picture 1.

The system of early notification and reacting structure



The main components of informational SENR are the subsystems of: the data collecting and storage, analytical data processing and decision-making.

Data collecting and storage subsystem. The main source of the work is data, which are divided into inner operational and outer. The sources of outer data are: financial bodies, external Database of other organizations, electronic catalogs, press and so on. Inner operations can be divided into: accounting data, analytical data, calculation of the current and planned macro and micro indexes, financial data, regulatory and inquiry information [11, 12].

For the effective work the access of the information from outer and inner sources is required. Data introduction into SENR is conducted with the help of integrated means of data-collecting, which are to provide [11–14]:

- automatic document transformation from paper to electronic form;
- registration, accounting of the whole amount of output, input and inner documents
- initial examination and registration of the documents, data input into the Database of subsystem.
- efficient document search and the document search according to the inquiry by attributes of a document (registration number, date, authors, executors and so on), key words and documents fragments description.
- optimum use and databank classification according to the SENR needs.
- e-mail, file system and web-technology integration and interaction.
- different source of information receiving support.
- Work possibility with modern SDBM.

The constant data accumulation causes its amount growth. To store safely the large amounts of data in SENR means for data storage are used. They consist of 2 main parts: DB and SDBM. The function of the means for data storage in SENR environment is closely connected the solving of unstructured and loosely structured tasks, which require a large amount of data restructuring operations and a large set of functions. Moreover, it is needed to foresee means in DB, with the help of which the user can adapt it to his/her own requirements. This possibility causes the existence of the procedures and commands for the flexible restructuring of a SDBM scheme subset. This subset is a cover that helps to get the DB during tables' structure organization and their filling up [13].

Modern SENR are organized to minimize the time of data entry and correcting. Data used in SENR can be stored in different DB and while its analyzing some problems with format support and its coding can occur. This problem is solved by creating a databank that is subject oriented, integrated and invariable, which supports chronological data entry. The idea of data division forms the ba-

sis of databank conception. It is used for the efficient analysis and for solving its tasks. Thus, databank conception defines the general construction principles of analytical system and, in the first place, is concentrated on the data properties and requirements, but not on the ways of its organization and presenting DB.

Analytical data processing subsystem. For the analytical data processing in SENR the following means are used: efficient analytical processing, analytical analysis and modeling [11–15].

The methods and means of analytical data processing (OLAP – On-Line Analytical Processing) are based on the classical statistic approaches and average indexes on the basis of which the check of beforehand formulated hypothesis is carried out and a rough investigative analysis. The standard static methods deny non-typical observations – so called ups and downs. Such information can create a particular interest for the study, characterizing some important phenomena. Analysis and detailed examination of such observations is useful for the understanding of objects and phenomena under study [13, 16].

On the basis of OLAP conception is multidimensional data presentation by multidimensional tables' construction, which can be accessible for the user's inquiries. Those multidimensional tables will be on the base of input data and are stored in the form of relational and multidimensional database. By using OLAP, the user can make flexible information observation and get different data cut, to carry out analytical operations of particularization, convolution, overall distribution and time comparison. Today the great number of OLAP means is used. They can differ in the way of data storage, location and the preparedness for use.

Data mining (DM). The main tasks solved with DM are: the search of functional and logical regularities in piled data; hidden rules and regularities finding; model and rule construction, which describe the state or forecast the development of particular processes. In general DM is divided in such stages [13]:

- regularities revealing (free search);
- the use of revealed regularities for the unknown meaning forecast (forecasting modeling);
- analysis of exclusions, appointed to the revealing and explanation of abnormalities in found regularities.

According to the work principals with the initial experimental data all methods DM can be divided into 2 large groups [13]:

- those, based on immediate use of experimental data;
- those, based on the use of data received from the primary data and transformed into separate formal construction.

The methods of the first group are used on the stages of the forecasting modeling and the exclusion analysis. This group of methods includes: cluster

analysis, method of a nearby neighbor, method of k-neighbor, analogue thinking. The second group of methods includes: logical methods (genetic algorithms, solution trees, indistinct inquiries and analysis, symbolic rules); visualization methods; cross-tabulation methods (agents, buyers' networks, cross-tables visualization); methods based on an equation (statistic methods and neuro-networks).

