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THE SIMULATION MODELING OF SYSTEMS TAKING INTO ACCOUNT THEIR INTERNAL PARAMETERS CHANGE

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Introduction.

Currently, the simulation of systems as a certain scientifically-applied procedureis used virtually in all human activities. The simulation is used for the system to be examined learning, training, prediction of output or system states, system management, and automation. Not always but generally, when it comes to the simulation of any system, it is intended the simulation of its functioning.In particular, it is caused by understanding of the phenomenon "the system".

Despite a diversity of informal and formal definitions of the concept "system", all these definitions capture the fact, that any system functions, i.e. interacts with the environment and changes its state eventually. It may be considered for universally acknowledged statement that any system operates if it exists and conversely, if it exists consequently it functions. For example, Uyemov A. I. in his work [1] suggests to consider the system as a set of the elements combined by the general functional environment and the purpose of functioning; Melnikov G.P., in his work [2] - as the functional object which function is caused by higher tier object function. Whereas the last approach to system allows to specify the concept "functioning of system" which, taking into account this approach, can be considered as implementation process by system in time of the functional request of supersystem [in the same place]. Thus, the simulation of systems is, first of all,the simulation of their functioning.

There are a lot of methods and different systems functioning process simulators at the present time [3].

Ever since last century, the system researches development led to appearance of system modeling methods, based, in fact, on the system approach.First of all, the graphical- analytical tools of process approach, applied to difficult organizational systems modeling and also business and administrative processes can be attributed to them [4].

Within the systems functioning modeling, the greatest difficulty is represented by the modeling, considering not only inputs, outputs and statuses of system, but also its internal parameters (structural and substantive) conversion.

The solution to such a problem is actual for a wide range of areas. For example, for the analysis and management of large enterprise IT support as difficult organizational and technical system, where one of the main functioning peculiarities is the change of its parameters and structure under the influence of objective and subjective factors [5]. Besides, in case of designing and managing of computer systems as queuing systems [6]. And also during the analysis of animals and human being adaptation processes to the biological and social environment.

The questions of the synthesis and analysis of difficult technical and technical - organizational systems with adaptive variable structure were considered in depth in the works of M. Yu. Okhtilev, B. V. Sokolov, N. M. Aleksandrovsky, A. D. Tsvirkun, V. N. Fomin, L. A. Rastrigin and others. The literature also provides the conception of knowledge representation model for the description of difficult adaptive systems, according to which such a model must allow to synthesize and destroy the elements and couplings and all the model components must have an opportunity to change with the course of time [7].

Herewith the publications on this subject analysis shows that the methods, offered for systems functioning modeling taking into account its internal parameters change, are generally oriented on different mathematical tools, they are also suggested for the decision of well-defined applied problems and don't use the principles and regularities of the system approach. Thus, the researches intended to the use of the systems approach to such a modeling are urgent.

Methodology.

Let's consider the possibility of the use of the systems approach to the functioning systems modeling with taking into account systems internal parameters change. The modern continuation of systems process approach tools is a system-object approach «Unit-Function-Object» (UFO-approach), allowing to build the formalized graphical - analytical systems models of different nature, taking into account simultaneously their structural, functional and substantive characteristics [8].

The system-object UFO - approach is successfully applied both to creation of static graphical-analytical models of the processes, describing the systems functioning [9; http://www.UFO-toolkit.ru], and to dynamic simulation models creation, at the cost of formalization of the latter by algebraic tools of Abadi-Kardelli objects calculation [10; http://ufomodeler.ru].

At the same time, in the authors` opinion, UFO - approach can be applied not only to modeling of processes of transforming by systems input threads into output threads, but also for functioning systems modeling and specifically taking into account the internal parameters change of systems themselves. This accounting can be provided as follows.

The use of UFO-approach for the simulation modeling assumes the representation of a model element (an element «Unit-Function-Object» - the UFO element) in the form of specialized abstract object (a nodal object) of the objects calculation mentioned above. For the accounting of internal parameters system change it is necessary to consider the dependence of system internal parameters on time in this formal UFO - element representation.

