ANALYSIS AND SYNTHESIS OF GOALS OF COMPLEX INDUSTRIAL SYSTEMS

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***Abstract**: A problem of incompatible and contradictory of results of making decisions in industrial organization-and-technical complexes (OTC) is outlined. A system-and-goal approach and a semiotic approach to make system of decisions satisfying requirements of logical correctness and completeness are concretized. A concept model of knowledge-based dialog system of analysis and synthesis of goals (DS ASG) to make system of goals is considered. Using the DS ASG decision-makers work out not only the system of goals but corresponding plan of goal-achieving satisfying requirements of logical correctness and completeness and in this way solve the problem of incompatible and contradictory of results of making decisions in OTC.*

***Keywords**: organization system, goal setting and achieving, goal analysis and synthesis,*

***ACM Classification Keywords**: Management, Systems analysis*

Introduction

The results of making decisions in industrial organization-and-technical complexes have to be complete, compatible and non-contradictory. On account of OTC complexity, vagueness of its environment and some other difficulties these requirements are seldom satisfied. As our study showed a problem of complete, compatible and non-contradictory results of making decisions in OTC may be reduced in two main sub-problems. The first sub-problem is caused by general character of a regulative part of making system of decisions (MSD) methodology. The second sub-problem is caused by high at the scale of good sense and intuition in MSD-process and a little formalization of its procedures.

We concretized a MSD-regulative component specifically approaches and principles. Concretizing a system-and-goal approach was carried out via constructive definition of organization-and-technical complex as a specific system and definition of its goals (a system of goals). Concretizing a semiotic approach was carried out via: 1) definition of semantic relations between goals, functions, criteria of goal-achieving; 2) work out a semiotic system (model) for reasoning about goals. Concretizing principles of MSD-methodology is carried out via: 1) unity of goal-setting and goal-achieving; 2) completeness and logical correctness of OTC goals; 3) co-ordination of good sense and intuition of decision-maker and opportunities of formal-and-logical system to discover and correct incorrectness and incompleteness in results of goal-analysis; 4) co-ordination of goal-synthesis (goal-achieving plans) results and the results of goal-analysis [Лукьянова, 2007].

We allocated nine main stages of making systems of decisions in OTC (Figure 1). The key result of making system of decisions in OTC is system of goals that is formed by work out a scheme of goal-achieving and match it with the structure of goals (titles of corresponding stages in Fig. 1 are marked out by the bold font).

Formalization of procedures of goal-analysis and goal-synthesis is carried out via semiotic (logic-and-linguistic) modeling of goals in MSD-process. The paper presents some models for further its realization in a dialog system of analysis and synthesis of goals that will secure man-machine working out a system of goals satisfying requirements of completeness and logical correctness.

Models for working out a system of goals

In Figure 2 a concept model of working out a system of goals and a corresponding plan of goal-achieving is shown. It includes two main components: models and interfaces.

