Expert-optimization modeling of control actions choice and allocation of functions in dynamic organizational structures

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Abstract:

A lot of modern enterprises have a network organizational structure. Along with the rapid expansion of external networks of cooperation with contractors, the incompany network organization is being transformed into a new, perspective means of a company dynamization. Compliance of the dynamic organizational structure with the targets of an enterprise functioning is determined by the degree of the control actions influence. To select the optimal control actions providing development of the dynamic organizational structure of an integrated enterprise management system, the adaptive choice algorithm diagram based on the results of the enterprise functioning indicators monitoring and expert assessments, is dIn order to select the reasonable variant of distribution of functions between levels and elements, the multi-alternative expert optimization model of an enterprise dynamic organizational structure improvement, based on the adaptive procedures is developed. By the example of a real enterprise, the example of building of the dynamic structure of business process management in an integrated management system (IMS) is considered. An approach to the development of an entity-relationship model of the decision maker (DM) organizational interaction system within the selected business process with the use of temporary databases, which provide support to an enterprise procedure, rules and regulations, as well as efficient information processing in real-time mode.

Key words:

Expert and optimization modelling, dynamic organizational structure, integrated management system, business process modelling, expert methods, adaptive approach.

ACM Computing Classification System:

Business process management, Business process modeling, Business process management systems, Business process monitoring, Cross-organizational business processes, Business intelligence

Introduction

Organizational structure of a modern enterprise determines effectiveness of its activity and achievements of the determined business objectives.

Currently a new ideal organizational type, called network organization, is characterized by a network structure of freely interconnected equal and independent participants. The main configuration of network organization can be determined as a self-organizing political structure, forming with an orientation to specific goals and objectives and changes with every new problem situation uprising without disturbing the established managing relations balance. The basis of such a structure is constant, all-system communicational, reflexive interactions [1, 2].

New organizational-managerial forms are characterized with the following specialties:

- a «flat» hierarchy with clear power legitimation;
- responsibility decentralization with group forms of labour orientation;
- vertically and horizontally directed organizational connections and communication lines;
- cooperation coordination with the help of strict rules, goal setting and exact result evaluation.

Along with rapid outer contractor cooperation networks expansion, the intracorporate network organization becomes a new, perspective means of an enterprise dynamization and the practical organizational-managerial forms dynamization strategies can be divided into the following types.

Dynamization by introducing market mechanisms. Hierarchal management by means of power and rank is replaced at the enterprise by marketing powers on the basis of profit centres, participation in profits and other financial incentives. As a result of "inner markets" creation the money partly takes the function of the means of power coordination in a traditional organizational pyramid upon itself.

Dynamization on the individual behaviour level. In this case an effort is made to overcome the disadvantages of traditional forms by programme initiatives of inner enterprise spirit raising, aimed for individual behaviour dynamization.

Dynamization with the help of innovative combinations of different managerial strategies. In this case an effort is made to interlink the advantages of market logic with hierarchal control, minimizing the disadvantages of the latest and orientating on interorganizational cooperation forms, such as alliances, strategic networks and virtual enterprises. This strategy is based on new managerial logic – management using expert knowledge, and ultimately it means developing the intercompany network organization on the basis of trust and cooperation capability.

Correspondence of a dynamic organizational structure to the enterprise functioning goals is determined by the rate of managerial actions' influence. Simultaneously with the set of actions determining you have to determine their realization rate [3, 4].

1. Modelling of the process of choosing managerial actions, providing development of dynamic organizational structure of integrated enterprise management system development

It is helpful to grade the set of managerial actions in correspondence with the result of informational monitoring of enterprise activity factors for the current moment using the priory ranging method and choose the most significant ones, which will build the basis for building an assembly of managerial actions measures for a dynamic organizational integrated enterprise management system structure development.

Realization of these measures in modern conditions should be flexible and consider the possibilities of quick change of managerial actions priorities. An adaptive scheme of choosing actions with forecasting on the basis of informational monitoring results is suggested in order to provide the stated demand.

The following information sources for flexible choice of managerial actions set are used in the adaptive scheme:

1) forecasting expert evaluations of enterprise management about the efficiency of the j^{th} ($j = \overline{1,n}$) managerial impact on the i^{th} factor, characterizing the organizational structure development

$$B_{ij} = \begin{cases} 1, \text{ if the expert is satisfied with the effect} \\ -1 \text{ if not} \end{cases} \quad (1.1)$$

2) the data of informational monitoring of the i^{th} factor changes at the j^{th} impact;

$\nabla y_{ij} > 0$ – change in the desired direction;

$$\nabla y_{ij} < O \text{ – otherwise;} \quad (1.2)$$

3) forecast evaluation models

$$\pi = p[y_{ij}^{M}(t_k) \le y_i^{D}], \quad (1.3)$$

where π is the value of probabilistic forecast evaluation;

p is the probability value;

y^{M}_{ij} is the i^{th} factor, calculated using the mathematic model for the t_k moment of time;

y^{D}_{i} is the value of the i^{th} factor, desired by the expert.

If forming of (1.1), (1.3) evaluation doesn't require additional expert evaluation and monitoring results processing, it's necessary to form a forecast model of the time sequence for the y_i factor of the following type

$$y_i(t) = \varphi(a_0, a_1, a_2, t),$$

where $\varphi(\bullet)$ is the functional dependency from t, expressed analytically; a_0, a_1, a_2 are the φ function parameters.

The existence of an array of possible random φ function realizations with the industry sector's financial-economic state factors irregularity is considered as the result of the $\tilde{a}_0, \tilde{a}_1, \tilde{a}_2$ parameters' stochastic nature. In this case a random process is expressed by the following model:

$$\tilde{\varphi}(t) = \varphi(\tilde{a}_0, \tilde{a}_1, \tilde{a}_2, t),$$

and computing of numeric characteristics, such as: the m [φ(t)] mathematical expectation and the D[$\tilde{\varphi}$ (t)] dispersion, necessary to get the evaluation, is performed on the basis of

approximate mathematical statistics formulae using the $\widetilde{a}_0, \widetilde{a}_1, \widetilde{a}_2$ parameters' numeric characteristics.

