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DECISION MAKING IN CORPORATE SYSTEMS

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ABSTRACT

This paper considers the mechanisms allowing to build flexible distributed human-machine procedures of decision support. Emphasis is on making the process of forming solutions for informal models of factors that are not formally considered. The characteristic feature of the enterprise systems is the presence of priority in deciding between different subsystems that are the part of corporate system in accordance with their responsibilities range. Solving the problems of self-governance in each of the subsystems generates the parameters of coordination tasks. Each subsystem is affected by local external and internal disturbances that are associated with the change of the generalized information from lower levels. To get the sought linking mechanisms, the $F(A, x)$ functional of the system and the number of auxiliary functional g_i =1, ..., I, g satisfying the properties of operation of corporate systems were formed.

ПРИЙНЯТТЯ УПРАВЛІНСЬКИХ РІШЕНЬ У КОРПОРАТИВНИХ СИСТЕМАХ

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У статті розглядаються механізми, що дають змогу будувати гнучкі людино-машинні процедури підтримки прийняття рішень, застосувати в процесі формування рішень неформалізовані моделі факторів. Характерними особливостями корпоративних систем є наявність пріоритету при прийнятті рішень між окремими підсистемами, що входять до складу корпоративної системи згідно з їхнім діапазоном відповідальності. Розв'язок задач самоуправління в кожній із підсистем формує параметри задач координації. Враховуються як локальні зовнішні збурення, так і внутрішні, що діють на систему і залежать від узагальненої інформації від підсистем нижчих рівнів. Введення цих обмежень переводить задачу пошуку допустимих рішень корпоративної системи до класу задач системної оптимізації і дає змогу враховувати обмеження різного виду. Для побудови механізмів управління формується функціонал F(A, x) і декілька допоміжних

функціоналів g_i, $i = 1, \ldots, I$, що задовольняють властивості функціонування системи.

***Ключові слова**: корпоративні системи, підсистема, самоуправління, координація.*

Introduction. The current status of complex organizational structures management, which includes enterprise systems, requires new methodological and planning technologies and management.

There are various means of distributing the corporate system into components, leading to different types of organizational structures that are allocated to the functional, regional, production and other characteristics [1; 2].

The term "corporate system" refers to any organization of production or administrative direction. It consists of a set of interacting components; each of them in turn can have a personal part, and function as a single entity [2; 3]. This definition of the corporate system is formed due to the need to decentralize the decision-making processes of all complex problems which are solved by organization to meet the terms of their physical implementation based on the minimization of information processed. In other words, each individual component of the corporate system takes the decisions of individual tasks within the solution of common problems for the corporate system as a whole. In addition, the elements of the corporate system are related and interact with other corporate systems that are external to it as informative and functional.

Purpose of the Article. This paper considers the mechanisms allowing to build flexible distributed human-machine procedures of decision support. Emphasis is on making the process of forming solutions for the informal models of factors that are not formally considered. The mechanisms inherent in the possibility of adapting the model of the corporate system are considered.

Materials and Methods. Characteristic features of the enterprise systems involve the priority in deciding between different subsystems that are the part of corporate system in accordance with their responsibilities range [4; 5]. Also the subsystems of one level share the same priorities in choosing solutions in relation to each other and each subsystem; all subsystems except the first level solve two problems: self-performance through their functional activity and task coordination of subordinated subsystems of lower level with its local optimality criteria.

Connection of subsystems of lower level to higher level subsystems and their interrelation shall be effected by the generalized information about the status of these subsystems, and connection of subsystems of upper level with the subsystems of lower level subordinated to the higher level ones by means of administrative actions, which come from the top-level subsystems. Connection between the subsystems of one level is done directly by output variables that affect their functioning.

Models of coordination problems in each of the subsystems, except for of subsystems of the first level, are constructed according to the summary information about the behavior of the entire set of subordinated to them subsystems at lower levels.

Solving problems of self-governance in each of the subsystems generates the parameters of coordination tasks. Also the subsystems of lower levels between the

two neighboring phases of coordination problem solving in subsystem of upper level that controls these subsystems have the right to take independent decisions based on management actions derived from the top level.

Each subsystem is affected by local external and internal disturbances that are associated with the change of the generalized information from lower levels.

When describing the corporate system, the following is taken into account [3—5]:

- Restrictions that describe "external structure" of the corporate system (products which are manufactured; resources which are consumed, expected profit).

