



# ***Modeling of dynamic organizational structures building process in enterprise management system of various orders***

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## ***Abstract:***

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*The three types of control: closed loop control, open-loop control and isolation control are introduced from the standpoint of rational manufacturing enterprise management. The problem of building a dynamic enterprise management structure is defined. The six levels of detail of the business processes integrated management system (IMS) are suggested for the implementation of the above-mentioned challenge. For a more detailed representation of the IMS elements functionality, the aggregation-decomposition approach is proposed in the work. It represents the system as a set of interrelated elements of different level of detail. To formalize the relationships between the variations of the ISU elements building, the alternative-graph formalization is suggested. The mathematical model of interaction between a decision maker (DM), objects of control and business processes, based on the Petri nets apparatus is developed.*

## ***Keywords:***

*Enterprise management, dynamic organizational structure, network management structure, aggregation-decomposition approach, modeling, Petri nets.*

## ***ACM Computing Classification System:***

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

## **■ Introduction**

The task of manufacturing enterprise sustainable governance remains a live issue today on both practical and theoretical grounds.

There are three management types: closed-loop management, open loop management, and isolated management. If a management subsystem belongs to the management

system, its activity and development control is carried out in a closed loop by means of the system's output feedback with input. The presence of the feedback provides an impact on production factors by means of their own resources, which allows to reach the production system self-organization. There's no feedback between the output and the input in the open loop management. The isolated management is reached by organizing input and output filters, preventing undesirable inputs to enter the system from the outer environment and undesirable outputs to exit the system to the outer environment.

All the three management schemes are combined in real enterprise management systems. The correlation between closed-loop and open loop management changes depending on the enterprise's legal organizational forms.

Management types are stipulated by using different means of the management system, which is a variable quantity. It is common to determine the programme, the supervisory, the adaptive and the extreme management types [1-4].

In the programme management the management programme is determined in time. This is the most widely used management type for an enterprise in general, as the productive capacity is planned in connection with the calendar.

In the supervisory management the management programme depends not on time but on some leading (supervisory) value. An essential condition for using supervisory management is good organization of the supervisory value study and prediction works, allowing to reorganize production timely. Conversely, the necessity of timely production reorganizing depending on the supervisory value requires perfecting of the production organization and technology in the line of their flexibility raise.

When adaptive management is used, there's no determined supervisory value and the management sets the programme on the basis of prior experience. That's why accumulation and summing up conclusions from prior experience are mandatory conditions of adaptive management.

When extreme management is used, the management programme is aimed for reaching some function's maximum or minimum, with any given parameters being set as variables (input, the state of the controlled system or output). Extreme management can be realized with a limited level of outer environment stability [5-7].

Most often production systems management has complex character combining all four management types.

The management process should be carried out on the basis of the system approach principles, as it represents the complex of many interrelated processes.

You have to take many decisions, performing planning, work organization, people's motivation, controlling and coordinating all the processes, taking place in the organization, in the course of management functions fulfilling. That's why management can be presented in organizational and technical systems as a sequence of functions, making up the management technological cycle [8-10].

The task of building an effective management structure comprises of an optimal choice: interaction between DMs; variants of realization of management functions (goals), business-processes and their distribution between management objects. However, completing this task is possible for a specific set perspective time period and for some set system functioning conditions. The management system's strategic reaction to the outer environment's disturbing inputs assumes completion of the dynamic effective management structure designing task. Such a task optimizes not only the structure of management objects, DMs and interlinks between them, functions distribution for the given moment of time but also suggests the variants of the system functioning in force-majeure conditions.

Management systems functioning process may include a variety of aspects, representing a stage when specific goals are set for the system and it has to reach them. That's why the management system structure must be designed in way to react to the disturbing inputs adequately. Therefore, the dynamic goal of building an effective management structure consists in the choice such an array of management objects, DMs, interrelations between them and such distribution of functions and responsibility for the resources on each business-process, that the requirements to the system's quality characteristics would be met on every moment of its functioning [11].