In the circumstances of the starting economic growth, related to realization of measures of influence on the organizational structure the

$$\varphi(t)=a_0+a_1t+a_2t^2. \quad (1.4)$$

quadratic model seems the most acceptable

The (1.4) approximation has the biggest margin of error in comparison to the line exponential and logarithmic functions. It is helpful to determine the (1.4) model's coefficients on the basis of the exponential smoothing method, as it allows to consider the values of $y_i(t)$ monitoring, close to the choice at the moment of four managerial actions' priorities with bigger significance.

The following peculiarities of random process disposal using the (1.4) model are stated as a result of statistic data of an enterprise financial state factors.

1. The a_0 parameter depends on the state of the economic sector under the influence of influence measures and on the stage of reanimation and transition to stable development is a determined value.

2. The relative mean square deviation for the a_1 linear factor is significantly smaller than the corresponding value of the a_2 non-linear factor in connection with different tendencies of financial state dynamics for specific links of the economic sector's organizational structure:

$$\frac{\sigma(\widetilde{a}_1)}{m(\widetilde{a}_1)} << \frac{\sigma(\widetilde{a}_2)}{m(\widetilde{a}_2)},$$

where m (•) is the mean-square deviation designation.

That's why you should use the

$$a_1=m(a_1).$$

parameter value during calculations.

3. Realization of the a_2 random value that depends on changing a big quantity of random factors, influencing the enterprise functioning process, showing no obvious domination, conforms the normal probability law

$$f(\widetilde{a}_2)=\frac{1}{\sqrt{2\pi}\sigma(\widetilde{a}_2)}\exp\{-\frac{a_2-m(\widetilde{a}_2)}{2\sigma(\widetilde{a}_2)}\},$$

where f(·) is the random value frequency curve designation.

In this case the p(0) function's numeric characteristics are determine the following way:

$$m[\widetilde{\varphi}(t)]=a_0+m(\widetilde{a}_1)t+m(\widetilde{a}_2)t^2$$

$$D[\widetilde{\varphi}(t)]=D(\widetilde{a}_1)t^2+D(\widetilde{a}_2)t^4.$$

As the $\widetilde{F}_{ij}$ distribution tends to normal for the set period of managerial decisions taking, the (6.3) evaluation is calculated the following way

$$\pi=0.5+\Phi(\frac{y_i^*-m[\widetilde{\varphi}(t)]}{\sigma[\widetilde{\varphi}(t)]}),$$

where φ (•) is the normalized Laplace's function,

y^*_i is the value of the i^{th} economic sector state factor, desired from the point of crisis state escaping stage.

Rational choice of influences using the (1.1)-(1.3) array of evaluations is performed during multiple stages:

1. Transition from the ordinal evaluations scale of measures of influence priorities in correspondence with the results of monitoring for the set period to probabilistic evaluations:

$$p_j^1 = 1 - \frac{Q_j}{\sum_{j=1}^{n} Q_j},$$

where Q_j is the ordinal evaluation of the j^{th} managerial action;

n is the quantity of influence measures;

$Q_{j1} > Q_{j2}$, if the significance of the j_2 influence is bigger than that of the j_1 influence;

P^1_j is the initial probabilistic evaluation.

$$\sum_{j=1}^{n} p_j^1 = 1.$$

2. The choice of an influence measure for the latest (k = 1,2...) period of the y_i factor change in the desired direction.

That's the goal of using the following logical rule. For the first (k = 1) period we use the managerial action, that has the smallest Q_j degree, acquired in accordance with the results of the y_i factor monitoring.

For the following (k > l) periods we perform the comparison of the p_j^k, $j=\overline{1,n}$ probabilistic evaluation with a random ξ number, well-distributed on the [0,1] interval. If $0 < \xi > p^k_1$, then we carry on managing using the previous influence, otherwise we proceed to the next one and so on.

3. Correction of p_j^k, $j=\overline{1,n}$ probabilities values for new management periods.

The necessity of p_j probabilities values correction for the k^{th} period is determined after the π^k evaluations. If $\pi^k < 0.8\pi^{k-1}$, then the correction is necessary.

The p_j probabilities values correction using the (1.1), (1.2) evaluations is carried out by the following algorithm:

$$p_j^k = p_j^{k-1} l^{-1/k * Sign\ [B_{ij}^{k-1} B_{ij}^k]}$$

$$p_\nu^k = \frac{P_\nu^{k-1}(1 - P_\nu^k)}{1 - P_j^{k-1}}, \nu = \overline{1,n}, \nu \neq j,$$

$$if \quad SignB_{ij}^{k-1} = SignB_{ij}^k = -1$$

$$or \quad p_j^k = p_j^{k-1} l^{-1/k * Sign\ [\nabla_{ij}^{k-1} \nabla_{ij}^k]}$$

$$if \quad Sign\ \nabla y_{ij}^{k-1} = Sign\ \nabla y_{ij}^k = -1;$$

$$p_j^k = \frac{p_j^{k-1} + \varepsilon^k}{1 + \varepsilon^k}, \; p_\nu^k = \frac{p_\nu^{k-1}}{1 + \varepsilon^k},$$

$$\varepsilon^k = \varepsilon^{k-1} l^{-1/k * Sign\ [B_{ij}^{k-1} B_{ij}^k]}$$

$$or \quad \varepsilon_j^k = \varepsilon_j^{k-1} l^{-1/k * Sign \ [\nabla F_{ij}^{k-1} \nabla F_{ij}^k]}$$