Such a formal representation looks like this:

$$G = [l?_i = a?_i, l!_j = a!_j; l_n = F(l?_i)l!_j; l_m = b_m(t)],$$ where:

- G–the nodal object (the UFO element);
- $l?_i$–the nodal object field (can represent a set), which containsthe value of input streaming objects$a?_i$and, consequently, has the same data type;
- $l!_j$-the nodal object field (can represent a set), which contains the value of output streaming objects $a?_i$ and, consequently, has the same data type;
- l_n- the nodal object method (can represent a set), transforming input streaming nodal objects into output ones;
- l_m - the nodal object field (can represent a set), which contains the given object main internal characteristics ($b_m(t)$),depending, in this particular case, on time.

In this formal representation the fields$l?_i$and $l!_j$describe the system in terms of node (the structural characteristic of system in general); the field $l_n$describes the functional characteristic, i.e. the system function; the field l_m - substantive characteristic, i.e. the system as the material object. And value of the last field ($b_m(t)$), in this case, depends on time.

The connection\stream is also represented by way of specialized abstract subject (stream object) of the calculation mentioned:

$$a_i = [l_j = b_j],$$ where:

- a_i – the stream object;
- $l_j = b_j$ – the stream object fields with some values b_j.

In terms of UFO - approach the system simulation model, first of all, represents a configuration of UFO - elements (UFO- model), "with adequate accuracy describing this system".

Mathematically the UFO- simulant represents itself a combination of nodal objects and stream objects, which interaction is defined by the rule of call the method of a nodal object of the form: $\boldsymbol{G.l_n l!_j \{l?_i \mapsto G\}}$.

Let us consider an example of functioning system –the furnace forplastic.

This is the device, where plastic granules are chuted on inlet shuttle, then theyare distributedin the special bunker acrossthe heating cameras.

After heating this plastic is blown under pressure from the furnace in the form of heated briquettes or lamina.

Let's define one stream object of ***p***– plastic with the following characteristics:

- lp_1= a form – it takes one of three values–the granules, the briquettes, the lamina;
- lp_2= a temperature – is measured by degrees Celsius;
- lp_3 = a weight – is measured by grams.

We describe the furnace for plastic in the form of a nodal object:

$$G_{печь} = [l?= p?,\ l! = p!_j;\ l_n = F(p?)p!;\ l_m =(b_1(t) \dots b_7(t))],$$

where:

- ***l*?** - the nodal object field (furnace), which contains the value of input streaming of plastic in granules ***p*?**;
- ***l*!**-the nodal object field (furnace), which contains the value of output streaming of plastic in briquettes ***p*!**;
- l_n- the nodal object method (furnace), transforming input streaming nodal objects into output ones, i.e. plastic in granules
- ***p*?** into plastic in briquettes
- ***p*!** anddefined by the technological process provided by the furnace construction;
- l_m - the nodal object field (furnace), which contains the given object main internal characteristics $(b_1(t) \dots b_7(t))$,

  depending, in this particular case, on time:

  - productivity – gram per minute $(b_1(t))$;
  - single cycle time – in seconds $(b_2(t))$;
  - temperature in the 1st heating camera – in degrees Celsius$(b_3(t))$;
  - temperature in the 2nd heating camera – in degrees Celsius $(b_4(t))$;

- temperature in the 3rd heating camera – in degrees Celsius **($b_5(t)$)**;
- temperature in the 4th heating camera – in degrees Celsius **($b_6(t)$)**;
- stock turns – revolution per minute **($b_7(t)$)**

Let's considerthat in the point of time $t_1$the furnace is in the condition, defined by next internal systems characteristics indicators. (Fig. 1):