## 1. Development of a model of a dynamic network management structure

Solving the dynamic enterprise management structure designing task is realized on six levels of integrated management system (IMS) detalization by business-processes. On the top level the goals, realized by IMS, are formalized, then the performed management functions and goals, which can be detalized to separate technological and administrative business for each DM are formalized.

The generalized task of an enterprise management system building in the conditions of an integrated management system can be represented with the following set of information:

$\langle A, B, C, D, F, G, K, W \rangle$ ,

where A represents – the tree of IMS' goals;

B – the variety of tasks, resolved by IMS;

C – the array of management functions, realized in IMS;

D – the array of management objects;

F – the array of administrative business-processes;

G – the assembly of DMs, forming management hierarchy;

K – the array of choice criteria (in accordance with the enterprise's regulations);

W – the array of acceptable alternative variants of the dynamic management structure, realized in IMS.

The mechanism of building a dynamic network management structure within the framework of an IMS to choose a rational managerial solution from the array of acceptable alternative variants in order to reach the set goals, is chosen in accordance with the criteria, set at the enterprise. The dynamic management structure model will be as follows:

$$W_i = \bigcup_{i=1}^G (A_i B_i C_i D_i F_i) . \quad (1)$$

In order to reflect the links between the elements in the IMS the integrated enterprise model in three dimensions (fig. 1) is used, where the following are realized:

- IMS management structures business-processes lifecycle;
- Enterprise presentation as a hierarchal organizational structure, reflecting DMs' powers and responsibility with regard to management functions;
- IMS management objects presentation with regard to their properties.

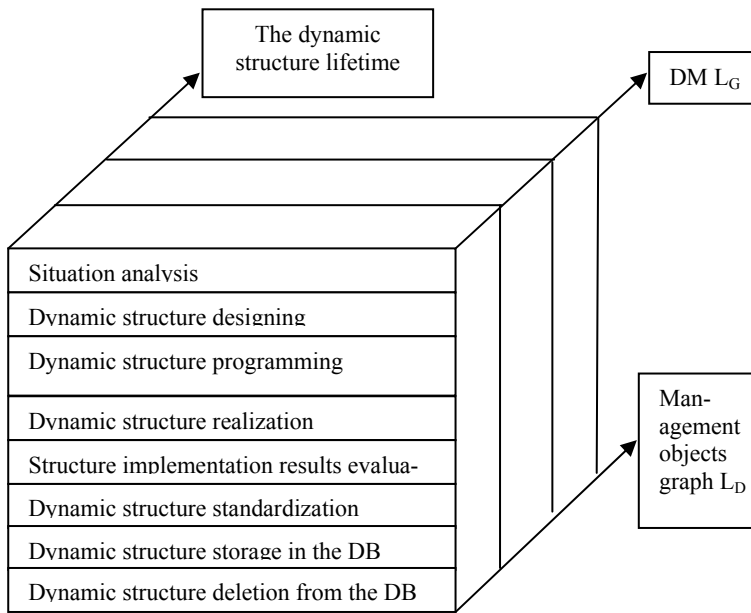


Figure 1. Presentation of interlinks between IMS elements with business-processes

## 2. The aggregation-decomposition approach for IMS elements modeling

In order to reflect the interlinks between IMS elements the aggregate-decomposition approach, consisting in the system's presentation as an array of interlinked elements of different detalization levels, is used in the work. In order to formalize interlinks between different variants of IMS elements building the alternative-graph formalization, in which different management system elements (or such elements' arrays) building variants are set as an alternative graph node and the arcs reflect the character of relations between them, is used [12-14].

The aggregate-decomposition approach includes two related stages:

- the sequential decomposition of the functions, goals, business-processes, carried out by the system;
- aggregation of elements on the corresponding detalization level to generate variants of building correlations in the management system in general on the considered detalization level.