$$if \quad Sign \ \nabla F_{ij}^{k-1} = -1, \ Sign \ \nabla y^k = 1,$$

$$where \quad Sign \ (z) = \begin{cases} 1, if \ z > 0, \\ -1, if \ z < 0. \end{cases}$$

$$p_j^k = 1, \ p_\gamma^k = 0, \ \gamma = \overline{1, n}, \ \gamma \neq j,$$

$$if \quad SignB_{ij}^{k-1} = SignB_{ij}^k = Sign \ \nabla y_{ij}^{k-1} =$$

$$Sign \ \nabla y_{ij}^{k-1} = 1;$$

$$p_j^k = p_j^{k-1}, \ p_\nu^k = p_\gamma^{k-1}$$

$$if \quad SignB_{ij}^{k-1} = 1, \ SignB_{ij}^k = -1$$

$$or \quad Sign \ \nabla y_{ij}^{k-1} = 1, \ Sign \ \nabla y_{ij}^{k-1} = -1$$

2. Expert-optimization modelling of the process of functions distribution in dynamic organizational structures of an integrated enterprise management system

Development of an enterprise's dynamic organizational structure is carried out simultaneously with perfecting the integrated management structure. This process is related to adaptive distribution of management functions between the top – administrative – and the bottom – production – management levels. The efficiency of measures of influence on the development of a dynamic organizational structure is determined by justification of management functions' distribution [5-7].

The expert-optimization modelling is used to choose the rational variant of functions' distribution between management levels.

The economic segment's top management level is represented by $j = \overline{1, n}$ elements and performs $i = \overline{1, m}$ management functions in correspondence with the realized business-processes.

It is necessary to determine the significance of every i^{th} management function on the first stage for decision taking at the higher level. Such a possibility is presented by group expert evaluation of these functions using the priori ranging method. The value of a_i rates can be from 1 to m depending on function significance. Normalized values are introduced to increase the comfort of using such evaluations:

$$b_i = 1 - \frac{a_i}{\sum_{i=1}^{i} a_i}.$$

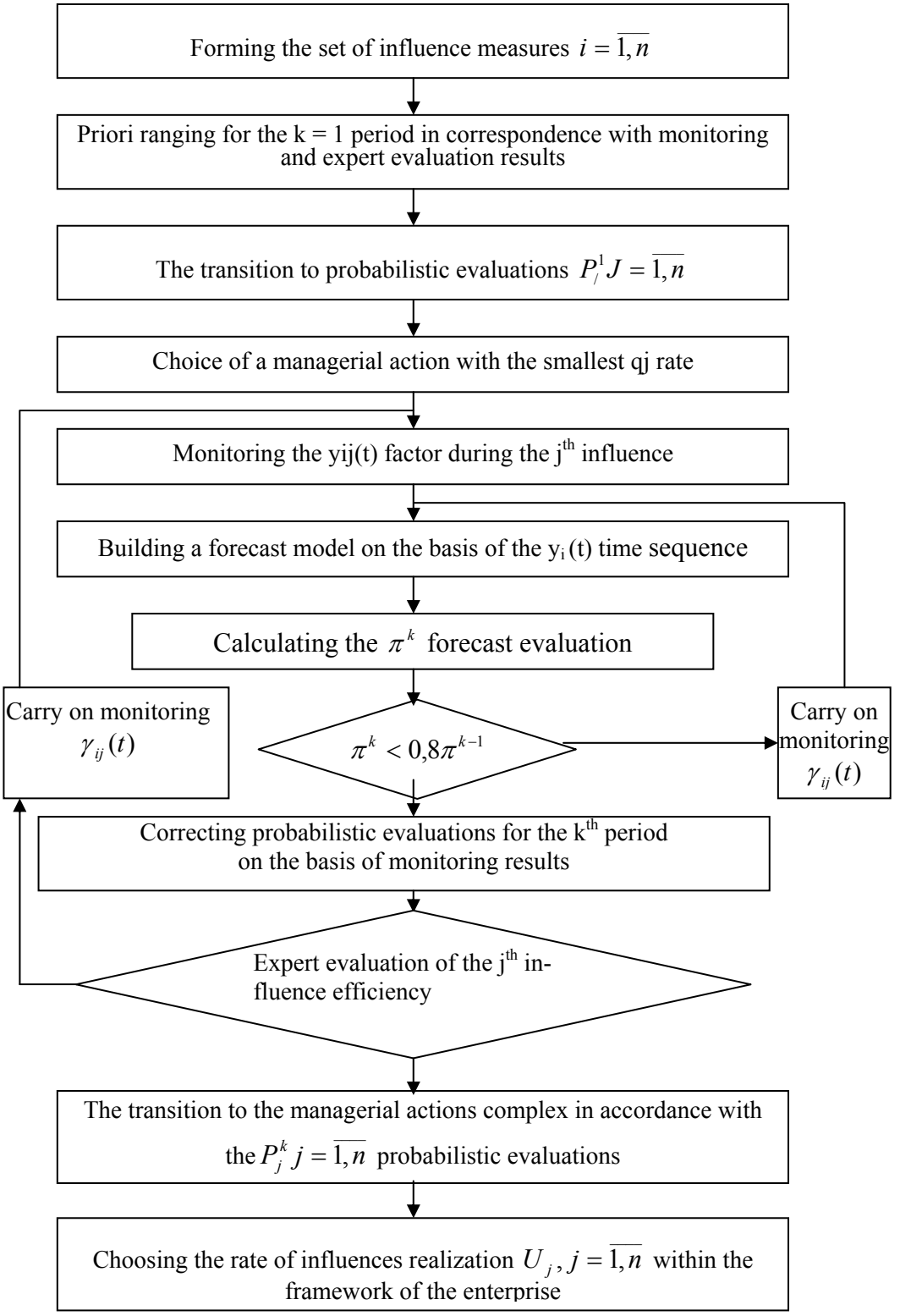


Figure 1. A structural scheme of adaptive choice of managerial decisions in accordance with the results of the enterprise's functioning factors monitoring and expert evaluations

The character of the j = $\overline{1,m}$ management functions performing by top level elements is determined by the following discrete value:

$$C_{ij} = \begin{cases} 1, \textit{ if the } i^{th} \textit{ function can be fully carried out by the } j^{th} \textit{ element} \\ 0.5 \textit{ if the } i^{th} \textit{ function can be partly carried out by the } j^{th} \textit{ element} \\ 0, \textit{ otherwise} \end{cases} \quad (2.1)$$

j = $\overline{1,n}$, i = $\overline{1,m}$.