They are needed in order not to overstate the limits of resources (e.g., money, currency) to produce the required quantities without overstocking and deficit and have the form

$$B_i \le \sum_{j=1}^{J} a_{i,j} x_j \le D_i, \tag{1}$$

where i, $i = 1, \dots, I$, — limitation indexes (1);

- Restrictions that describe the "internal structure" of the corporate system (the relationship of the price of labor, energy, materials and resources)

$$\gamma_r \le (\alpha_r, A(x - y^{(r)}) / (\beta_r, A(x - y^{(r)}) \le \overline{\gamma_r}, \tag{2}$$

where $r = 1, \dots, R$ — index of type limit (2);

- Restrictions which are imposed on the specific characteristics of the corporate system

$$A_j \in Q_j, \tag{3}$$

where $j = 1,\dots, J$ — index of components of the vector of variables x, A_r, $j = 1, \dots, J$, column vector of transmissivity matrix A,

$$A = (a^{i,j})_{i,J=1}^{I,J};$$

- Constraints that describe the technological limitations on the range of the variables of the system:

$$x \in Q. \tag{4}$$

Introduction of these restrictions converts problem of finding feasible solutions of the corporate system to the class system optimization problems and takes into account environmental constraints and the selection of promising technologies. The system (1)—(4) cannot be solved fully by automated methods. The process of permissible decisions making affects people, professionals, decision makers (DM).

They are in the process of using formalized understanding of the task and the subject area, heuristic techniques and methods. This could result in the solutions acceptable under constraints but meaningless from a content point of view. In addition, different groups of equations (1)—(2) can be operated by a variety of professionals who do not have other limitations of (1)—(2).

Thus, we have a set of local operators D, $s = 1, \dots, S$, s forming the groups of equations (1) and (2) heuristic means and methods. This leads to the necessity of developing the procedures of distributed decision support system (1)—(4) by a

series-parallel formation of s-s local tasks that meet the requirements which are demanded in practical procedures for decision support.

The main tasks include the iteration procedure with the possibility of gradual correction of input data and solutions. That causes a problem of the construction of mechanisms linking decisions s-s local problems in the serial-parallel formation of acceptable solutions of (1)—(4).

We consider the problem of building such relationships, which allow the restructuring of the corporate system (1)—(4), changes in system settings (B_i, $a_{i,j}$, D_i, Q_j, Q) in shaping acceptable solution. Changes in the structure decomposition of the corporate system in the formation of acceptable solutions caused by the necessity of discharge the most important and critical at the current time of formation of acceptable solutions group constraints (1) and (2).

To construct the sought binding mechanisms, we introduce the functionality F (A, x) disagreement system (1)—(4) and a number of support functionalities F, $g_{b,i}$, $i = 1, \ldots, I$, $g_{\gamma,r}$, satisfy the following attributes [2]:

Attribute 1.

$$F(Ax)\min\{\tilde{F}(Ax-\tilde{b},\gamma(x)-\tilde{\gamma})\,\big|\,\tilde{b}\in B,\tilde{\gamma}\in\Gamma),\ \text{where}\ \Gamma=\left\{\gamma\,\middle|\,\underline{\gamma}\le\gamma\le\overline{\gamma}\right\}.$$

Attribute 2.

$$g(\tilde{F}(b,\gamma))\le\tilde{F}_b(b)+\tilde{F}_\gamma(\gamma).$$

Attribute 3.

$$\tilde{g}_b\,(\tilde{F}_b\,(\sum_{l=1}^{L}\xi_l\,b^{(1)}))\le\sum_{l=1}^{L}\xi_l\,g_{b,l}(b^{(l)}).$$

Attribute 4.

$$\tilde{g}_\gamma\,(\tilde{F}_\gamma(\gamma))\le\sum_{\rho=1}^{P}b_{\gamma,\rho}(\gamma_\rho).$$

Attribute 5.

а) $g_{b,l}(0)=0$, $g_{b,l}(tb^{(l)})$ — strictly monotonically increasing on t, $t\in R_+$, smooth function for all nonzero vectors $b^{(l)}$ (from the first class).

б) $g_{\gamma,\rho}(0)=0$, $g_{g,\rho}(t\gamma_\rho)$ — strictly monotonically increasing on t, $t\in R_+$, equal function (*by* $\gamma_\rho\neq 0$).

Let us consider the mechanisms allowing to build flexible distributed human-machine procedures of decision support. Emphasis is on conducting the process of forming solutions informal models of factors that are not formally considered.

Mechanisms are inherent in the possibility of adapting the model of the corporate system.

General view of the procedure. General k-th step.

System (1)—(4) S is divided into subsystems consisting of *i*'s, groups of equations $i\in I_{s,k}$ (1), *r*'s groups of equations $r\in R_{s,k}$, (2) and restrictions (3)—(4). Simultaneously, the matrix A is broken into $\tilde{S}-i$, $\tilde{s}=1,\ldots,\tilde{S}_k$ — and, groups of

columns $\tilde{J}_{\tilde{s},k}$. With every *s*-th local subsystem consisting of *I*'s $i \in I_{s,k}$ equations (1) *r*' s, $r \in R_{s,k}$ equations (2) with every — $\tilde{S}$ -group of *j*'s, $j \in \tilde{J}_{\tilde{s},k}$ columns also runs a DMP specialist.

1. DMP specialists working with c *s*-local subtasks as tips available options, satisfying (3)—(4) automatically generated $x^{(s,\,hint,\,k)}$ *s*-making tasks.

2. DMP specialists working with $\tilde{S}$ groups of the columns of *A* matrix, as a hint offered options $A_j^{(\tilde{s},\,hint,\,k)}$, $j \in J_{\tilde{s},k}$, (3).