Means for enterprise function modeling. Modeling is very important means of task solving, especially in conducting analytical study in enterprise functioning. The model is a simplified representation of a real object, process or phenomenon. Modeling – is the process of object representation with the appropriate model and carrying out experiment with the model to get the information about the object under study. With the help of the models in SENR useful, previously unknown information is revealed. This information is used for decision making. Model can be represented in the form of images, schemes, mathematical formulas and so on [15]. The simplest formal description of the model is provided with the help of the following functional subordination:

$$Y = f(x_1,...,x_n,\ z_1,...,z_m,w_1,...,w_k)\,.$$

Where Y – subordinate variable; $x_1, \ldots, x_n$ – independent variables, which are the inner characteristics of a study object; $z_1, \ldots, z_m$ – independent variables, which are the outer factors that influence a study object; $w_1, \ldots, w_k$ – unconsidered characteristics or factors.

The advantage of model usage for enterprise function study is their simplicity in comparison to the real enterprises. Model allows us to distinguish essential factors from the research's goal point of view. Developed models can have different complexity dependent from methods used and the study object complexity.

Models used in SENR can be classified according to the study object complexity [13, 15]:

- dynamic (objects modified in time) and static;
- determined and undetermined;
- continuous and discrete;
- linear and non-linear;
- statistic, expert, created by Data Mining means;
- forecasting, classifying and descriptive.

Classifying and forecasting models are the most widely used in SENR. Forecasting models allow to select the peculiarities of the enterprise function and to provide forecast on its basis. Let us call models that help to identify object class – classifying.

Models used in SENR are previously tested for reliability (adequacy), which involve the set of experiments. During model testing, sets of different

amount are presented as an input data. Model testing includes the level determination, where it really helps manager to make the decision.

When several models were developed, their selection is made on the basis of their characteristics and rating, and experts' opinion consideration. Main characteristics considered in model selection are precision and algorithm function efficiency. After the stages of testing, evaluation and selection comes application. At this stage, selected model is used in accordance with new data in order to solve the determined tasks.

Decision-making subsystem. Decision-making problem in informational SENR has the following features:

- situation selection uniqueness;
- hard for the evaluation character examined alternatives;
- aftereffect indetermination;
- the set of diverse factors needed to be considered in decision-making;
- presence of a responsible for a decision-making person (or group of people)

Decision-making problems in SENR can be divided into the following 3 classes:

- First – well-structured, formalized and quantitatively formulated problems;
- Second – unstructured, not formalized, and qualitatively represented problems;
- Third – loosely structured or mixed problems with both quantitative and qualitative elements.

Decision-making subsystem in SENR has the following functions [11, 12]:

- helps to evaluate the situation, choose criteria and to evaluate their relative importance;
- generates possible decisions and functioning scenario;
- evaluates and selects the decisions and scenario;
- provides the constant exchange and information sequence about the process and decision-making;
- modeling and analysis of possible outcomes of decision making;
- evaluates made decision realization and on the basis of its results provides further examination.

The subsystem of decision support should have a potential possibility of decision-making procedure automatization, but the excepted decisions have o

be clear for people. For the achieving of the necessary level of managerial decisions, the procedure itself has to be transparent and open for the discussion and analysis. The result of the decision-making subsystem function is the conclusion about the existence of possible bankruptcy risk in a separate enterprise and the improvement of some of its elements. The task on decision–making in indeterminate conditions is usually formulated as a task on best decision search from the set of admissible decisions. The main input information for the solving of those tasks is loss function, which depends on 2 arguments: solution and situation. The solving of the task of decision-making consists of loss function transformation into the risk function, which reflects the dependency of risk level the enterprise runs. The way such a transformation is carried out is not simple and depend on the risk criterion the enterprise has chosen [12].

