

Algorithmization of dynamic enterprise management structure building and target function of its development

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Abstract:

One way to improve an enterprise operation efficiency is to improve its control system. To solve this problem based on the analysis of the main approaches to the development of enterprise management structure and organizational structure design principles, an algorithm for building a dynamic management structure in conditions of the business processes integrated management system (IMS), and an algorithm for building a target function of its development are proposed. The first algorithm consists of 11 consecutive steps. Its functioning in real time is performed via the decision-maker query system to the enterprise integrated data base. The second algorithm is based on the building of a resultant set of performance indicators of a single criterion with an application of the axiomatic and adaptive approaches. The developed algorithm is based on the expert information and provides accounting of the quantitative prognostic assessments of enterprise business processes.

Keywords:

Dynamic management structure, organizational structure, target function of enterprise development, business process, expert methods, adaptive approach.

ACM Computing Classification System:

Cloud computing, Client-server architectures, n-tier architectures, Peer-to-peer architectures, Grid computing

▀ Introduction

An organizational structure creates conditions for the enterprise's activity performance and reaching the set objectives. It develops and changes influenced by the peculiarities of the enterprise's strategy, its inner complication and changes of the outer environ-

ment. There's a wide range of structures, stretching from stable monolithic formations to dynamic monolithic formations of modern organizations [1].

Material and economic elements of an organization's structure and the process, that take place in it are inseparably associated and they organize the unity of its static and dynamic characteristics.

If you consider an enterprise as a management object you can singularize the following directions of its integration:

- management methodology: policy, mission, goals, principles, methods, enterprise functioning technology;
- management process: communication lines, elaboration, realization, managerial decisions' technical support;
- enterprise management structure;
- functional, organizational structures, human element;
- enterprise integration process technical support.

The integration process represents uniting all subsystems into one banded system. Whereby the methodological basis for an enterprise integration are system analysis methods, used in enterprise management system perfecting, new organizational management forms designing and modeling.

It's important to pay attention to the process of changing the management style from authoritarian to democratic during an enterprise management systems integration. This leads to the evolution of management systems from the bureaucratic model, which is a strictly regulated system, to the dynamic model. One of the evolution factors is management decentralization. Decentralization means delegation of authorities to lower levels, which encourages better functionality of managers' activities. Decentralization practice in administration structures indicates its different advantages. Firstly, it activates development of managers' professional skills, which raises their responsibility for decision making. Secondly, a decentralized management structure stimulates the growth of competitiveness in the organization, creates the challenging atmosphere. Thirdly, a manager expresses more independence and can see his contribution into problem solving in such a structure, which influences the results of the company's overall performance positively [1-4].

It is worth noting that Adaptation of an enterprise to new social-economic circumstances depends significantly on the efficiency of solving the task of forming the target integrated enterprise management structure function formation in correspondence with the realized business-processes [5-7].

▲ **1. The main approaches to the development of enterprise management structure and the optimal organizational structure design principles**

There are two typical approaches to an enterprise management structure formation. The first one implies building the management structure regarding the enterprise's inner formation, division of labor and management rationalization. The second one originates from proceeds from the necessity of constant management structure adjustment to the outer environment conditions.

The first approach has become the basis for formal (hierarchal) management structures, based on the following statements:

- division of labor on the basis of functional differentiation;
- strict power hierarchy;

- a system of rules, defining each enterprise member's rights and duties;
- a system of procedures, defining operation procedure for all situations you can face in the organization functioning process;
- ignoring personal behavior in relationship between the organization's employees;
- employee choice and promotion on the basis of their qualification.

Hierarchical type organizational structures contain:

- line-functional structure, based on a line management vertical and managerial labor differentiation in regard to the organization's functional subsystems;
- line-headquarters structure with a group of specialists, the so-called headquarters or operational analysis cell, being created to help the manager. Its goals include collecting and analysis of information about the outer and the inner environment, performing control, preparing solution projects, current information sharing and consulting the manager;
- divisional structure motivating an enterprise's division into elements and blocks by types of goods and services, groups of consumers or geographic regions.