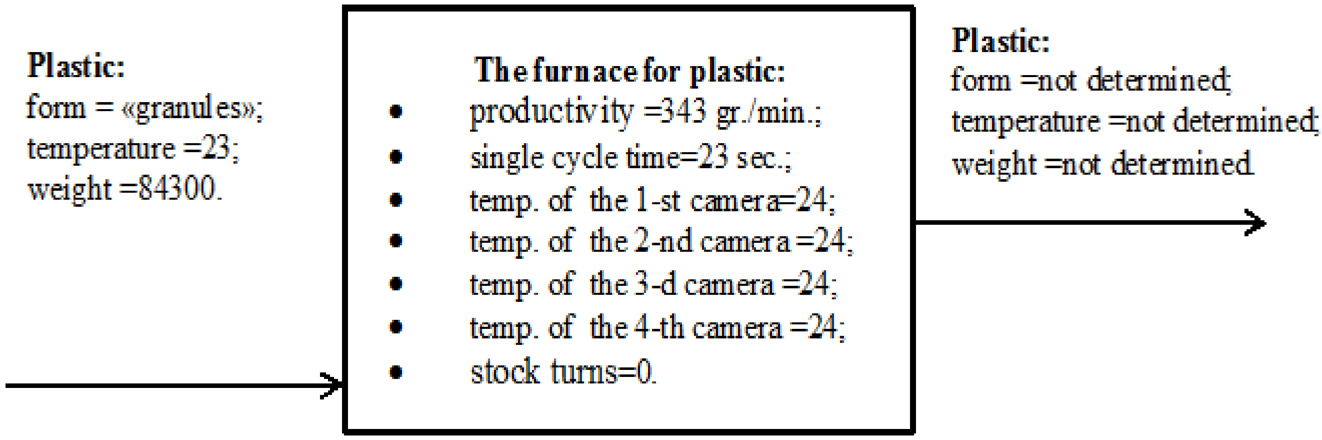

Figure 1.The system in timepointt_1.

After the furnace turning on in timepointt_2 the system will be in a state, shown in the Figure 2.

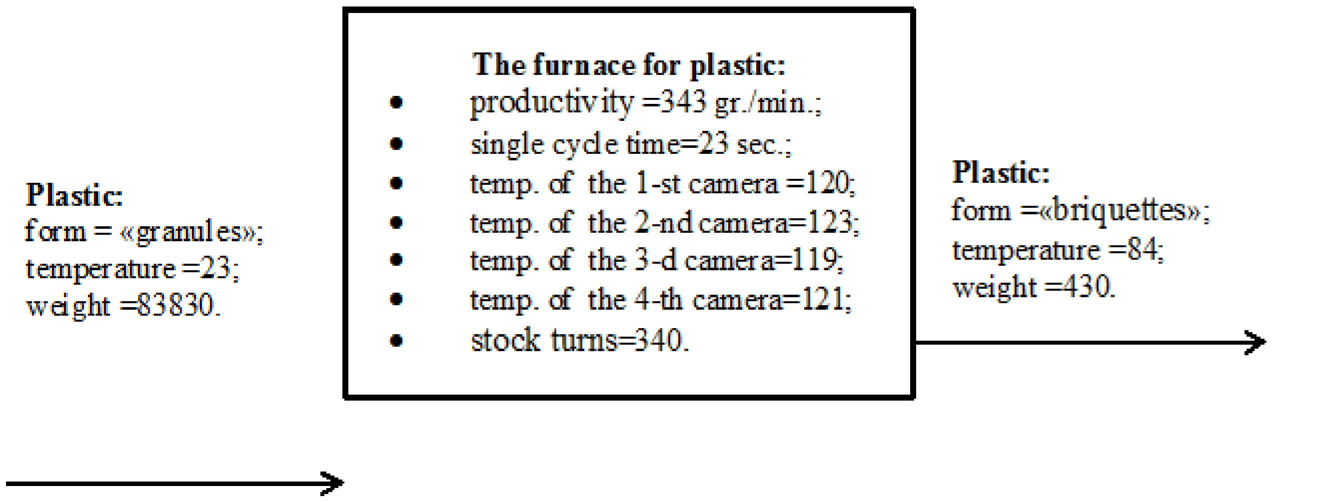

Figure2.The system in the time point t_2.

It is visible from theFigure 2 that characteristics of stream objects and some characteristics of a nodal object acquired new values eventually at the expense of what generated a new status of system.At the same time, for example, such characteristics of a nodal object as "productivity" and "single cycle time"remainedunchanged.The transition to a new status happens due to actuating of a nodal object method, which, actually, changes system characteristics and, naturally, it takescertain time. The presented technique of simulation modeling allows to considerin models not only the process of inputs to outputs conversion,but also system internal parameters change with the required accuracy rating.

Results and Discussion.

According to the authors, UFO - approach can be applied not only to modeling of conversion by systems input threadsinto output ones processes taking into account their internal characteristics change, but also to functioning systems modeling taking into account theadaptation and evolution of these systems processes. This statement is based on that fact, the conceptual framework of system-object approach provides constructive system understanding of the systems adaptation and evolution processes in the course of which the processes of their structural and substantive conversion occur.

