Intelligent Environment of System-Situation Management of Complex Socio-Technical System Using Multilevel Semantic Nets

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***Abstract*—The problem of construction of the intelligent environment of complex socio-technical system management based on system and situational approach to achieve the best result of activity and to form the effective development strategy is considered. The model of life cycle support system, the hierarchical model of property indicator and the genetic algorithms with the dynamic choice of genetic operators in group for search of the optimum managing parameter are offered**

***Keywords*—intelligent environment, socio-technical system, system and situational management, concept of life cycle, property of system, development indicator, genetic algorithm.**

I. INTRODUCTION

In the 20th century, development of social sciences and engineering activity has led to formation of the concept the socio-technical systems (STS) [1].

This approach presents the research object – organization - as opened, self-organized complex system with heterogeneous structure and purposeful behavior.

The modern environment of STS development is characterized by the dynamic and unpredicting nature of changes [2,3]. In this regard the information asymmetry described by the untimely and distorted response to influences is formed.

Thus, STS development requires generating management allowing achieving goals effectively in the conditions of uncertainty and risk.

The solution of this problem includes development of the methodological instruments including models of STS, subsystems, their interactions and progress, and algorithms of search of the operating effect that are united in the uniform intelligent environment.

II. THE MODEL OF COMPLEX SOCIO-TECHNICAL SYSTEM DEVELOPMENT

Development of complex socio-technical system is based on obtaining a certain result and can be described on the basis of the concept of life cycle of the organization.

The strategy of goals achievement represents a trajectory in space of time and states. At the same time a condition of STS are characterized in the term of operation efficiency at the each stage.

Thus, an important task is development of the general model of STS progress which present a template of model of life cycle system support in the conditions of event set.

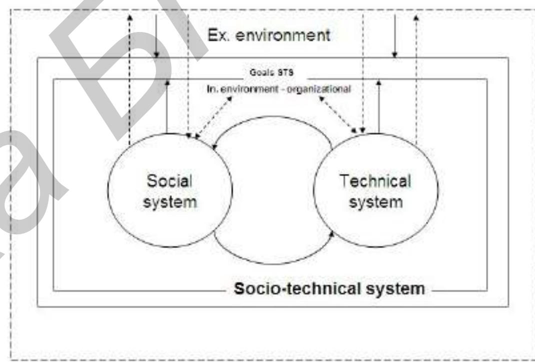

Figure 1. General STS model

In general this model reflects dynamics of system changes the highest order including socio-technical system and the external environment.

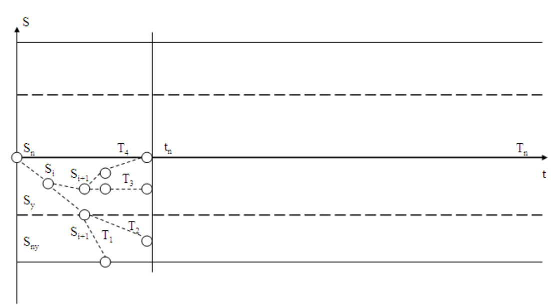

Figure 2. The life cycle of STS based on system and situational approach

The external environment which is characterized by stochastic behavior can be described in terms of the scenario and probabilistic model representing a tree of events. Approach of a certain event is characterized by the probability changing over time. The general set of probabilities at this stage is considered as a tree root matrix. Possible compositions of events form a situation so that a final element of a tree is the matrix of possible situations setting set of probabilities of approach of events with different scenarios.

Logically internal environment of STS includes the operated system which is representable in the form of structural - functional model, system of elaboration of the operating influences and the database and knowledge.

The structural - functional model reflects heterogeneity of the entering elements which are allocated on the basis of the carried-out functions and set of characteristic properties.

Properties create usefulness of the object and are estimated by the indicators characterized by intervals of changes and boundary values. Near these boundary values the element is nonfunctional, so it is not to ensure steady effective functioning of all system.On the other hand these changes influence on properties of other elements in such a way that the system passes into an unstable state.

The general hierarchy of properties of subsystems forms a complex indicator of activity efficiency of STS.

The internal operating system, contains two interconnected subsystems.