The organizational structures, stated above, are characterized as complicated (with big number of horizontal and vertical interconnections); high-formalized; with top downward communications and insignificant participation of lower personnel in decision making.

The second approach to building an organizational management structure has appeared in the second half of the XX century. Its main characteristic is the orientation to the organization's link with the outer environment and its changes. This approach is represented by the matrix, brigade and project management structures, significant for group and individual responsibility of every employee for the general result. When such an approach is used there's no necessity in deep labor differentiation by types of works and special relations, imposed not by structure, but by the solved problem character appear between management process. That's why you have to consider the following principles while building organic type management structures:

- orientation on problems and abilities;
- lowering hierarchy to the minimum; polycentrism and changing leaders depending on the problems being solved; temporary functions assignment to groups;
- high level of horizontal integration between personnel; the orientation of relationship culture on cooperation, the personnel's mutual information awareness, self-discipline, development and self-organization.

The main tendencies of organizational structures evolution are the following:

- decentralization, reducing the quantity of levels in the management apparatus. Big companies have created or are creating strategic profit centers, that have gained wide-ranging powers in performing independent production and commercial activities, with this aim. Such centers (departments) fully finance their activity, enter business partners' relations with any companies;
- organizational structures reorganization;
- operations diversification, creation of small companies with innovative functions, oriented on production and active promotion of new products and technologies in the markets, aiming for reaching firm positions in the markets, within big enterprises;
- waiving administrative bureaucratic managerial structures. Wide usage of efficient means and ways of motivation, including distribution of shares between employees, and creating companies, being collective property of their employees, in the course of management process;

- orientation on market environment and satisfying the requirements of and inquiries of clients (an important factor of continuous perfecting and building organizational structures);

- expansion of charitable, humanitarian activities of organizations. Companies can't function and evolve successfully being reserved, «buttoned-up» organizations, only interested in reaching their own inner goals.

At an enterprise creation, building the management structure and system organizational designing methods are used.

The main aim of organizational designing is providing high level of an enterprise's activity organized nature. In order to reach high level of organized nature of any activity it is essential for it to be designed, directed with necessary instructions, information and resources, performed by a rational technology for this data [8].

When a new organizational structure is designed the enterprise must tend to reach the following goals.

1. Determine the types of physical and intellectual labor to be performed.
2. Distribute duties according to positions in such a way that they would be performed successfully and responsibility for their performance could be laid on individuals or groups, establish functions and responsibility for their performance.
3. Provide employees of all levels with:
 - information and other means, necessary for more effective duties performance (including feedback regarding the quality of their work);
 - efficiency measures, coinciding with the organization's goals and objectives;
 - motivation for working with maximum performance.

Moreover, when you design an organizational structure, you have to consider the following factors:

- forming final activity objectives as an initial basis for organizational structures creation;
- consistent consideration of organizational structures;
- variant-typologic arrangement of organizational structures' fundamental properties;
- multifactorial evaluation of management system requirements from the management object;
- working out an organizational method of the management system performance.

System approach to designing an organizational structure is displayed in the following aspects:

- it's important to consider the maximum quantity of factors, influencing each management task;
- it is required to identify and interconnect a system of functions, rights and responsibility in the management vertical – from the top to the bottom production management link in connection with the set goals;
- it is required to explore and institutionalize all links and relations in the management horizontal, i.e. in relation to coordination of activity of different links and management organs while performing general running tasks and perspective interfunctional programs realization;
- it is necessary to provide a seamless combination of management vertical and horizontal, considering finding a correlation of management centralization and decentralization, ideal for the given circumstances.

All of this requires a profoundly elaborated step-by-step structures designing procedure, detail analysis and definition of a system of goals, circumspect organizational divisions and their coordination forms detaching.