Such understanding is caused, in particular, by inclusion in UFO - approach conceptual framework all known systemic principles and regularities [11] that let offer their correlation conceptual model, leaning on the basic system - object approach concepts(Fig. 3). It is possible to get acquaintedwith the description of the systemic principles and regularities in the publication [12], with the basic system - object approach concepts– in work [8, 11], and also on the website www.UFO-toolkit.ru.

As it is obvious from Figure 3, the system determination used in system - object approachestablishes the fact that the system on any hierarchy tier is a part of higher tier system, i.e. supersystem. Therefore, *the hierarchical orderliness* systemsregularity isthis systems concept integral part. *The monocentrism principle* is a consequence of systems hierarchical orderliness that is justified by means of the system - object approach conceptual framework in works [13, 14]. Within this approach the understanding of properties through coupling, and coupling as streamselements, representingcoupled systems specifieddeeptiers substances, naturally leads to the account of*systems communicativeness*. Now therefore, the hierarchy of systems, the monocentrism principle and thesystems communicativeness follow logically from determination of system and understanding of the couplings, used in system - object approach.

The principle of feedback and the principle of mutuallycomplementary ratios fix specific types ofsystemscommunicativeness, and also they are considered in the system -object approach concept in the form of system composition rules and, in particular, the rule of closure [8, 11].

In monocentricsystems with communications hierarchy *the structuring continuity principle* will be naturally conducted.

Along with that *the compatibility principle*and *thesemiotic continuity hypothesis*, apparently, can be considered as the result of the compatibility principle.

The appearance inevitability of new system integrative properties, that are nonpresent in system`s elements i.e. an *emergence of systems*, as a result of the hierarchy and monocentrism, is formally justified with the use of system - object UFO - approach and the Grenander patterns theory in work [15].