In order to solve the dynamic network organizational structures in an object-functional enterprise management system it is necessary to build the following graphs:

- the  $L_A$  graph sets correlations of the alternative variants of management goals reaching;
- the  $L_B$  graph sets alternative variants of management tasks fulfillment;
- the  $L_C$  graph sets alternative variants of management functions realization;
- the  $L_D$  graph reflects correlations between management objects;
- the  $L_F$  graph reflects variants of administrative business-processes realization, regarding technologic ones, and it can be detalized to separate business-processes' and aggregates' stages;

- the  $L_G$  graph determines DM hierarchy and possible correlations between them while managerial decisions realization [15-17].

Typical system parts are separated during business-processes level aggregation. Aggregation on the tasks level leads to separation of typical tasks and aggregation on higher levels allows to determine the system's aggregated functions and its goals.

In order to solve the task of a dynamic management structure building it is necessary to determine every detailization level as classifiers:

$$L_A = (A, N), \text{ where } A = \{A^0, A^1, \dots, A^{G-1}\} \quad (2)$$

$$L_B = (B, M), \text{ where } B = \{B^0, B^1, \dots, B^{G-1}\} \quad (3)$$

$$L_C = (C, Z), \text{ where } F = \{C^0, C^1, \dots, C^{G-1}\} \quad (4)$$

$$L_D = (D, X), \text{ where } D = \{D^0, D^1, \dots, C^{G-1}\} \quad (5)$$

$$L_F = (F, Y), \text{ where } F = \{F^0, F^1, \dots, F^{F-1}\} \quad (6)$$

Let  $\varpi$  be an operation of array elements displaying. The optimal displaying should provide some target function (functions') extreme point in case of set limits adherence.

The generalized network management system building task is described by the following definition:

$$A \in n; \quad (7)$$

$$c \in C(A); \quad (8)$$

$$D \in \overline{D}; \quad (9)$$

$$[c \in C(A)]\varpi[D \in \overline{D}]. \quad (10)$$

If technologic processes and the management system objectives tree are set, then the dynamic structure building task lays in the (7)-(10) definition; if technologic processes, the system's objectives tree, the performed management functions and the array of management objects are set, then it lays in the (10) definition.

Solving the dynamic management structures building task is closely related with the problems of distributing functions, responsibility for the enterprise's resources with a permanent set of management objects, DMs, management levels number. That's why there's the necessity of solving the dynamic management structure building task, including the choice of an IMS functioning principles and algorithms. In general case these problems are interrelated, because if you change the structure the system of target functions and inner links also changes and, consequently, the system of the system's elements' behavior also changes [1-4].

It is possible to point out the following directions of dynamic management structures building:

- building a structure with set system functioning algorithms and functions;
- synthesis of functioning algorithms, functions, the rules of DM behavior and their interactions within the set hierarchal system;
- building a management structure, including both management system functioning optimization, and functions distribution along IMS nodes and their contents choice.
- Solving the third goals unit is suggested using the aggregate-decomposition approach. Depending on the level of detailization of the tasks, functions and goals performed by the system and on their displaying by IMS levels the following typical management structure building task settings can be used:

- the optimal displaying of the tree of objectives, performed by the system (the  $L_A$  graph) on the hierarchal organizational management system (the  $L_G$  graph); the array of

DMs and their correlations are mainly determined by peculiarities of the system objectives graph;

- the optimal displaying of the array of functions, tasks, performed by the system, management objects (the  $L_C, L_B, L_D$  graphs) on the DMs array (the  $L_C$  graph) regarding the peculiarities of the  $L_F$  graph;

- optimization of the administrative business-processes contents and realization variants and DMs' (the  $L_F$  and the  $L_G$  graphs) during the managerial decisions taking process.

The dynamic management structure building task consists in the directed DMs choice from the array of management objects  $\{D\}$  of such an assembly of  $D_C \in D$  elements, that would provide performing the array of the function system elements  $\{C\}$ . The management objects array concept design model can be presented as follows:

$$C^G \rightarrow \theta^G \rightarrow D_{\varphi\varphi}^G = \sum_{i=1}^I D_{\varphi\varphi}^G \in D^G, \tag{11}$$

where  $\psi$  is the alternative network management structure variant index;  $0 \leq \psi \leq V$ ,  $V$  is the alternative network structure variants quantity;

$\theta$  is the correlation of management elements arrays and management functions.