Alternative variables are introduced in order to analyse variants of functions distribution:

$$x_i = \begin{cases} 1, \textit{ if the } i^{th} \textit{ function can be transferred to the higher level} \\ 0, \textit{ otherwise} \end{cases} \quad (2.2)$$

i = $\overline{1,m}$.

Optimization is carried out following the principle of maximum significance at management functions delegating to a higher level of the enterprise's dynamic organizational structure, which corresponds with the optimality criterion

$$\sum_{i=1}^{m} b_i x_i \to \max . \quad (2.3)$$

Limitations are connected with management functions performance labour intensity by the higher level elements.

Average labour intensity of performing the i^{th} management function by the j^{th} element for the specific calendar time period is designated as t_{ij}, the planned labour intensity of the j^{th} element management activity is T_j. In this case the limitations are presented in the following way:

$$\sum_{i=1}^{m} t_{ij} c_{ij} x_i \le T_j, j = \overline{1,n} . \quad (2.4)$$

Considering (7.1)-(7.4) the optimization model looks the following way:

$$\begin{aligned} &\sum_{i=1}^{m} b_i x_i \to \max, \\ &\sum_{i=1}^{m} t_{ij} c_{ij} x_i \le T_j, \; j = \overline{1,n}, \\ &x_i = \begin{cases} 1, \\ 0 \end{cases} \quad i = \overline{1,m}. \end{aligned} \quad (2.5)$$

A random generation of accepted variants, answering the (2.4) limitations is carried out in order to solve the (2.5) optimization task. Each variant of $x_l, l = \overline{1,L}$ is a set of random x_i values:

$$X_l = (\tilde{x}_1,...,\tilde{x}_i,...\tilde{x}_m),$$

$$where\ \tilde{x}_i = \begin{cases} 1, if\ \tilde{\xi} \le p_i \\ 0, otherwise, \end{cases}$$

$\tilde{\xi}$ is a random number, well-distributed on the (0, 1) interval;

p_i is the set probability that the variable $x_i = 1$.

Building new variants, providing maximization of the target (2.3) function on the accepted (2.4) array, is carried out on the basis of genetic algorithms.

The array of x_l, $l = \overline{1,L}$ variants is represented by the $\Pi = (x_1,\ldots,x_l,\ldots,x_L)$ population, in which any two specimen of x_l, x_t on the basis of the acts of syngamy and meiosis. The algorithm of aggregation is determined firstly, by the way of choosing a x_l, $x_t \in \Pi$ parent pair, bearing the father's and the mother's gamete correspondingly (the system of breeding), and secondly, by the scheme of multiplication. The values of the target (2.3) function, which are interpreted as the $\mu(x_l)$ rate of adaptation for every x_l specimen, having the $E(x_l)$ genotype, are calculated in order to realize the stated.

The system of breeding, defining the choice of specimen for a parent pair is considered during aggregate tasks solving. In order to realize the breeding system, connected with genotype panmixis, all the specimen $(x_1,\ldots,x_l,\ldots,x_L)$ are divided into local populations $\Pi g \ne 0$, $g = \overline{1,G}$ $(g \le L)$, in each of them the Hamming distances between any pairs of genotypes equal zero. As a $(x_l, x_t) \in \Pi$ parents pair any two $x_l \in \Pi_{gl}$ and $x_t \in \Pi_{g2}$ ($\Pi_{n1} = \Pi_{n2}$) specimen are chosen, where the local populations are chosen randomly following the probability distribution

$$P_g = L_g / L,\ g = \overline{1,G}, \tag{2.6}$$

where L_g is the size of the local Π_g population.

Other breeding systems are determined by Hemming distances between the $E(x_l)$ and $E(x_t)$ genotypes of the two x_l, $x_t \in \Pi$ specimens. If it doesn't exceed the set positive number d_0

$$d[E(x_l), E(x_t)] = \left\| E(x_l) + E(x_t) \right\| \le d_0, \tag{2.7}$$

where $E(x_l) = (l_0(l,...,l_0(m),...,l_0(M),l_0(m))$ is the allel of the m^{th} locus of the 1^{st} specimen, $l_0(m) = Z_{ml} >$, then the specimens are considered close relatives and choosing a parent pair from the specimens, meeting the (2.7) condition, leads to the system of breeding called inbreeding. A diametrically opposite system to this one is outbreeding, when the choice of a parent pair is carried out on the assumption that

$$d[E(x_l),E(x_t)] > d_0.$$

Using the quantitative evaluation of the $\mu(x_l)$ rate of adaptation we can form the systems of assortative breeding. In case of positive assortative breeding during parent pair formation those specimens, that have close and high levels of adaptation rate are chosen. Specimens are chosen on the basis of the following probability distribution:

$$P_t = \frac{\mu(x_t)}{\sum_{t=1}^{L} \mu(x_t)}, t = \overline{1,L}. \tag{2.8}$$

In case of negative assortative breeding one of the specimens is randomly chosen following the (2.8) distribution and the second one is chosen on the basis of the following distribution:

$$P_t = [1/\mu(x_t)]\sum(\frac{1}{\mu(x_l)}), t = \overline{1,G}. \quad (2.9)$$

An isolated situation of positive assortative breeding is selective breeding, during which the specimens, that have the levels of adaptation, which are lower than the average adaptation rate of the μ_{ave} population are excluded from the Π population.

$$P_t = [\frac{1}{\mu(x_t)}]\sum_{i=1}^{L}(\frac{1}{\mu(x_l)}), t = \overline{1,G}.$$

Next, the random choice, following the (2.9) probability distribution, is used.