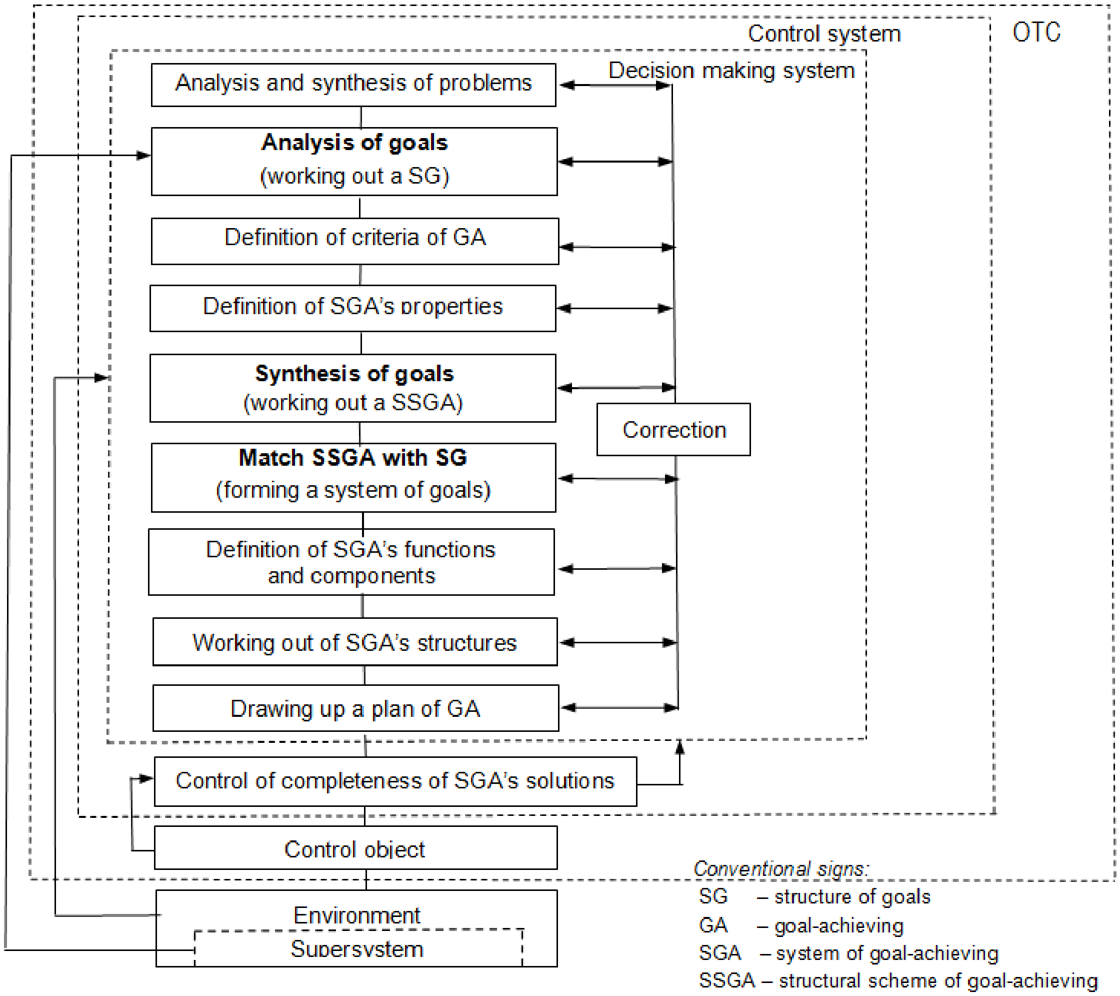

Figure 1. The main stages of making decisions in OTC

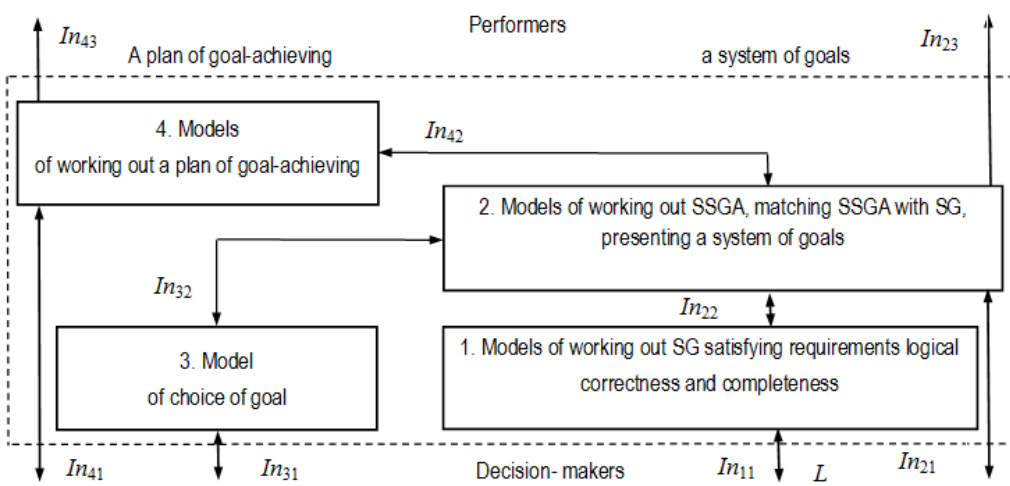

Figure 2. The concept model of working out system of goals and plan of goal-achieving

To work out a system of goals satisfying completeness and logical correctness requirements it is proposed the following models: 1) a semantic model of goal-wordings; 2) semantic graphs of goals and goal-achievement; 3) logical-and-linguistic model (semiotic system [3]) for reasoning about goals.