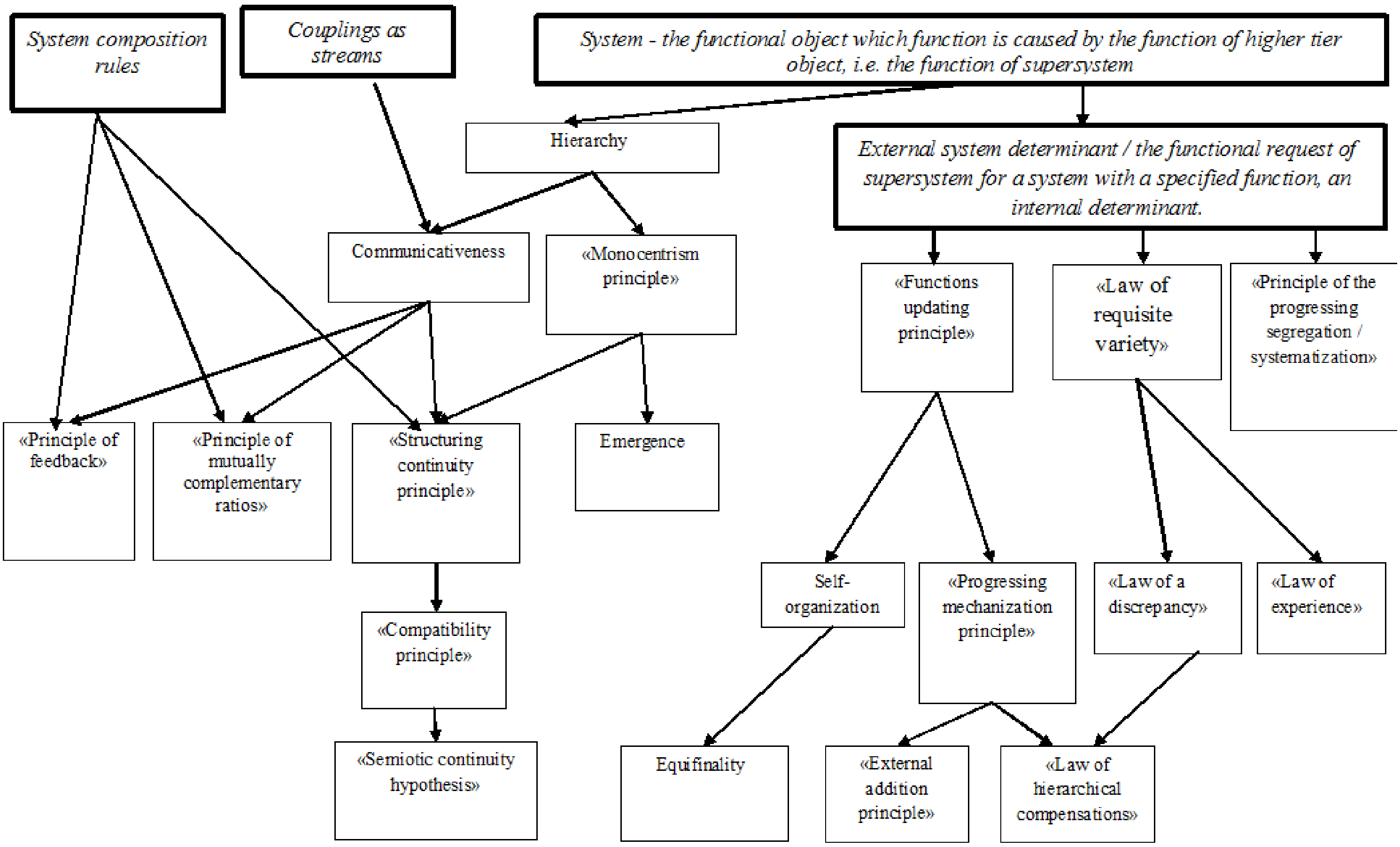

Figure 3. Conceptual model of the systemic principles and regularities correlation.

Such system - object approach concepts as "an external determinant" and the "an internal determinant" borrowed from G. P. Melnikov'ssystemology are of the greatest interest to this research. At the same time the external determinant represents the functional request of supersystem for system with a certain function. Real current systems functioning is its internal determinant, derivatives from which represent external determinants for subsystems of given system.

The relation of external and internal system determinants can be described as the relation of field of required functional states (**FRFS**) of system in accordance with the request of supersystem to a field of possible states (**FPS**) of a source material for demanded system: **FRFS/FPS** = $\mathbf{M_s}$, where$\mathbf{M_s}$ - systemacity measure. When forming the system with the required function in the supersystem node upon the request of the last, a source material is chosen for the required system. For this source material next expression will be correct: **FPS⊃FRFS** and **0 >M_s< 1**.Other choice will demand either creation of several systems instead of one, or will lead to failure of the nature law as the systemacity measure can be neither equal to zero, nor unit equal.

At the heart of system understanding of adaptation and evolution processes concepts of external and internal determinants and relations between them underlie. Adaptation is considered as process of approximation of an internal determinant to external (**FPS** to **FRFS**; i.e. the level of adaptation is the higher, the M_s is closer to **1**), and evolution is considered as adaptation to the changing functional request. Such adaptation and evolution understanding allows taking into account in conceptual model of the systemic principles and regularities the following principles:

The functions updating principle, which establishes the fact, that the tendency of systems development is a tendency to a progressive functionalization of their elements, and , as a matter of fact, it is the result of interaction of external and internal determinants at more and more deep levels of system hierarchy, i.e. the result of its adaptation to the functional request of a supersystem.

At the same time *self-organization* of system, obviously, represents the process of its elements progressive functionalization i.e. as a type of the functions updating principle. At the same time the system - object approach conceptual framework registers not only the fact of system self-organization, but also the mechanism of this process in the form of process of system adaptation to the supersystem functional request.

The progressing mechanization principle, claiming that parts of system during its development specialize or become fixed in relation to certain functions or mechanisms, is a consequence of that fact that supersystem functional request (i.e. an external determinant of system) is the cause of system occurrence and its formation.The supersystem defines the functions to the systems which, in turn, define theirsubsystems functions. All these systems and subsystems adaptation to the external determinants (requests) leads to the larger compliance of their functioning to requirements of a supersystem and systems which requirements become more and more specific (specialized) with the lowering of of hierarchy level.It is also necessary and sufficient condition of specialization or the progressing mechanization which, thus, represents a look or implementation variation of functions updating principle.

The foregoing correlation of the required and possible statuses areas during the forming of system and the source materialchoice corresponds to *the law of requisite variety*, at least, in its such interpretation that for creation of the system, capable to cope with a solution of problem, having a certain variety, it is necessary to provide for the system bigger variety of opportunities, than the variety of the problem being addressed.