The first subsystem stores information on influence of this or that event and a STS situation. It carries out on the basis of parameters of the studied system and the external environment assessment of element and system state transitions by using operating parameter.

The second - contains information on resources and restrictions of internal system and on the basis of this information and functions of influence of the external environment forms the optimum operating influence from the point of view of effective achievement of goals.

After acceptance and implementation of the decision the system passes into the following state which will be optimum taking into account a condition of the internal and external environment, the functioning purpose.

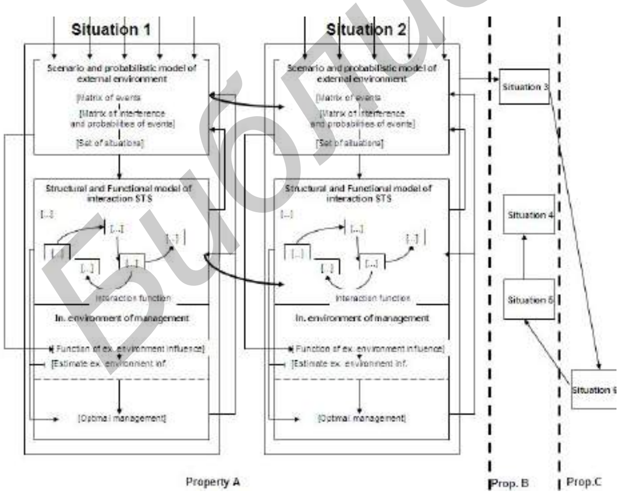

Figure 3. The model of life cycle system support

Further when state of STS is changed by the external environment and other phenomena, the total situation changes is formed.

Thus, process of effective achievement of the objectives, also changing under the influence of external and internal factors, is dynamic and continuous. It is controlled by system of support of STS life cycle.

The described model of support of system life cycle allows to predict on the basis of information on the external environment and the purpose of functioning of STS behavior without the operating influence, to estimate management in the conditions of multiple development of the external environment and to form the strategy of effective achievement of the objectives.

III. Mathematical problem definition of system and situational management of complex socio-technical system

Modern conditions require using of complex system and situational methodology of development of management decisions [4].

This approach will allow to satisfy to the basic principles of a systemology and to consider stochastic factors. The system approach forming a target vector and considering properties of each element and all system in general will create the general development strategy (the principle of a adaptability).

The situational approach will solve the unique tasks formed by the unstable, changing environment and will allow to create effective behavior (the principle of a unprediction).

Thus, key parameters in the task of system and situational management is the following:

- the state of system (S) depending on states of elements,
- the functional efficiency (F),
- expenses demanded for formation of the operating parameter (Z),
- restrictions (R),
- factors of the external environment (v).

So, life cycle of STS (L) can be presented in the form of the interconnected chain of transitions (x) between states (S) which are expedient for estimating in the terms of functional efficiency (F).

In that case, mathematical problem definition of system and situational management can be presented in a general view:

$$Y = f(L(x), S(F), Z, R, v).$$

where Y – the operating parameter.

S(F) accepts values from some set S1,..., Si , and F presents as a complex indicator. At the same time the optimum operating parameter of Y is formed provided that

$$F->max; Z->min; x->max.$$

This process is dynamic so each transition characterized by correction of a trajectory of life cycle in connection with change of internal and external conditions is carried out.

IV. DEVELOPMENT OF OPERATION EFFICIENCY INDICATOR OF COMPLEX SOCIO-TECHNICAL SYSTEM BASED ON PROPERTY INDICATORS OF SUBSYSTEMS USING OF MULTILEVEL SEMANTIC NETS

Assessment of a condition of system by means of a complex indicator of efficiency of functioning demands the corresponding algorithm. The structure of complex socio-technical object is made by heterogeneous subsystems: social, technical, information, resource, process, ecosystem (marketing), administrative [5,6].