The basis for specimens breeding schemes and building new aggregated variants is gene recombination. Recombination leads to appearance of new combinations of parent genes, as the allel of any gene of the parent's homologous chromosome is fully propagated to the ancestor in accordance with the law of dominance. At this the parents' homologous chromosomes are compared by the contents of each gene. If the allels in the m^{th} (m = 1,M) locus are the same in the father's and the mother's chromosomes [$l^{oe}_0(m) = l^M_0(m) = l_0(m)$], then the $l_0(m)$ allel is kept in the ancestor's m^{th} gene. Otherwise, [$l^{oe}_0(m) = l^M_0(m)$] there's a 50% probability that the allel or the $l^M_0(m)$ allel is brought into the m^{th} locus of the ancestor's gamete. This operation of random division of the parents' genes along the ancestors' gametes allows to form new aggregated variants. Mutual exchange of homologous chromosomes' sections (crossing-over) is also possible. During simple crossing-over homologous chromosomes-zygocites, before they split into child gametes of the ancestors, are torn apart in the random α spot into two M^M_1 and M^{om}_2 parts, containing genes from (α + 1) to M, and then they are provided with the corresponding sections of tangled genes or are restored in the initial state.

If the new variant's adaptation rate $\mu(x_{L+1}) > \mu^{max}(x_1)$, then this variant is included in the array of perspective variants and the variant with $\mu^{min}(x_l)$ is excluded from the array. Then this method of parent pairs choice is used. The process finishes after all possible parent pairs are handled.

In order to cut down the array of perspective variants of parent pairs a reproductive group is formed on the basis of selection schemes. Two basic schemes are the most widely spread.

In the first case all specimens are harmonized in the descending order of their adaptation factor value. The L^0 reproductive group number is set. Only L 5_0 0 of the harmonized specimens are included in the R reproductive group.

In the second case the average adaptation rate of all specimens is determined:

$$\mu^{ave} = (\frac{1}{L})\sum_{l=1}^{L}\mu(x_l).$$

Only the specimens with the level of adaptation, which is higher or equals the average one, are included in the reproductive group:

$$R = \{x_l|\mu(x_l)\} \geq \mu^{ave}(x_l), l = \overline{1,G}.$$

The variants that have been included in the reproductive group are then subject to expert evaluation for the ultimate choice of the rational variant.

3. Building a dynamic enterprise business-processes management structure within an IMS

The mathematic model of interaction between DMs, management objects and business-processes is built using the Petri net apparatus. When building a Petri net positions

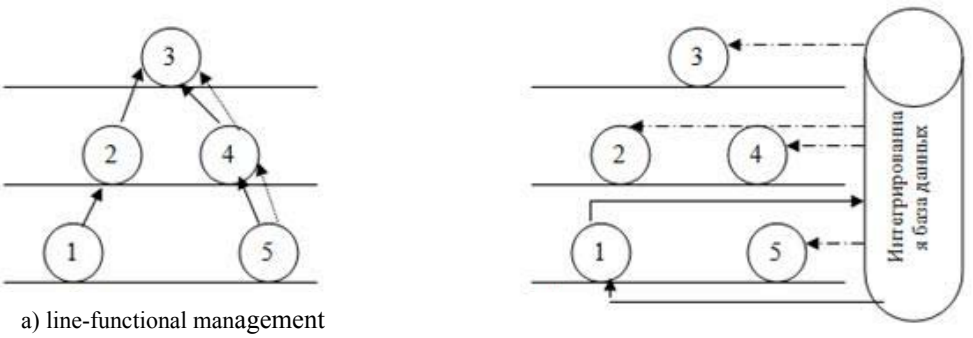
can be displayed as DMs as well as situation analysis state; and the transitions can display both managerial decisions and messages about some events. In order to reflect a complicated transition in the network an element is used, which considers an assembly of inner situations while taking managerial decisions about the transition from one DM to another. The contents of positions and transitions in Petri nets reflects the sequence of taken managerial decisions and functional connections between DMs rather fully (Fig. 2.).

Building a management structure in the circumstances of an enterprise IMS is considered using the example of OJSC Vodmashoborudovanie plant (Voronezh), which specializes in producing equipment for drinking and sewage water treatment and fire-exstinguishing equipment.

The work assumes setting channels of rational interaction between management objects and DMs to provide the process of functioning of technologic business-processes of the considered enterprise. Meeting these requirements assumes determining of the necessary input and output information for every integrated enterprise object to make managerial decisions. The organizational structure allows to determine a system of DMs' organizational interaction within the chosen business-process [9-13].

The result of building informational interlinks in the existing management structure is forming an information model of an enterprise with new functional DM relationships.

Determining new informational relationships between DMs changes document workflow for managerial decisions making within business-processes. Based on this consumption we can build a new informational enterprise model as a cube with one of its edges being represented by Petri nets, built for managerial decisions realization within technologic business-processes. That's why every DM in the circumstances of an IMS in the process of decision making acts within the framework of his personal functional duties in accordance with the Petri nets within the enterprise's regulations. The new informational interaction between DMs allows to reduce the time for managerial influences on functional business-processes realization functioning significantly (fig. 2).