Using the procedure of choice the array of alternative network management structures array is formed inside the  $D^G$  array following the  $\theta^G$  links in IMS circumstances for every DM –  $W_{\psi}^G$ . The task of a DM is choosing a rational scheme of relationship while taking managerial decisions using the following parameters:

$$W_{\psi}^G(S_C^G) \in W_{\psi}^G, \tag{12}$$

where  $S$  is the range of dynamic management structures within the IMS framework.

The mechanism of dynamic network management structures building within an IMS is presented on figure 2 [1, 12-14].

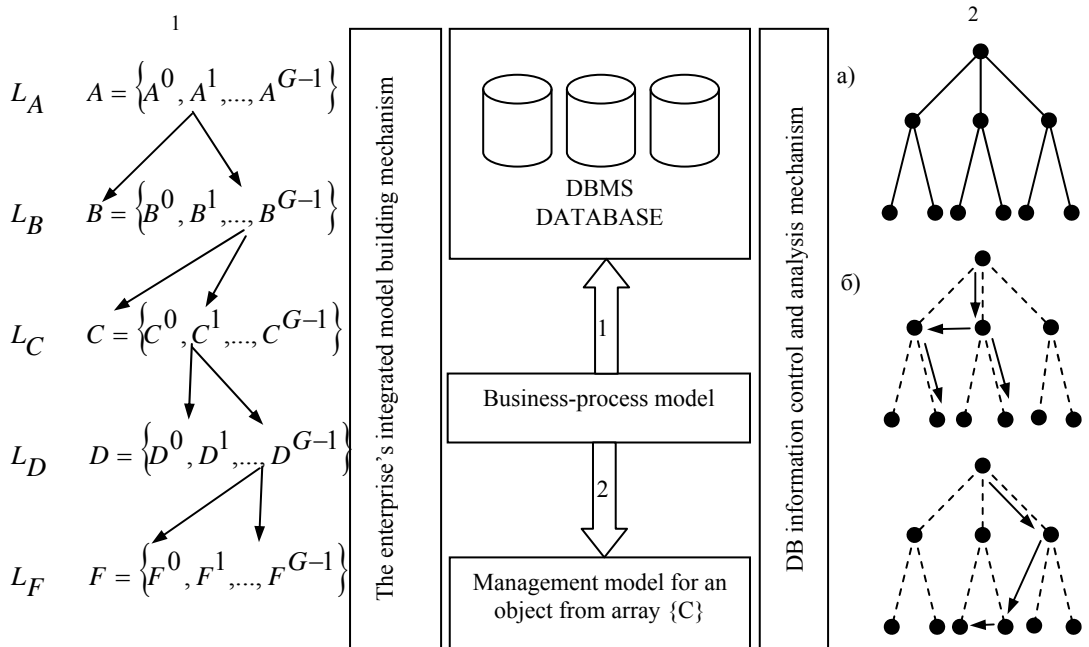


Figure 2. The mechanism of dynamic management structures building within an IMS by business-processes

Legend:

I. – Enterprise presentation as graph-arrays

II. a) the LG array,

b) variants of dynamic management structures for a managerial decision realization.

1 – data modeling

2 – management functions modeling.

► **3. The mathematical model of interaction between a decision maker (DM), objects of control and business processes, based on the Petri nets apparatus**

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. 3).

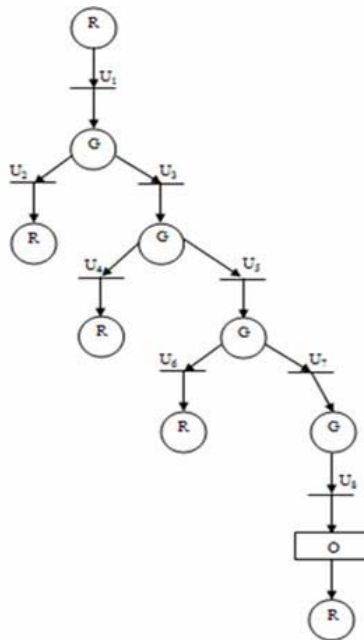


Figure 3. Petri net of an integrated enterprise management system building

Legend:

$G_1 - G_4$  – DMs, an entity from the  $\{G\}$  array,

R – the customer

O – an element of time interval, equal to the order realization time, from the start of production to being given to the customer

$U_1 - U_8$  – managerial decisions, an assembly from the  $\{F\}$  array.

