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MODEL OF DISTRIBUTED DYNAMIC INFORMATION SYSTEM ON THE BASIS OF THE USE OF LOGICAL MEANS

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The article suggests a new approach to the construction of a distributed information systems based on logical means. This approach is based on a formal mathematical description of logical connections between the components of distributed information systems and their tasks in the process of the system functioning as a whole.

Key words: *logical model, information system, moving objects.*

Set of the Problem. At the present stage of the development of the processes of information systems design, the latter are increasingly considered as distributed computing and information systems, managed by the distributed data flows in an integrated, territorially distributed information and telecommunication environment. This approach requires new concepts, technologies, and architectural solutions when designing data systems based on a geographically distributed information and telecommunication environment that uses dynamic, flexible processes for obtaining and processing the corporate information. These processes are based on distributed computing and information resources that are transported in the information and telecommunication environment.

Analysis of Recent Research and Publications. The direction of designing the information systems has been studied by many experts in the field of automatic control of complex systems [1 - 4]. The most famous domestic scientists of this industry include L.M. Artyushin, B.V. Durnyak, S.P. Kondratenko, O.A. Mashkov, I.T. Strepko, M.S. Sivov, H.N. Titov, O.V. Tymchenko. But the topics of these studies do not cover the subject area of constructing logical models of the information distributed systems.

Aim of the Article is to design a model of a distributed information system in the form of formal mathematical descriptions on the basis of logical means.

Main Material of the Research. An information system for ensuring the management of moving objects (*RO*) and ensuring the implementation of the set tasks is a distributed information system, since every *RO* owns its own computing resources. Unlike traditional distributed computing systems, the information distributed system of *RO* group management is a dynamic system [5]. Since, within the framework of the system we solve the applied problems of different types, then the dynamics of the distributed information system (*ISU*) is determined by the following factors:

1) the spatial distribution of individual *RO*, which we will also call mobile components (*MK*), in the process of the system work as a whole, change their position;

2) the various tasks are solved within different *MK*, which in general can make one task for the whole distributed system;

3) the tasks solved within the framework of separate *MK*, can be solved in different moments of real-time functioning of the whole system *ISU*;

4) the distribution *ISU* can have a centralized synchronization of the task solving or the system functioning as a whole;

5) the distribution *ISU* can be combined with the functional synchronization of the whole system functioning;

6) different types of the distribution *MK* within the framework *ISU*;

7) uniformity of the distribution *MK* within the framework *ISU*.

Since in the distributed management systems one common task is solved in most cases, all components of such a system must be logically linked [6]. The description of such logical dependencies is realized within the framework of logical models $L = F(L_1, \ldots, L_n)$. The feasibility of using such logical models for the implementation of management processes within *ISU* is determined by the following factors and reasons:

- within the framework of logical models of individual fragments of tasks $L_i \in L$, the problem of approximation of events arising in the process of solving in the form of a certain logical scheme is solved;
- the logical model allows at its level to solve the problems of identifying contradictions in the process of solution, even before the manifestation of such a contradiction in the implementation in the environment of actions associated with the solution of the problem;
- determining the completeness of logical circuits and a separate logical scheme $L_i(L_{i1}, \ldots, L_{in})$ can justify the possibility of achieving the goal in solving the problem;
- the use of $L_i(L_{i1}, \ldots, L_{in})$ allows solving the problem of compatibility, when implementing the entire process of solving between fragments of the process;
- on the basis of the logical model, there is an opportunity to realize the prediction of the occurrence of situations which can turn out to be critical for the process of solving the problem.

Before examining and studying the peculiarities of the methods of modeling the processes of solving management problems *ISU* on the basis of the means of mathematical logic, it is necessary to formulate, in more detail, the description of the interpretation of all possible components of the model $L = F(L_1, \ldots, L_n)$ and the methods of transforming the logical formulas L_i [7, 8]. This is due to the fact that logical models L_i use a binary interpretation of their variables, or $L_i(L_{i1}, \ldots, L_{in}) \in [0,1]$, and the subject area of the solvable problems operates, in most cases, with the values of variables x_i , that are defined on discrete and continuous intervals.