а) line-functional management system

б) IMS dynamic structure

——————► - a DM's managerial action for making a decision

- - - - - - - - - ► - managerial decision realization control

—·—·—·—·—·— ► - a DM's query to the database, realizing the function of managerial decision realization control

Figure 2. The procedure of managerial action passing in a line-functional management system and a dynamic IMS structure

From the point of technical realization of an enterprise's managing information systems the corresponding instruments are used, which allow to realize the system's func-

tional abilities completely. The main requirement, applied to the information storage environment is correspondence of the information kept to specific time intervals, and presence of the "time" attributes of the data. Presence of such attributes of the data management system itself provides maximum efficiency while working with temporary data. The main function, laid on temporary databases, has been determined as automated and, in some cases, automatic adherence to the regulations of decision makers' (DMs') work, and performance discipline control. The principal scheme of using a temporary database in a system of supporting managerial decisions of the considered enterprise is presented on figure 3. [11, 14, 15].

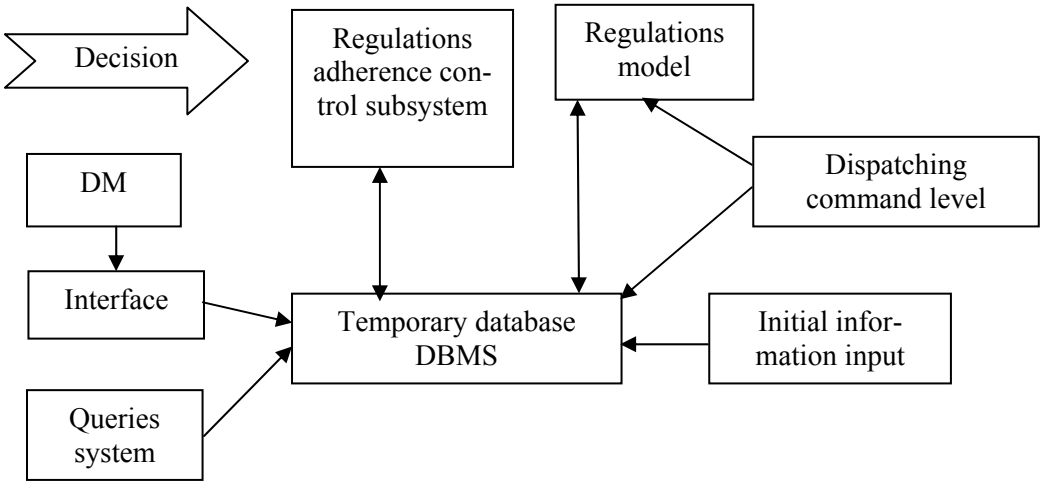


Figure 3. The scheme of using a temporary database for managerial decisions realization control

Temporary databases have been used in order to support the working capacity of the automated integrated management system. Every attribute has the time property: it possesses actual time, determining its value timeliness and the transaction time, which determines the time of information writing to the system. Time attributes have been set for such dynamic processes, as dispatching command subsystems, procurement subsystems, current technologic equipment maintenance subsystems and some others.

In order to provide effective information processing, distribution of transactions handling and methods of working with the database's time attributes, has been made. Queries are processed by the DBMS itself, while forming queries to the temporary database is carried out by the user himself. Regulations of the enterprise management system interaction is realized in the form of functions, the DMs should adhere to. These functions include time attributes as well. Controlling of the regulations adherence is carried out by the business-rules, set on the application server level. Supporting feedback is also carried out by means of the application server's functionality. Taking into consideration the deviation of the values from the set ones, one or another management business-function is carried out.

However, as a result of technologic business-processes' functioning deviations from the normal values, set at the enterprise, can occur. In such cases new Petri nets are built to provide conflict-free process of managerial decisions making in real-time mode. When a situation, requiring managerial decision to be taken by a DM, the person responsible for managerial decisions making for specific management objects will initially act in corre-

spondence with the Petri net, that has been designed and is kept in the integrated DB, containing information about correlations between DMs, management objects, management functions. That's why any deviations from the normal performance of business-processes are fixed in the integrated database. The DM {рп} finds the reasons that had led to the non-standard situation using the Ishikawa diagram, after the situation occurs [11, 16, 17].

Detecting reasons of business-processes' deviations from normal work on the level of DMs {рп} should be carried out strictly within the limits of time set by the enterprise's standard. In case if the given reason detection time limit is exceeded by DMs {рп}, this operation is transferred one level higher along the management hierarchy. This cycle of detecting the reasons that had led to deviations in the business-process flow, will repeat until the top management level is reached, where power delegation for this management function is not possible anymore.

After detecting the reasons a new Petri net is built by DMs {рп} to make a managerial decision, variants of network interactions are built for the "machine-tool repair" business-process participants in order to solve the resultant problem. It's important to point out that DMs can build new Petri nets only within their functional duties by management objects according to the built enterprise model. The new net is recorded to the integrated database for making a managerial decision at the current moment and to solve the similar problem if it happens again.

Production process has a specific time step and is determined by the enterprise's specific character. The period of time steps makes from a couple of minutes (for dispatching control) to multiple days.

We can pinpoint some time-consistent processes within this time step.

On the level of initial information, getting to the system at the specific time moment (it is determined as T4) we record the results of the technologic business-process that lasts in time since T1 till T2. The registered T3 time determines the final time of the technologic business-process end. Control of the personnel's actions' correctness and timeliness is performed till the T5 time. During the T6 time everything is ready for managerial decisions making on the basis of the recorded information, related to the technologic business-process since T1 till T2. The T6–T1 interval determines the minimum time step of the managing link reaction to correct the disturbing factor of the technologic business-process. The possible solution variants are determined by a set of attributes of the technologic process objects, that have the corresponding regulation range. T1, T2, T3, T4, T5, T6 time moments are the implicit attributes of the generalized enterprise informational model object.