While building a Petri net the following conditions have to be considered:

1. Interaction between IMS and outer environment, as well as between elements within the IMS is carried out by means of signal transmission, the mutual influence, performed outside the signal exchange mechanism, is not considered.
2. An input for any IMS represents an assembly of input information; the information flow is meant for receiving elementary signals  $x_i(t) < X, i = 1, n$ . The same way managing and output information flows are input.
3. The outer environment is reviewed as some aggregate, characterized by the assembly of input and output signals.
4. Elementary signals, transmitted by a specific output information flow, can be transmitted to a specific input or managing informational flow in case if an individual elementary data transmission channel, connecting the stated information flows, is realized in the system.
5. Each input and managing information flow is connected by not more than one individual channel. Every output information flow can be connected by any end number of individual channels in case that the input and the managing input of every IMS element is directed by not more, than one of these channels.

The structure of links between IMS elements and the outer environment is determined by the assembly of individual channels, realized in reality.

Thus, building correlations between IMS elements regarding the stated rules and realization of managerial decisions making processes within the framework of Petri nets, regulated by the enterprise standards, allows to avoid conflicts during business-processes.

The correlations of the assembly of integrated enterprise management systems' aims, tasks being solved, management functions, management objects, DMs can be represented as matrixes. Thus, the correlation of the management functions array and the management objects is represented by the  $A = \| a_{ij} \|$  matrix, where the  $a_{ij}$  value determines the efficiency of the  $j$  management function's managerial impact on the  $i$  management object.

The same way management objects array interaction matrix with the DMs array and management tasks array interaction matrix with the management functions array are built.

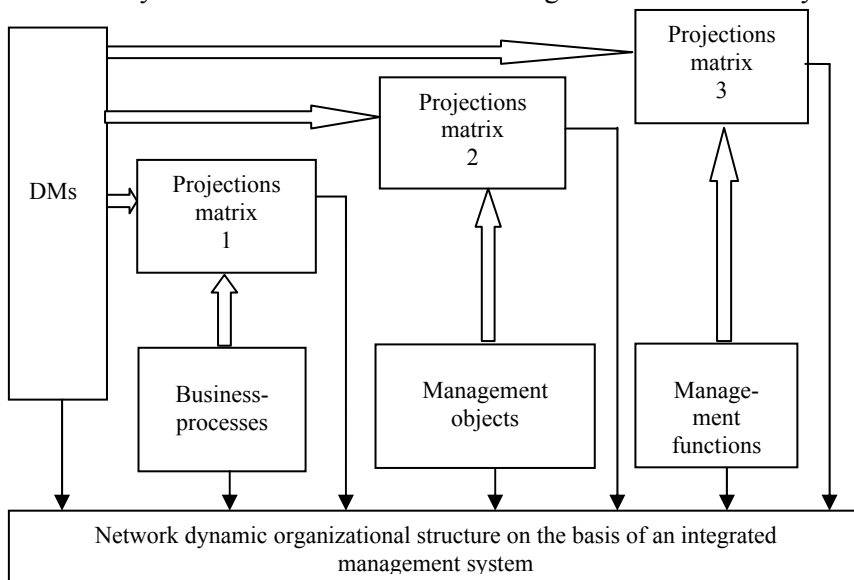


Figure 4. Building dynamic management structures within the framework of an integrated management system

## Conclusion

Therefore, as a result of this study a model of interaction between an integrated management system elements, providing realization of managerial decisions making processes within the framework of the Petri nets, approved by the enterprise's standard, has been designed.

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