When using logical formulas to describe a certain subject area, the latter represents a static structure that describes some essence at a certain point in time t_i . The process of the solution of the problem, like the entire distributed system consisting of the set

PMK_i and MK_i, is a dynamic process and, accordingly, a dynamic system, especially if we take into account that in the case considered, MK_i is a moving object that solves the tasks in the process of movement.

The description of the interpretation of variables in logical models is sufficiently closely related to certain tasks that are foreseen or can be solved with the use of the system of means of distributed mobile systems (RMS), consisting of MK_i, which is a moving object and mobile control centers or components PMK_i. When we assume that each variable used in $L = F(L_1,\ldots,L_n)$, corresponds to one object or factor that is described in the subject domain of the interpretation W_i of the task Z, or $W_i(Z)$. Such a description should be in a text format in a normalized form, which can be formally described as:

$$j(x_i) = [x_i := |< a_1,\ldots,a_n >|< p_1,\ldots,p_m >|< \varphi(p_1), \ldots,\varphi(p_m)\,]\!] ,$$

where x_i – is an ID of the object, e.g. one of the functional components MKi; a_i – is a separate word from a text description; p_i – is a parameter which characterizes x_i; $\varphi(p_i)$ – is a function which represents the range of values of the parameter p_i in the set $\{0,1\}$, where the value 0 corresponds to an invalid value of the parameter p_i from the range $\{a(p_i), \beta(p_i)\}$ and vice versa.

If only one parameter p_i of the object x_i is used to solve the problem z_i, the accepted interpretation is correct. If we use two or more parameters for x_i within z_i, the interpretation is expanded by functional dependencies, which in many cases are described in tables and reflect the relationship between the parameters p_i and p_j used and in the form $p_i = \psi(p_i)$. Since all objects used as separate means in $W_i(z_i)$ are technical means, then the dependencies between the parameters are defined. In this case, the interpretation $j(x_i)$ can be written as:

$$j(x_i) = [x_i := |< a_1,\ldots,a_n >|< p_1,\ldots,p_m >|< p_i = \psi(p_j), \ldots, p_k = \psi(p_e) >]\!] .$$

Based on the described interpretation, the values of the logical variables in the model $L = F(L_1,\ldots,L_n)$ vary in accordance with the values of the function $\varphi(p_i)$, and if $p_i = \psi(p_j)$, then this function determines the expansion of the functionality of $\varphi(p_i)$, written in the form $\varphi\{p_i = \psi_i(p_j)\}$, or $\varphi_i\{p_i, \psi_i(p_j)\}$.

The precision of approximation in mathematics means the accuracy of determining the value of an approximated function, with the value of the argument x_i, which is different from the values x_i^* obtained in the experiment, as well as the accuracy is determined by the method of approximation [9]. In this case, if y_i is the function of the argument x_i, then δy_i depends on the approximation level Δx_i^* and the approximation technique.

The accuracy of the approximation by logical models of some processes is determined by the level of generalization of the selected parameters as logical variables in relation to the full description of the simulated process. This factor is formally described by the following relation:

$$[x_i^p = f(x_{i1},\ldots,x_k\,] \rightarrow [\delta x_i^p = (\sum_{j=1}^{k<N} sg(x_j\,)/\sum_{j=1}^{N} sg(x_j\,],$$

where N – is a general number of variables, that determine the value x_i^p; k – is a number of variables $x_{\bar{j}}$, which are generalized by the parameter $x_{\bar{j}}$. The concept of generalization, in this case, is determined by the presence of the function that describes the relationship between x_i^p and $x_{i1},\ldots,x_k$, which is shown in the formula in the right part.