A semantic model of goal-wordings. As preliminary analysis is shown majority goals of industrial OTC are defined future real objects. For example one of goals of fishing industry is: 'Increase quantity, quality, and the variety of the fish products produced from fishes of an open part of World Ocean'. Such a goal is closely related to activity of fishing industrial system (in this case activity is 'production of fish products'). Therefore it is natural to use a model of activity for goal simulation.

Industrial goals are very complex and they should be measured to check degree of their achievement. It is possible by means of different kinds of scales and in principle on a ratio scale. It is natural to bring about syntactic, semantic, and pragmatic measurements of goals as it is required in semiotics.

Due to these considerations it seems necessary to study conception of rational formalization of goals. We base upon an idea that goal-setting is a human's prerogative. Managers can and must compass selection of pragmatically correct goals (it means their significance in current situation). Therefore pragmatic measurement of goal as a whole must charge managers themselves. However checking and calculation of pragmatic correctness of goal it is expediently to charge to the semiotic system by means of using basic pragmatic knowledge about goals of any industrial system.

OTC's goals (wordings of goals), as a rule, are described by infinitive (Inf) sentences. Such descriptions are realized in according of the following scheme [11]:

- Inf (e.g.: 'to design a fish processing machine');
- Inf <*a*> (e.g.: 'to develop technology and design machinery *of production of varies fish food products*').

As analysis showed goal-wordings are fixed activities either mean desired (e.g.: 'to design a fish processing machine of production of fish food products') or result desired (e.g.: 'to develop smoked fish food products by the automation line based on a conveyor type furnace'). In first case goal-wording consists in a reference on the result ('*of production of fish food products*') produced by the mean. In second case goal-wording consists in a reference on the mean that will produce this result ('*by the automation line based on a conveyor type furnace*'). Therefore for goal-wording partition formal describing we use a model 'means-result' of OTC activity. Adjusting the model 'means-result' on a subject region, increasing or restricting its functional components in according of pragmatic requirements of OTC and its environment we got the two-level model of goal-wording.

First level of the model is a level of functional semantic of means and a result. The corresponding base semantic structure of goal-wording is 'agence-techniques-technology-place-object'. Increasing this structure is carried in wide and deep. In wide it is carried by left-side increasing of supporting semantic-syntactic structure, and as minimum basis structure. In deep every functional component of supporting semantic-syntactic structure may be substituted by any possible structure. So, it is defined the special role frame as a first level model of goal-wording named 'sentence-goal', in which the word 'sentence' is used in the meaning of Frege.

It is rather sufficient the following function structure of 'goal-sentence' for OTC:

< < *agence* (or *1*) > < t*echnology-1* (or *2*) > < t*echniques* (or *3*) > < *object-1* (or *4*) > < *technology-2* (or *5*) >
< *place* (or *6*) > < *object-2* (or *7*) > >.

Example of description of a goal-wording 'to design machinery of production of food products from fish' in formal language in which the model is realized looks as

<<techniques: to design machinery > <object-1: fish>< technology-2: production>< object-2: food products >>

or in a compact form:

< < *3* to design machinery > < *4* fish > < *5* production > < *7* food products > >.

For second level of the model of goal-wording named ‘phenotype- phrase’ we use two categories: ‘thing’ and ‘property’ and represent thing that substitute every position (role) in ‘goal-sentence’ by measuring space of four kinds of properties: functional (FP), characteristic (CP), inscribed (IP) and physical (PP).

Example of description of a goal-wording ‘to design automation line of smoking fish based on furnace of conveyor type’ in formal language in which the two-level model of goal-wording is realized looks as

< <*G 3* automation line *FP* smoking > < *3* furnace *PP* type . conveyor> < *4* fish >

< *7* products *CP1* food *CP2* smoked > >.

To more adequateness of the descriptions relations of order of role phrases were added in the model.

Semantic graphs of goals and goal-achievement. Since we needed to construct the logically correct and complete structure of goals and structural schemes of the achievement of goals, we had to: develop the models named as graphs of goals G^a and tasks G^c [Поспелов, 1981]; represent them in the form of semantic directed graphs of goals ${}^cG^a$, ${}^cGN^c$ и ${}^cGK^c$; match the goals described linguistically (the language L_1, see Fig. 2) with the vertices of these graphs and specify both structural and some non-structural relations on the indicated vertices (on the goals).