In order to build an optimal management structure the following factors should be considered:

- stratification;
- formalization;
- centralization;
- organizational structure complication.

This being said, the new management structure has to be adaptive, possess minimum quantity of hierarchal steps and shortest ways of information transferring [9-12].

2. The algorithm of building dynamic network organizational structures within an object-functional management system

Realization of business-processes within an integrated management system may differ from the enterprise's approved standard. Under such circumstances DMs must interact following the designed algorithm, assuming taking rational managerial decisions in real time situation. The functioning of the algorithm in real time situation is performed using the system of DMs' queries to the enterprise's integrated database.

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

Step 2. The DM acts according to Petri net within the enterprise's regulations framework. For every group of problems, requiring managerial decisions to be taken, regulated Petri nets for DMs interactions are designed. Using these regulations allows to take rational managerial decisions in real time situation, excluding conflict situations.

Step 3. Checking the current business-process' compliance with the regulations within the IMS framework. The business-process' deviation from the regulations is recorded in the integrated database, allowing DMs $\{P^i\}$ to see the deviations occurred.

Step 4. The transition of managerial actions one level higher along the management hierarchy.

Step 5. Finding reasons of deviations from the regulations using the Ishikawa diagram on the level of DMs $\{P^n\}$ (fig. 2.1). Dynamic structures building in the IMS circumstances methodology efficiency evaluation criteria are interlinked and they represent reason-and-consequence strategy links: from the end financial results to the resources, inevitable for their reaching. That's why in order to provide rational management within IMS the system of feedback, based on aims and success factors interaction as the "one to many" correlation, has been created.

Step 6. Comparing actual time for the deviation reasons' detection with the enterprise's regulations. If $t < t_{\text{standard}}$ then transition to step 9 is carried out, if this condition is not met, transition is carried out to step 7.

Step 7. Transition to the next level of the management hierarchy.

Step 8. Comparing the management level with the end quantity of management levels on the enterprise. If after the cycle running from step 5 to step 8 the top management level has been reached, the transition to step 9 is carried out, if not, the transition to step 5 is carried out.