3. As an automatically generated hint $A^{(hint,\,k)}, x^{(hint,\,k)}$ — a new version of approximate solution of (1)—(4), for which the functional F disagreement better than *A* — the matrix $A^{(k)}$, $x^{(k)}$ and vector x variables after *k*-th step.

4. DMP-specialists working with s local tasks or provide hint unchanged or autonomously form their variants $x^{(s,\,evrist,\,k)}$ that satisfy (3)—(4) *s* solution of local problems.

5. DMP-specialists working with s columns groups of Matrix A accept the hints unchanged or generate their own options which satisfy (3) *J*, $J \in J_{\tilde{s},k}$, of columns $A_j^{(\tilde{s},evrist,k)}$, $j \in J_{\tilde{s},k}$.

6. Automatically formed by specialists "a weighted average" of local problems heuristic solutions $A^{(k,\,avrg)}, x^{(k,\,avrg)}$ that satisfy (3)—(4).

7. If $A^{(k,\,avrg)}, x^{(k,\,avrg)}$ in the terms of the convergence better than $A^{(k)}, x^{(k)}$ then $A^{(k,\,avrg)}, x^{(k,\,avrg)}$ should be taken over. Go to $(k + 1)$ — the first step.

8. If $A^{(k,\,avrg)}, x^{(k,\,avrg)}$ in the terms of the convergence worse than $A^{(k)}, x^{(k)}$ then following formulas should be used:

$$x^{(k+1)} = x^{(k,\,hint)}\,(1-t^*) + x^{(k,\,hint)}t^*,$$

$$A_j^{(k+1)} = (A_j^{(k,\,hint)}\,x_j^{(k,\,hint)}\,(1-t^*) + A_j^{(k,\,avrg)}\,x_j^{(k,\,avrg)}\,t^*)\,/$$

$$/(x_j^{(k,\,hint)}(1-t^*) + x_j^{(k,\,hint)}\,t^*);$$

$$x^{(k,\,corr,\,s)} = x^{(k,\,hint,\,s)}\,(1-t^*) + x^{(k,\,evrist,\,s)}\,t^*;$$

$$A_j^{(k,\,corr,\,\tilde{s})} = A_j^{(k,\,hint,\,\tilde{s})}\,(1-t^*) + A_j^{(k,\,evrist,\,\tilde{s})}\,t^*;$$

where t^* — is a task solution (5)—(7):

$$t \to \max, \tag{5}$$

$$0 \le t \le 1, \tag{6}$$

$$F\big(A(t), x(t)\big) \le F(A^{(k)}, x^{(k)}) - \delta^{(k)}, \tag{7}$$

Subject to:

$$\delta^{(k)} \le F(A^{(k)}, x^{(k)}) - F(A^{(k,\,hint)} x^{(k,\,hint)}),$$

and definitions

$$x(t) = x^{(k,\,h\mathrm{int})}\,(1-t) + x^{(k,\,avrg)}\,t,$$

$$A_j(t) = (A_j^{(k,\,h\mathrm{int})}\,x_j^{(k,\,h\mathrm{int})}\,(1-t) + A_j^{(k,\,avrg)}\,x_j^{(k,\,avrg)}\,t) / x_j(t)$$

Correction should be performed $A^{(k,\,avrg)}, x^{(k,\,avrg)}$.

Correction result $A^{(k,\,avrg)}, x^{(k,\,avrg)}$. is taken as $A^{(k+1)}, x^{(k+1)}$ and then goes to step $(k + 1)$.

Conclusions

We consider mechanisms that allow to build flexible distributed man-machine procedures for the support of decision making. The emphasis is made on entering into the process of making informal models of factors that formally are not counted. The opportunities to adapt the model of the corporate system are laid down in the mechanisms.

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ПРИНЯТИЕ УПРАВЛЕНЧЕСКИХ РЕШЕНИЙ В КОРПОРАТИВНИХ СИСТЕМАХ

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В статье рассматриваются механизмы, позволяющие строить гибкие распределенные человеко-машинные процедуры поддержки принятия решений, применять в процессе формирования решений неформализованные модели факторов. Характерными особенностями корпоративных систем является наличие приоритета при принятии решений между отдельными подсистемами, которые входят в состав корпоративной системы в соответствии с их диапазоном ответственности. Решение задач самоуправления в каждой из подсистем формирует параметры задач коорди-

нации. Учитываются как локальные внешние возмущения, так и внутренние, действующие на подсистемы и связанные с изменением обобщенной информации от подсистем низших уровней. Введение этих ограничений переводит задачу поиска допустимых решений корпоративной системы в класс задач системной оптимизации и позволяет учитывать ограничения разного вида. Для построения механизмов управления формируется функционал F(A, x) и ряд вспомогательных функционалов g_i, $i=1, ..., I$, *удовлетворяющих свойствам функционирования системы.*

Ключевые слова*: корпоративные системы, подсистема, самоуправление, координация.*