Forming queries involving the T1, T2, T3, T4, T5, T6 time moments we get the information, allowing to:

- perform the technologic business-process control;
- determine the set of possible solutions to correct the technologic business-process;
- perform the choice of administrative business-solution to correct the disturbing factor of the technologic business-process.

In an object-functional enterprise model such a technology of administrative business-processes production allows to distribute the possible variants of business-processes within DMs.

In order to illustrate the possibility of getting a business-solution using a time data model we can use the example of an information query, allowing to get information about the state of the object for the Ti moment of time (fig. 4.).

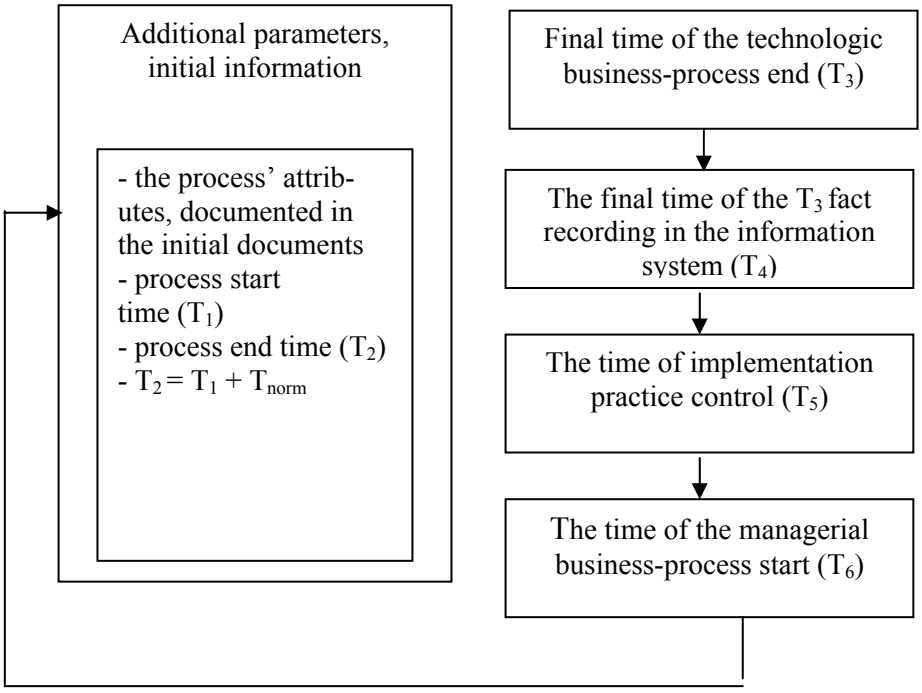


Figure 4. The generalized scheme of DMs interaction with the information system

A query is formed at first order predicate language:

$$\begin{aligned} &OSD_Inst = (\exists X1, X2, X3, X4, X5, X6, X7, X8, X9, X10, X11) \times \\ &(\exists S1, S2, S3, S4) \\ &(S1 \in OSD_Inst_Table) \wedge (S2 \in PSD_Table) \wedge (S3 \in OSDP_Table) \wedge \\ &(S4 \in Val_Table) \wedge X1 = S1.ID_OSD \wedge X2 = S1.Inst_ID \wedge X3 = \\ &S1.ID_OSDP \wedge X4 = S3.Display \wedge X5 = S3.Order1 \wedge X6 = \\ &S3.Multivdenc\ e \wedge X7 = S2.Type \wedge X8 = S2.Name \wedge X9 = \\ &S1.ID_Value \wedge X10 = S4.Value1 \wedge T_i >= S1.DateFrom \wedge \\ &T_i < S1.DataBefore \wedge X1 = C1 \wedge X2 = C2 \wedge X3 = S2.ID_OSDP \wedge \\ &X4 = C3 \wedge X3 = C4 \wedge X5 = C5 \wedge X6 = C6 \wedge X7 = C7 \wedge X8 = \\ &C8 \wedge X9 = S4.ID_Value \wedge X9 = C9 \wedge X10 = C10 \end{aligned}, \quad (3.1)$$

where XI, X2, ..., X12 are running terms;

C1, C2, ..., C10 are constant terms (the broadcast conditions of the managed object values samples);

S is the array of the sequences of specimens of the object in the application environment (OAE).

The same query in SQL language will look the following way:

Select A.ID_OSD, A.Inst_ID, A.ID_OSDP, C.Display, C.Orderl,
C.Multivalence, B.Type, B.Name, A.ID_Value, D.Valuel,
A.DateFrom, A.DateBefore
From OSD_Inst_Table A, PSD_Table B, OSDP Table C (3)

Where (A.ID_OSD=C1) And (A.ID_PSD=C2) And
(A.ID_OSDP=C3) And (C.Display=C4) And
(C.Orderl=C5) And (Multivalence=C6) And
(A.ID_Value=C7) And (D.Valuel =C8) And
(DateFrom >= T_i) And (DateBefore < T_i),
where OSD_Inst_Table is the table, containing OAE specimens;
PSD_Table is the table, containing information about AE;
OSDP_Table is the table, containing OAE parameters;
ID_OSD is the OAE identifier;
Inst_ID is the OAE specimen identifier;
ID_OSDP is the OAE setting identifier;
Display is the parameter of an application environment object's parameter displaying (AEP);
Order 1 is the order of AEP displaying;
Multivalence is the determinant of the AEP's multivalence;
Type is the type of the application environment parameter;
Name is the name of the application environment parameter;
ID_Value is the OAE parameter value identifier;
Value 1 is the OAE parameter value;
DateFrom and DateBefore are the dates of the version start and the end of the OAE.
C1, C2, ..., C8 are the parameters of the AEP parameters search method;
T_i is the regulations time (i = 1...6).

Thus, a system of information queries is presented to support the system of managerial decisions making in an object-functional management model by mean technologic business-processes control and operational management [1, 2].