To make decision in uncertain conditions input information is formed as a matrix, which lines are possible alternatives, and columns – enterprise condition. Each alternative and condition has a result (outcome) that determines winnings (or loss) in case of this particular alternative and this particular condition selection. Thus, when a_i represents alternative i ($i = 1,\ldots,n$), S_j gives the possible condition ($j = 1,\ldots,m$), $V(a_i, S_j)$ describes proper result. In case of decision-making criteria examination in uncertain conditions, the following matrix is used:

$$\begin{array}{c|ccc} & S_1 & \cdots & S_m \\ \hline a_1 & V(a_1,S_1) & \cdots & V(a_1,S_m) \\ \vdots & \vdots & \vdots & \vdots \\ a_n & V(a_{1n},S_1) & \cdots & V(a_n,S_m) \end{array} \qquad (1)$$

The task of alternative selection is reduced to the selection of a matrix line. For such a task solving different criteria are used. Let us consider the most famous ones:

Laplas's criterion. Laplas criterion is very often used in the conditions of the full uncertainty [12]. Given criterion is based on the use of inadequate grounding, which states that the system states S_1, S_2, …,S_m have equal possibilities. If to consider the previously mentioned statements, the primary task can be examined as a task on decision-making in risk conditions, when the alternative a_i is selected that provides the most expected winning R_1 (when $V(a_i, S_j)$ models the profit), or the least expected loss R_1 (when $V(a_i, S_j)$ models the expenses). So, to find R_1 we need:

$$R_1 = \begin{cases} \max\limits_i \left\{ \dfrac{1}{m} \sum\limits_{j=1}^{m} V(a_i,S_j) \right\}, & \text{if} \quad V(a_i,S_j) - \text{profit} \\ \min\limits_i \left\{ \dfrac{1}{m} \sum\limits_{j=1}^{m} V(a_i,S_j) \right\}, & \text{if} \quad V(a_i,S_j) - \text{expenses} \end{cases} \qquad (2)$$

where $\frac{1}{m}$ – the possibility of S_j state realization. Given criterion is worth using in the cases when the difference between the separate system conditions is big, so the dispersion value is big.

Vald's criterion. In alternative selection among all the worst Wald's criterion is used. It's the most careful and is called minimaxed [12]. When the result $V(a_i, S_j)$ reflects the enterprise losses, the biggest losses for a_i alternative, irrespective of possible S_j state, will be equal $\max_j\{V(a_i,S_j)\}$.. According to the minimaxed criterion the best chosen alternative is a_i that gives $R_2 = \max_i \min_j\{V(a_i,S_j)\}$..

Seviedge's criterion. The content of Sevidge's criterion consists in creating new loss matrix $W(a_i,S_j)$, with the help of following formula [12]:

$$W(a_i,S_j)=\begin{cases}\max_i\{V(a_i,S_j)\}-V(a_i,S_j), & \text{if} \quad V(a_i,S_j)-\text{profit}\\ V(a_i,S_j)-\min_i\{V(a_i,S_j)\}, & \text{if} \quad V(a_i,S_j)-\text{expenses}\end{cases} \tag{3}$$

Received numbers show the risk value m that is why criterion is is called the criterion of minimal risk. To select the optimum alternative with the help of minimal risk criterion becomes:

$$R_i = \min_i \max_j W(a_i,S_j). \tag{4}$$

Hurvits's criterion. Decision-making from the most optimistic to the most pessimistic is conducted with the help of this criterion. In the most optimistic approach you can chose the alternative, which gives $\max_i \max_j\{V(a_i,S_j)\}$,, where $V(a_i, S_j)$ – winning (profit). The similar situation with the most pessimistic approach:

$$\max_i \min_j\{V(a_i,S_j)\}. \tag{5}$$

Hurvits criterion achieves the balance between the most pessimistic and optimistic cases [12], while comparing both alternatives with the help of corresponding factors α, and (α–1), where $0\le \alpha \le 1$. If $V(a_i, S_j)$ represents the profit, we choose the alternative as follows:

$$R_i = \max_i\left[\alpha \max_j\{V(a_i,S_j)\}-(1-\alpha)\min_j\{V(a_i,S_j)\}\right] \tag{6}$$