The law of a discrepancy claims the fact that different parts of uniform system are exposed to forces, distinguishing in quality and value, in consequence of which they change variously. This law corresponds to a situation where two identical systems have two different external determinants (two different functional requests). Naturally, in the course of adaptation to different requests the progressing distinctions accumulation in the form of different internal determinants will be peculiar to these systems. It increases the variety and provides a universum with various source material. *The law of experience* claims the fact that uniform impact on some set of elements reduces variety of statuses of this set. The law of experience corresponds to a situation, where systems (or one system) are affected by the same (or constant) functional request (an external determinant) that in the course of adaptation leads to convergence of internal determinants or essential reduction of the determined system possible statuses area. This law is opposite to the previous law and reduces variety of universum.

The progressing segregationprinciple fixes the progressing loss of interaction between system elements during its differentiation in case of ties amplifying with some element appearing as a system center. The work of this principle is also based on the mechanism of supersystem and system interaction by means of the functional request of a supersystem or system external and internal determinants.

Only in this case a situation of not just an adaptation, but also evolution,takes place i.e. functional request changes where some part of system begins to perform function of supersystem for its remaining parts, which requirements include an amplifying of interaction of all with it and loosening of ties between the parts.At the same time the supersystem can require amplifying ofties between its systems that will correspond to *the principle of the progressing systematization*.

The equifinality, considered as ability of system to reach a status that doesn't depend on time and initial conditions, and depends only on system parameters, is the result of external and internal determinants interaction. It can be justified by the fact, that mentioned determinants of system are its major parameters. And the result of determinants interaction as it was shown above is an adaptation and self-organization of the system.

The principle of external addition, claiming that the coordinated elements impact, going back to system center, are exposed to peculiar "generalization", and the coordination pulses descending from system center are exposed to "specification" depending on the local processes nature, apparently, represents mentioned above progressing mechanization principle for information processes. In the simplified form it can be formulated as follows: "Any element of a system hierarchy possesses the information synthesis function from underlying elements for higher elements and information specialization function from the hierarchy upper tier elements for elements of the lower tier". *The law of hierarchical compensations* claims that thevariety growth at the uppermost level of hierarchy is guaranteedby its restriction at lower levels, or, from the point of view of A. A. Bogdanov, the level of the system center organization should be higher, than the peripheral elements organization level. By virtue of the fact this law uses the mechanism of the progressing mechanization principle, it has just the same rationale in terms of system - object approach. The system understanding of adaptation and evolution outlined above by means of systemic principles and regularities correlations conceptual model allows to formulate the methodology of simulation modeling of systems taking into account these processes. As an adaptation is the process of approximation of an internal determinant to external one, therefore, the simulation model of adaptation process should have tools for these determinants representation. Within the framework of UFO approach the external determinant of system (the functional request of a supersystem) corresponds to a node of the UFO-element representing some system in the model. The internal determinant of system corresponds to the same UFO - element function described by decomposition on subprocesses (subsystems). The simulation of system adaptation process to the functional request of supersystem with tools of UFO - approach can be implemented by dint of the steps described below.

Firstly, the graphical - analytical UFO - model context diagram of specific system is built. This diagram describes the system as the intersection of external functional relationships of system (theUFO-element node of the uppermost hierarchy level), i.e. describes the functional request to the modeled system (an external determinant).

Secondly, the simulating program basing on the context diagram forms the decomposition diagram, i.e. the description of the uppermost hierarchy level system function in the form of a configuration of the hierarchy next level UFO-elements, connected among themselves by the internal supporting communications. Automatic formation of such a diagram is carried out by means of the proposed below repeating procedures and the UFO-elements library containing suitable for specific system simulation source material. At the same time the node of each UFO-element in this configuration (diagram) defines an external determinant of the appropriate subsystem.

Thirdly, the simulator (UFOModeler) of the simulating program realizes the simulation of system functioning on the decomposition diagram if it has enough data for this purpose. At the same time simulation results are evaluated from the viewpoint of their compliance with qualitative and quantitative characteristics of modeled system external functional relationships (an external determinant).

Fourthly, if simulation can't be realized or its results don't correspond to an external determinant, then the simulating program creates the new decomposition diagram, using other source material from theUFO- elements library. Then the simulation repeats on other version of the decomposition diagram and the assessment of results is made.