According to the principle of hierarchy of the complexes [Лукьянова, 2007], the tree order relation, which is specified in the graph G^a by the semantic relation ${}^sR^{sub}$ of subordination of goals that form it, is the structure-forming relation of the graph ${}^cG^a$. This semantic relation acts as the basis for the semantic tree order. The names of the relations ${}^sR^{sub}$ correspond to the basic strategies of analyzing the goals that do not exceed ten in number in the complexes. For instance, the structures of goals in fishing industrial complexes include the goals connected by the relation ${}^sR^{sub}$ with the following names: the result-the means (I_1), the whole-the part (I_2), the sort-the type (I_3), the rank-the subrank (I_4), the system-the system aspect (I_5), and the system-the lifestyle stage of the system (I_6), so that $I^{sub} = \{I_j\}, j = 1(1)6$. The semantic graphs ${}^cGN^c$ and ${}^cGK^c$ are also formed by the relation of semantic tree order, which is inverse as compared to the graph ${}^cG^a$.

Graph of goals ${}^cG^a$ is a semantic model of SG. Graphs of goal-achievement ${}^cGN^c$ and ${}^cGK^c$ that are the initial and the last semantic models of *SSGA* matching with SG in system of OTC goals.

A semiotic system (logical-and-linguistic model) for reasoning about goals. A semiotic system W is a formal system $W=<T,B,A,P, \psi_T,\psi_B,\psi_A,\psi_P>$, given by the sets T, B, A and P of basic symbols, syntactical rules, axioms, and derivation rules (pragmatic semantic rules), respectively, and the sets ψ_T,ψ_B,ψ_A and ψ_P that give the rules of changing T, B, A, and P, respectively [Осипов, 2002]. A semiotic system S for reasoning about goals is built as a system of the class $SW1$, with its specific features mainly lying in semantics of the elements of the sets T and A. For example, the variables in different states of the system S denote either phrases f_{ij} of the goal sentences or their composing objects of different structuredness (basic and derived) and the names I_s of the semantic relations defined on them, and the axioms of the proper part of S represent the dependencies of analyzing and setting goals in OTC. The truth of propositions on the goals of a bush of goals and the correctness of the reasoning about them are the conditions, under which the system S proves the logical correctness of the bush formed by the decision maker. In the industry, the correctness of such reasoning is conventionally based on the consistency principle interpreted rather widely by the decision maker.

The semiotic system S secures working out structure of goals satisfying requirements of logical correctness and completeness and a structural scheme of goal-achieving in a system of goals matching with SG.

Model of choice of goal

Model of choice of goal secures choosing rational goal between alternative goals.

Here we use a wide-known hierarchical model [Saaty, 1991].

Models of working out a plan of goal-achieving

To work out plan of goal- achieving it is usually used a wide-known models realized in a programs of project management. Here we use models realized in a programs of project management 'Spider project Professional' [Spider project, 2009].

Interfaces

Interfaces of DS ASG includes two groups interfaces:

- external interfaces: In_{11} – an intelligent interface of man-machine interaction based on L and on a transformer from a linguistic form of goal description to logical one; In_{21} – a graphic man-machine interface based on L and semantic graphs: ${}^cG^a$, ${}^cGN^c$, ${}^cGK^c$; In_{24} – a graphic man-machine interface based on goal-wordings and semantic graphs: ${}^cG^a$, ${}^cGK^c$; In_{31} – a man-machine interface based on languages of program [http://www.expertchoice.com, 2009]; In_{41} – a man-machine interface based on languages of program [www.spiderproject.ru, 2009]; In_{43} – reducing In_{41}.
- internal interfaces: In_{22} – interface based on a transformer from a linguistic form of goal description to logical one; In_{32} – interface based on goal-wordings represented in a format of program [http://www.expertchoice.com, 2009]); In_{43} – interface based on goal-wordings represented in a text format of program [www.spiderproject.ru, 2009]).

Conclusion

Thus the knowledge-based dialog system of analysis and synthesis of goals allows decision-makers to build a system of goals and to help in solving the problem of incompatible and contradictory of results of making decisions in OTC specifically work out plan of goal-achieving satisfying requirements of logical correctness and completeness.

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