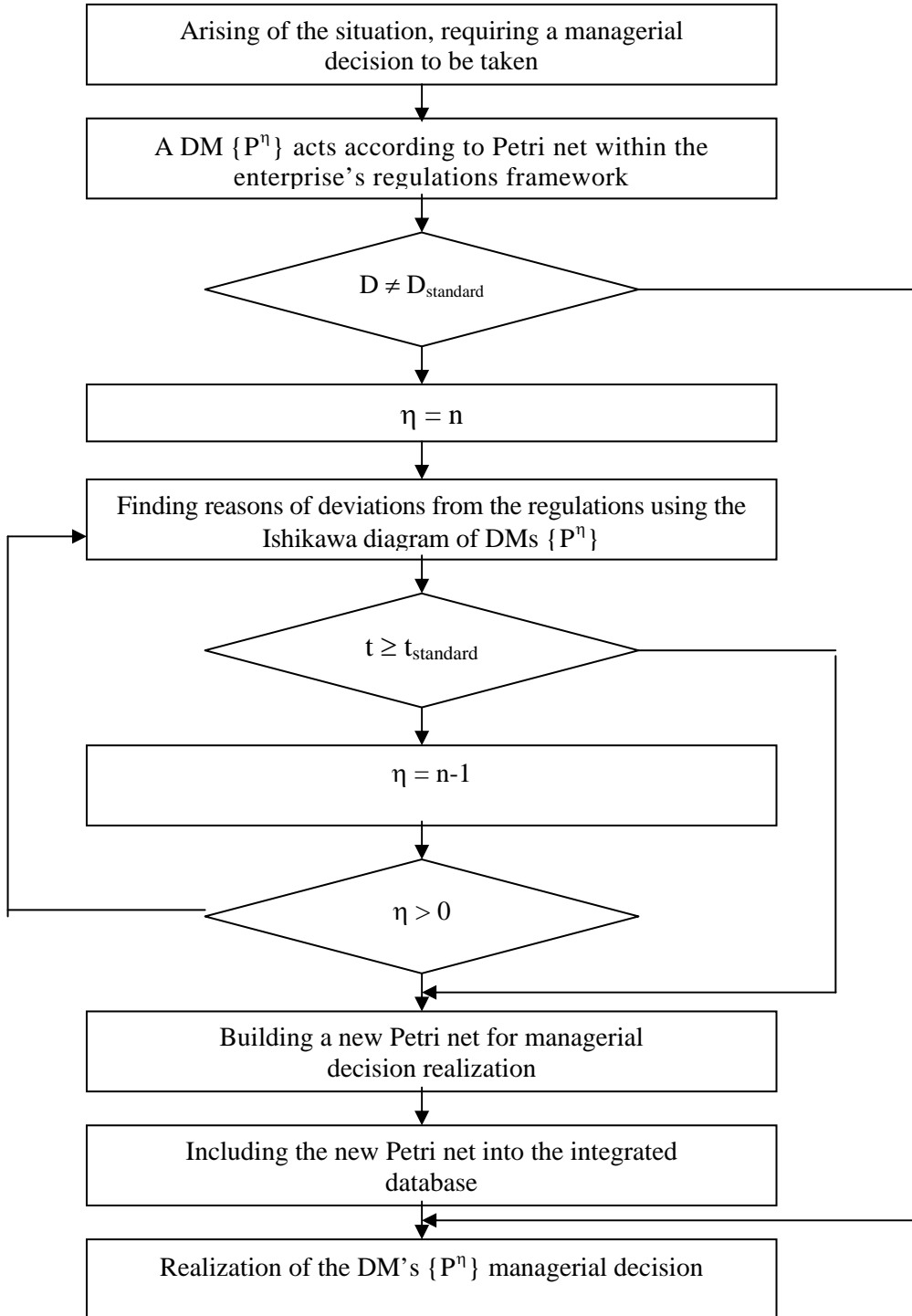


Figure 1. The algorithm of building a dynamic management structure within the IMS framework by business-processes

Step 9. Building a new Petri net for a managerial decision realization. Realization of this unit is performed by the DM of that management level, where the business-process

deviations from standard were detected. A Petri net can only be built by DMs, having powers in accordance with their functional duties.

Step 10. Adding the new Petri net to the enterprise's integrated database. Realization of this step is performed within the enterprise's regulations.

Step 11. Realization of the managerial decision on the DM $\{P^n\}$ level.

The method of building dynamic network management systems in the circumstances of an IMS allows to read information about the correlations between DMs, management objects, management functions from the integrated database. That's why any deviations from the business-processes' normal operation are fixed in the integrated database. A DM $\{P^n\}$ finds the reasons that had led to the non-standard situation using the Ishikawa diagram after the deviation appearance and then follows in accordance with the authorities given to him, considering the enterprise's designed time regulations (fig. 2).

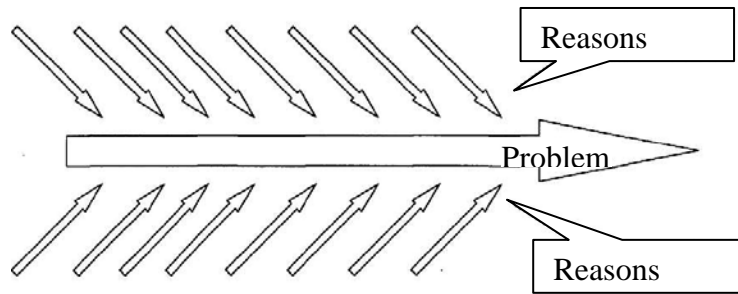


Figure 2. Ishikawa diagram of reason-consequence links in an IMS

3. Target dynamic organizational enterprise structure development function build-up process algorithmization

As the integrated enterprise management system development is characterized with a set of efficiency factors $y_i, i = \overline{1, I}$, which are reached in a specific sequence with various execution length $y_i(t)$, there should be the main condition, characterizing the target function of an integrated management system development by the enterprise:

$$Q(t) = \{y_1(t), \dots, y_i(t), \dots, y_I(t)\}. \quad (1)$$

Its forecasting should be carried out using the retrospective information. Multiple approaches are used in order to fold specific factors into generalized ones.