DMs in an IMS must interact with the information system following the developed algorithm, assuming rational managerial decisions making in real-time mode. Functioning of this algorithm in real-time mode is carried out using the system of DMs' queries to the integrated temporary database of the enterprise. A step-by-step description of the algorithm is presented on figure 5.

Step 1. Occurrence of a situation, requiring a managerial decision to be made. Such situations can happen on all management levels of the IMS during realization of the enterprise's standard business-processes.

Step 2. DMs are informed about the state of an object at the current moment of time by a background process of the temporary database.

Step 3. A DM $\{p^{\eta}\}$ acts in accordance with the regulations within the limits of his official duties. For every group of problems, requiring managerial decisions to be made, proceduralised Petri nets have been built for DMs' interactions. Using these regulations allows to accept the query to the temporary database about the state of the object at the current moment of time.

Step 4. If there are no alternatives, the analytic production information processing unit is turned on to determine the possible alternatives.

Step 5. Checking correspondence of the current business-process to the normal one within the framework of an IMS. Deviations of a business-process' parameters from the regulations are fixed in the temporary database, allowing DMs $\{p^{\eta}\}$ to see the deviations happening.

Step 6. Comparing the actual deviation reason detection time with the normal value stated in the enterprise's regulations. If $T \le T_{reg.}$, then the transition to step 7 is carried out,

if this condition is not met, the transition is carried out to step 8.

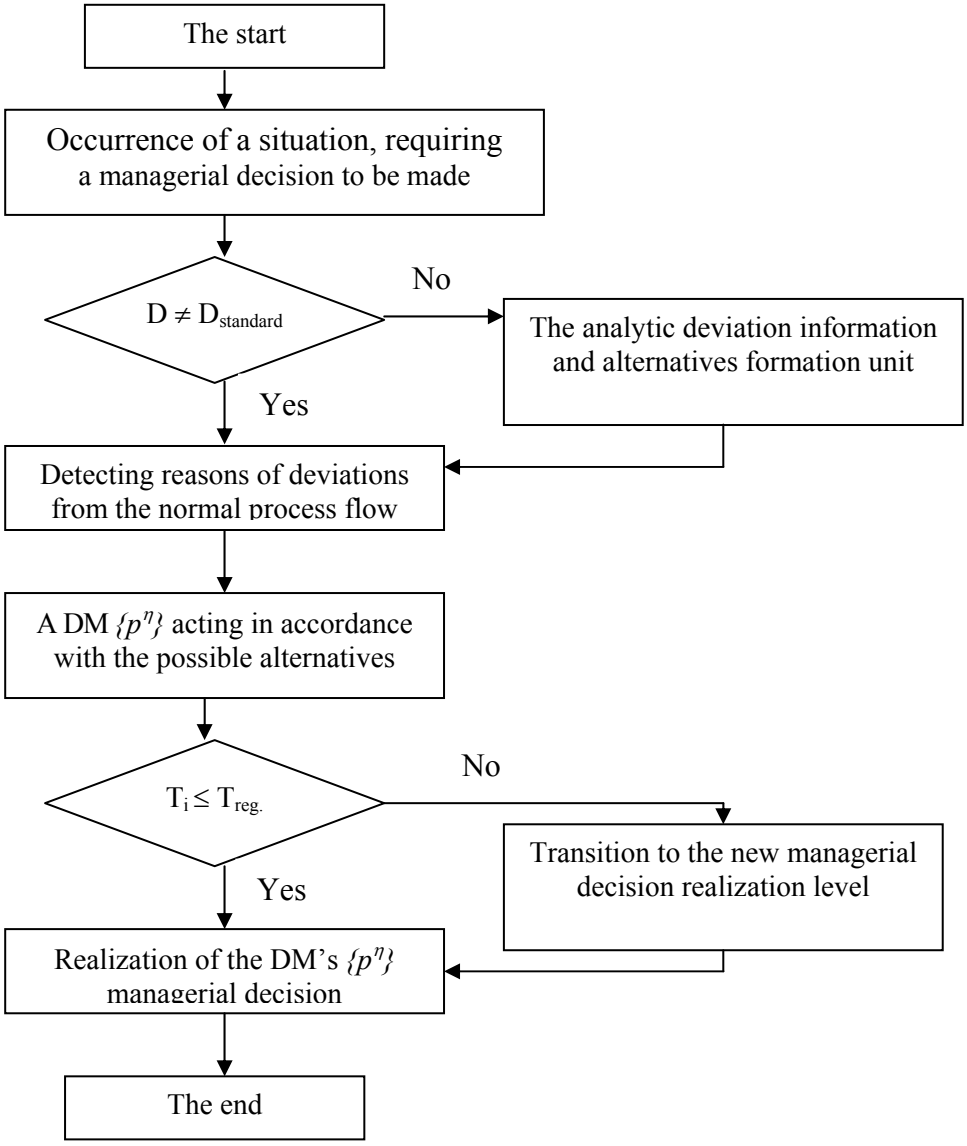


Figure 5. The algorithm of managerial decision making in the IMS circumstances

Step 7. Realization of the managerial decision and transferring the management object to the new state.

Step 8. Informing the higher management level about the managerial decision rejection and management transition to the administrative subsystem.

Conclusion

Therefore, as a result of this study the algorithmic scheme of choosing a set of managerial actions, based on the analysis of enterprise functioning factors evaluations, acquired on the basis of information monitoring results, has been suggested.

A multi-alternative expert-optimization a dynamic organizational enterprise structure perfecting model, characterized by the procedure of adaptive choice of the variant of distributing functions between management levels and elements, has been designed.

An approach to forming an information model of a system of organizational interactions between DMs within the framework of a chosen business-process using temporary databases, providing the enterprise functioning regulations and effective information processing in real-time mode support on the basis of information arrays structuring in an integrated database, determining the key information arrays and organizing the interaction between them, has been suggested.

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