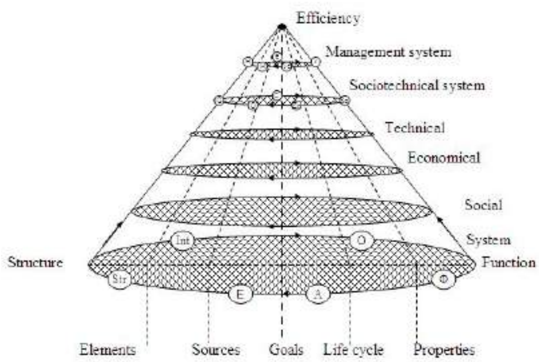

Figure 4. Hierarchical property STS model

Then, formation of efficiency of functioning has to based on the basis of hierarchical model of indicators of properties of subsystems:

- system, providing existence of system: synergetic effect, degree of structure, functionality, integrity, autonomy, organization;
- social (psychical and physiological and competence-based and behavioural);
- the technical, describing characteristics of devices and networks;
- the information, including indicators of assessment of technological level and the software;
- economic;
- resource;
- the marketing (ecosystem), including indicators of influence of competitors, partners and other contractors; process (formalization, stability, convertibility, description accuracy, for business processes and additional processes);
- socio-technical: heterogeneity, focusability, openness, self-organization, autonomy, adaptability;
- control systems: safety, reliability, stability, observability, controllability.

Formation of this hierarchy of property indicators is carried out on the basis of multilevel semantic network. In such a way that the model of properties of system is transformation of model of interrelations of elements of system and their parameters.

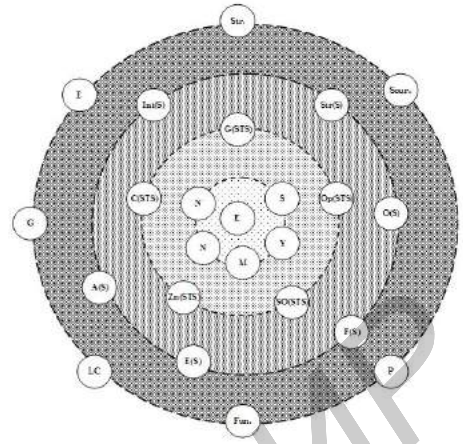

Figure 5. Centric property STS model

V. FORMATION OF THE OPTIMUM OPERATING PARAMETER WITH USING OF THE GENETIC ALGORITHM

It is effective to carry out search of the optimum managing parameter in the conditions of multicriteria with using the genetic algorithm with the dynamic choice of genetic operators in group adapting to the statements of the problem changing at each stage [7].

At the same time the choice of the genetic operator can be carried out on the basis of several parameters:

- decision accuracy (convergence to the optimal solution);
- working hours of operator before obtaining the best decision;
- variety of elements of set;
- stability of the received decision;
- the required resources;
- quantity of the received elements with suitability above an average.

VI. CONCLUSION

The offered information environment of system and situational management of complex socio-technical system includes model of life cycle system support in the conditions of multiple event set, hierarchical model of formation of operation efficiency as transformation of multilevel semantic networks of system elements for assessment of a STS condition, model of a genetic algorithm with the dynamic choice of genetic operators in group for the optimum managing parameter search.

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ИНТЕЛЛЕКТУАЛЬНАЯ СРЕДА СИСТЕМНО-СИТУАЦИОННОГО УПРАВЛЕНИЯ СЛОЖНОЙ СОЦИОТЕХНИЧЕСКОЙ СИСТЕМОЙ С ИСПОЛЬЗОВАНИЕМ МНОГОУРОВНЕВЫХ СЕМАНТИЧЕСКИХ СЕТЕЙ

Бородулина Е.Н.

Рассматривается задача разработки интеллектуальной системы управления сложной социотехнической системой (СТС) на основе концепции жизненного цикла. Построение стратегии развития описывается как целенаправленный переход между состояниями СТС, которые оцениваются с точки зрения эффективности достижения цели. Формирование эффективности как свойства системы осуществляется с помощью иерархической модели свойств подсистем и их оценок. Частные оценки формируется на основе многоуровневых семантических сетей элементов. В условиях неопределенности и недостаточности информации системное управление осуществляется как поиск оптимальных с точки зрения эффективности достижения цели состояний СТС для перехода на основе генетического алгоритма с динамическим выбором генетических операторов в группе. При этом ситуационное управление реализуется на подуровнях путем достижения определенных значений параметров свойств оптимальных с точки зрения общей эффективности.