Firstly, priori folding is used, which allows to fold separate factors into a united one on the basis of the information you have. It's important to find out the possible factor folding structures using this approach. Additive folding is used, which should satisfy the following conditions.

1. The $Q(t)$ function should be invariant to shear transformation

$$y'_i(t) = y_i(t) + C_1, \quad (2)$$

where C_1 is any constant.

This means that the following condition is met:

$$F\{y_1(t), \dots, y_i(t), \dots, y_I(t)\} = Q\{y'_1(t), \dots, y'_i(t), \dots, y'_I(t)\}.$$

2. The $F\{y_1(t), \dots, y_i(t), \dots, y_I(t)\}$ function must be invariant to changing the scale of any factor

$$y''_i(t) = I_1 y_i(t), \quad (3)$$

where I_1 is any positive number.

This means, that the following condition must be met

$$F\{y_1(t), \dots, y_i(t), \dots, y_l(t)\} = F\{y''_1(t), \dots, y''_i(t), \dots, y''_l(t)\}.$$

3. The $F\{y_1(t), \dots, y_i(t), \dots, y_l(t)\}$ function must be invariant to towards transformation

$$\widehat{y}_1(t) = I_1 y_1(t) + C_1. \tag{4}$$

The following folding meets the stated demands (5.2)-(5.4)

$$F\{y_1(t), \dots, y_i(t), \dots, y_l(t)\} = \sum_{i=1}^l \alpha_1 \frac{y_1(t) - y_1^{\min}}{y_1^{\max} - y_1^{\min}} = \sum_{i=1}^m \alpha_1 y_1(t), \tag{5}$$

where α_1 are scale coefficients, $0 \leq \alpha_1 \leq 1$, $\sum_{i=1}^l \alpha_1 = 1$;

y_1^{\min} , y_1^{\max} are the assumed minimum and maximum values of the forecast $y_1(t)$ function correspondingly.

A posteriori folding is performed in situations, when the information you have is enough for precise generated factor statement.

In this case there's a possibility in active information accumulation during the forecasting process. You can often manage to perform accumulation after carrying out a small number of experiments.

Experiments lay in checking the conjecture of some hypothesis about an enterprise's behavior as an economic system, which, after being performed, lead to partial or full elimination of the uncertainty, caused by determining the main restructuration program condition – the choice of a generalized factor and its parts. Such an approach is axiomatic.

The axiomatic approach is the most applicable from the point of efficiency among the considered approaches. If the axioms are used wisely, it is possible to reduce and sometimes even fully eliminate uncertainty in choosing the generalized factor. However, application of axiomatic methods is associated with significant problems. Firstly, the existing axiom systems are not always easily verifiable in specific tasks. Secondly, building axiom systems is impeded by the fact that they must be not complicated on one hand and informative enough to eliminate the possible uncertainties, on the other.

It is also possible to use adaptive approach, when each of the experiments carried out is not as informative as when the axiomatic approach is used and in order to eliminate uncertainties in choosing the generalized factor you have to carry out a significantly bigger number of such experiments. When such an approach is used each next experiment is carried out with regard to the result of the previous and factors folding represents an axiomatic target.

In order to build an adaptive algorithm of forecasting using a generalized factor it is suggested to unite forecasting and α_1 scale coefficients setting in one cycle of the generalized $Q(t)$ function (5.5) using expert information [11-17].