Fifthly, if simulation on the first decomposition diagram, after all, can't be realized or its results don't correspond to an external determinant all the time, then the simulating program realizes the formation of the source system subsystems decomposition diagram and launches the simulator at the following level of hierarchy. Results of simulation at this level of hierarchy are exposed to the same check as mentioned above.

Sixthly, if results of simulation don't correspond to an external determinant, then the simulating program creates deeper level of hierarchy for more detail description of system functioning and repetition of its simulation with results assessment.

Seventhly, if it isn't possible to create a system model which simulation shows the results corresponding to an external determinant of the source system, then it is necessary to replenish the UFO- elements library with the source material, more suitable for this case. The repeating procedure of decomposition diagram formation based on context model can be seen in Figure 4.

Forasmuch asthe efficiency of this procedure depends generally on the quality and a UFO - elements library completeness (the source material), the researches of requirements to similar libraries, which were formally justified by means of the algebraic appliance of theGrenander patterns theory in work [15] were conducted earlier.

Conclusion.

Thus, at this investigation phase the methodology of system - object simulation modeling is offered. The methodology allows to model not only the system functioning process, but also the system in general taking into account all its system properties and characteristics.

It also allows considering the system internal parameters change, and in particular, considering modeled systems adaptation and evolution processes.

According to authors, this direction of researchesis extremely perspective, because it allows to modeldata domains of the real world more fully, than in comparison with simulation modeling classical paradigms.

As the results of work in this direction the authors plan in prospect to create methodical and device tools which can be applied to the problem solution of prediction of technical - organizational systems development

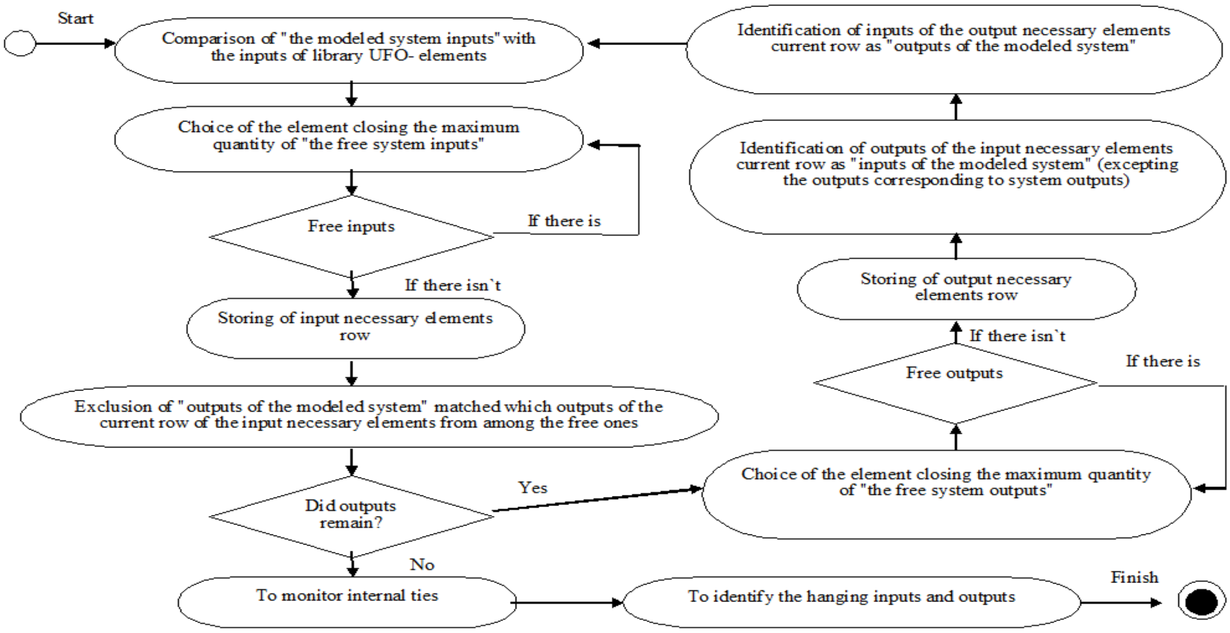

Figure 4. The repeating procedure of decomposition diagram formation based on context model.

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