When $V(a_i, S_j)$ represents loss, we choose the alternative as follows:

$$R_i = \min_i\left[\alpha \min_j\{V(a_i,S_j)\}+(1-\alpha)\max_j\{V(a_i,S_j)\}\right] \tag{7}$$

Variable is optimism index (level of certainty), when $\alpha = 1$, criterion is very optimistic; when $\alpha = 0$ – very pessimistic. α $(0 \le \alpha \le 1)$ value can be determined according to the manager character, who makes the decision. The more complicated the situation is and the bigger the uncertainty is, the closer to 0 is α. The use of such criterion becomes more complicated when there is not enough information about the α value, which according to the subjective reasons due to different decisions and in different situations gets not the same value. When $\alpha = 0$, we get:

$$R_i = \max_i\{0 \cdot \max_j V(a_i, S_j) + (1-0) \cdot \min_j V(a_i, S_j)\} = \max_i \min_j \{V(a_i, S_j)\}, \quad (8)$$

when $\alpha = 1$:

$$R_i = \max_i\{1 \cdot \max_j V(a_i, S_j) + (1-1) \cdot \min_j V(a_i, S_j)\} = \max_i \max_j \{V(a_i, S_j)\}. \quad (9)$$

When the compromise is made, the desired decision is selected with the use of:

$$R_1 = \begin{cases} \max\limits_i \left[\dfrac{\max\limits_j \{V(a_i, S_j)\} + \min\limits_j \{V(a_i, S_j)\}}{2} \right], & \text{if} \quad V(a_i, S_j) - \text{profit} \\ \min\limits_i \left[\dfrac{\max\limits_j \{V(a_i, S_j)\} + \min\limits_j \{V(a_i, S_j)\}}{2} \right], & \text{if} \quad V(a_i, S_j) - \text{expenses} \end{cases} \quad (10)$$

Bayes's criterion. This criterion is used when the possibilities distribution of enterprise's states is known [12]. Let us assume that we have the possibilities value $\{p_j,\ j = 1,\ldots, m\}$, the received conditions of enterprise $\{S_j,\ j = 1,\ldots, m\}$,, which are set by the corresponding distribution. The existence of the enterprise condition distribution law allows us to identify the mathematical expectance of the usefulness in each alternative. The alternative is considered optimum that provides the extreme value (min or max) of a given mathematical expectation:

$$R_1 = \begin{cases} \max\limits_i \sum\limits_{j=1}^{m} p_j \cdot \{V(a_i, S_j)\}, & \text{if} \quad V(a_i, S_j) - \text{profit} \\ \min\limits_i \sum\limits_{j=1}^{m} p_j \cdot \{V(a_i, S_j)\}, & \text{if} \quad V(a_i, S_j) - \text{expenses} \end{cases} \quad (11)$$

It is worth mentioning that the criterion selection for making the managerial decisions and its parameters determination belongs to the complicated tasks of the decision-making subsystem. Usually SENR has to deal with not full and concrete information. There exists the set of uncertainty sources, which can be

divided into 2 large categories: not enough knowledge about the subject area and not enough information about the particular situation. Conventionally the possibility-statistical methods were used to solve such problems. Their use is restricted by their demand of versatile, even controversial information and the factors with non-static nature. Those factors neglecting lead to the wrong decisions. Modern mathematical device that allows reducing the uncertainty level of output information in making the managerial decisions is the theory of indistinct sets. One of the methods that can be used in subsystem of decision support is the setting of alternatives' balance a_i (i = 1,...,n), namely receiving the proper matrix value [1].

Conclusions

1. SENR development is worth conducting on the basis of integrated approach, which covers informational technologies, methods and means of analytical data processing, modeling, forecasting and decision-making and is based on the following construction principals: systemic, equipment content variability, modularity, openness, compatibility and use of basic project decisions.

2. For the forecasting and search of not obvious regularities support by the conventional means of operational analytical processing it is reasonable to supplement it with the methods of intellectual data analysis (Data Mining).

3. SENR has to possess variable means set that requires the core and variable modules existence that help the core to adapt to the particular usage and ensures the following functions performance: collecting, evaluation and intellectual data processing, risks classification and the situation development prediction at the enterprise.

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