In order to perform forecasting in the specific $[n+1]$ moment of time using the known $y[1], y[2], \dots, y[n]$ time series the

$$y[n+1] = a_0 y[0] + a_1 y[1] + \dots + a_n y[n] + \varepsilon_{n+1}. \tag{6}$$

line model is accepted.

In order to determine the unknown a_j coefficients in the (5.6) equation we'll use the least squares method. We'll define the $y[n+1]$ value with the help of a line combination and the $z_i[n+1], \dots, z[n+1]$ functions, which take the $z_j[n+1] = y[n-1]$, $j = 0, 1, 2, \dots$ values. These functions are independent variables. All the data, subject to processing, is collected into table 3.1.

We'll use the statistical criteria to choose those, which are enough while building the

$$y[n]=a_0z_1[n]+a_1z_2[n]+...+a_{k-1}z_k[n], k < n. \tag{7}$$

line model, from the full array of independent variables, given in the table.

In order to set scale coefficients it is suggested to the expert to set the assumed border level of each $y_i(t)$ factor mentally at the y_i^{border} forecasting stage. In this case it is considered, that the factor's scale coefficient in the $Q(t)$ generalized function and the y_i^{border} scale coefficient coincide on the forecasting stage.

Table 1 – Values of parameters and the corresponding functions

Stage number	Parameters value	Independent variables					
		$z_1[n]$	$z_2[n]$	$z_3[n]$.	$z_{n-1}[n]$	$z_n[n]$
0	$y[0]$	-	-	-	.	-	-
1	$y[1]$		-	-	.	-	-
.
n-2	$y[n-2]$	$y[n-3]$	$y[n-4]$	$y[n-5]$.	-	-
n-1	$y[n-1]$	$y[n-2]$	$y[n-3]$	$y[n-4]$.	$y[0]$	-
n	$y[n]$	$y[n-1]$	$y[n-2]$	$y[n-3]$.	$y[1]$	$y[0]$

The $y_1[n+1]$ line forecasting model is built for every factor. The α_1 coefficients are set and the forecast generalized

$$F[n + 1] = \sum_{i=1}^I \alpha_1 \widehat{y}_1[n + 1]. \tag{8}$$

factor value is determined on the basis of priori information.

Simultaneously the following value is counted

$$F^{border}[n+1]= \sum_{i=1}^I \alpha_1 \widehat{y}_1^{border}. \tag{9}$$

After the computing, stated above, the information is analyzed by an expert. If the expert is not worried about the quick approaching to border values regarding the generalized factor and each individual factor, the generalized factor reflects individual factors' tendencies, then the α_1 coefficients are used for the next step of forecasting. In case of contradictions between the evaluation of the generalized factor changes and some (S^{th}) factor the adaptive adjustment of the α_1 coefficients for the $(n+1)^{th}$ step of forecasting is carried out.

The evaluation of contradictions, stated by the expert, is formalized the following way:

$$A_s^n = 1; A_i^n = -1; (i = \overline{1, I}, i \neq s),$$

The coefficients adjustment algorithm looks like this

$$\alpha_s^{n+1} = \frac{\alpha_1^n + \varepsilon^{n+1}}{1 + \varepsilon^{n+1}}; a_1^{n+1} = \frac{\alpha_1^n}{1 + \varepsilon^{n+1}} (i = \overline{1, I}, i \neq s)$$

$$\varepsilon^{n+1} = \varepsilon^n \exp[a \text{ sign} A_s^n - A_s^{n-1}],$$

where α is some positive constant.

The structural scheme of the target enterprise management system development function forming algorithm, providing record of quantitative forecasting evaluations of the realized business-processes on the basis of expert information is presented on figure 3.

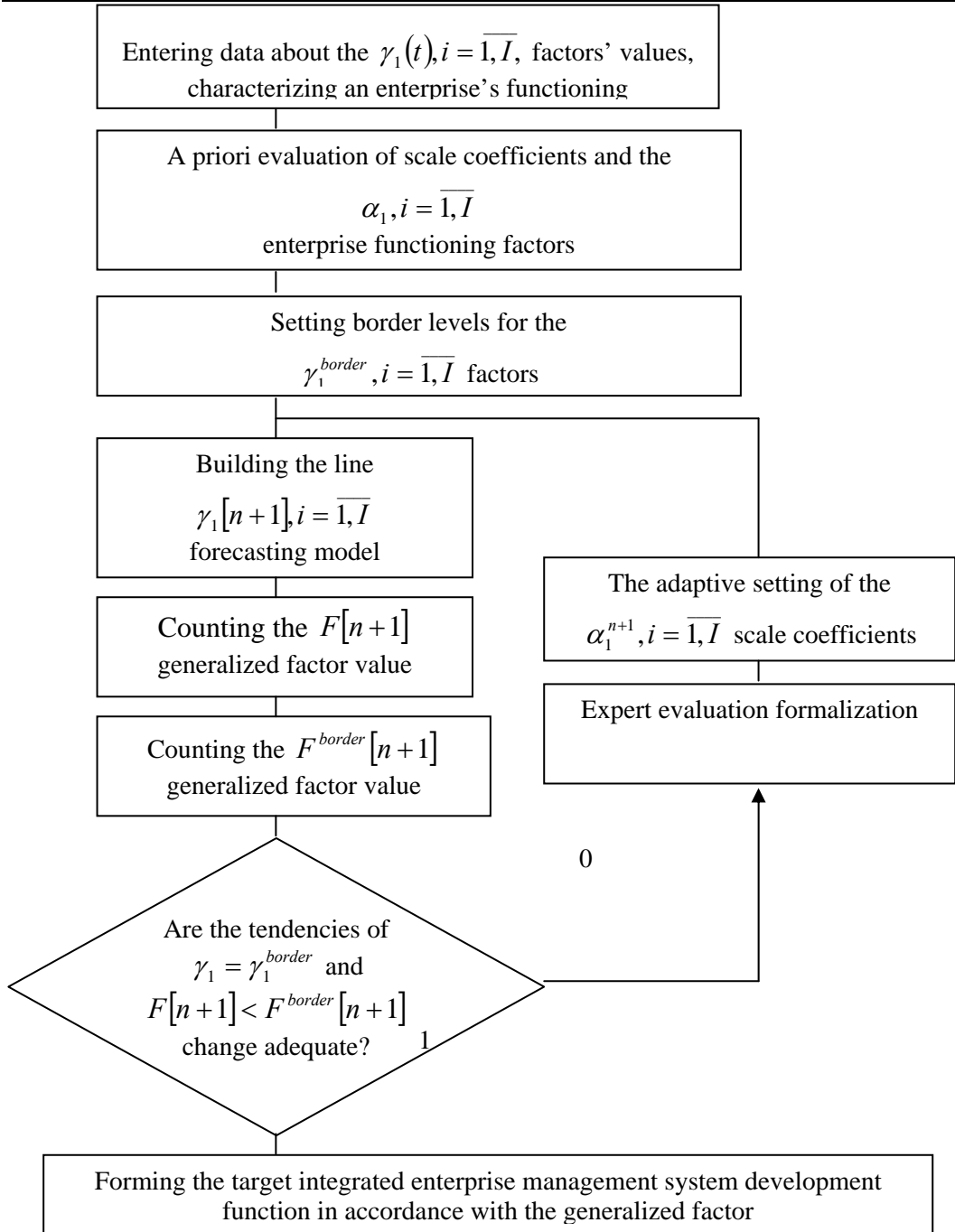


Figure 3. Structural scheme of the target integrated enterprise management system development function forming algorithm

Conclusion

Therefore, as a result of this study the algorithm of building a dynamic structure in an integrated enterprise business-processes management, realized in real-time mode and

allowing to make rational managerial decisions, excluding conflict situations, has been formed; the algorithm of generation of a target function of an integrated enterprise management system development on the basis of expert information forecasting and analysis procedures, has been developed.

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