The second factor that affects the accuracy of logical interpretation is the accuracy of determining the range of parameter values that are displayed on the set $\{0,1\}$. The error determined by this factor depends on the number of parameter values that are identified by one or the other binary values and the difference between the values is not greater than a given value. Since the value of the parameters $x_i^I = f(x_{i1},\ldots,x_k\,)$ can be *n* then $x_{i1},\ldots,x_{\bar{n}}$ can be considered as vectors of *n*-dimensiona space, in which the values x_i^I are defined. To display x_i^I in $\{0,1\}$ in the *n*-dimensional space, it is necessary to get a hyper-plane, which separates all values x_i^I into those that are interpreted by the number 0 and those interpreted by the number 1. The construction of such a hyper-plane depends on the accuracy of the calculation x_i^I. If the dependence $x_i^I = f(x_{i1},\ldots,x_k\,)$ is calculated by numerical methods, which is most likely, then the error in determining the value x_i^I consists of a methodical component and a residual error and a number of other errors. Therefore, the values x_i^I, placed in the limits of the distribution plane may have errors, as a result of which they can be erroneously assigned to 0 or 1.

Since in the system *RMS* the basic components are mobile and the processes are dynamic, then the logical model should show the time aspects of the logical variables. The traditional approach to introducing the time aspects is the introduction of time quantifiers, for example, Et_i, which determines the moment t_i, at which there is a certain variable or statement *a*, written as $Et_i(a)$ [10]. Similarly, it is suggested to show space within logic systems, for example, $(\forall P)(Pa) \leftrightarrow P(b)$, which means that individuals *a* and *b* are identical to certain spatial characteristics. In the case of the system under consideration, logical models should be associated with certain components that can interact with each other at the data exchange level and at the command transfer level. Therefore, it is not necessary to show spatial aspects in $L = F(L_1,\ldots,L_n)$.

In the logical model L_i, different variables can vary in different time. Let us assume that the time parameter varies only in the direction of growth, when functioning *ISU* in real time. Let the time change discretely at a constant interval δt_i. Then, the timestamps will remain in such a sequence:

$$T_i = \{t_0, \delta_1 t_1, \delta_2 t_2,\ldots,\delta_n t_n\},$$

where $\delta_i = i * \delta$; δ – is a step of time calculation which is assumed to be constant for the whole period T_i of functioning ISU in the process of the task solving.

In this case, the logical formula for one of the fragments of the process will be described as the following relationship:

$$L_{ij} = [x_{j1} * (\delta_1 t_1) x_{j2} * \ldots * (\delta_k t_k) x_{jn+1} * \ldots * (\delta_n t_n) x_{jn}\ ],$$

where * – means the operator of the logical function. Among the variables used in L_{ij}, there may be elements whose variable is not synchronized with timestamps. This variable has the value that does not change as a result of the transfer of the initial data to the corresponding fragment, and the time indexes may not coincide with the index of variables. This means that the timestamp $\delta_i t_i$ for the variable x_k may correspond to the moment that precedes $\delta_e t_e$, though $e < i$, and the index of the variable is $k > e$. This means that the numbering of the timestamps does not correspond to the numbering of the variables. Moreover, the numbering of timestamps for many variables within the framework L_{ij} can be the same. This means that the corresponding variables have changed their meaning at the same time. The use of timestamps in L_{ij} allows solving the following tasks in the process of the analysis of the system L_i:

- you can extend the system of rules of the transformation for L_i or the system of the axioms L_i can be expanded by the axioms that take into account the time of changes that occur with individual variables;
- to solve the problem of forecasting events at the level of the logical approximation of the management process;
- to intensify the process of initializing the transformations more.

The extension of the rules of the output system, which we will denote by the symbol Ξ, consists in the fact that in the composition of the axioms system, for example, the Hilbert system, we introduce the rules in which we analyze timestamps [11]. Such rules allow to eliminate a variable, introduce active variables in L_i and analyze the possibility of conducting logical transformations based on the classical output system. The classical Hilbert axioms system is described by the following relationships:

$$H(G)=\{[x_i \to (x_j \to x_i)]\ ,$$

$$[(x_i \to (x_j \to x_k)) \to ((x_i \to x_j) \to (x_i \to x_k))],$$

$$[(x_i \& x_j) \to x_i],\ [(x_i \& x_j) \to x_j],\ [x_i \to (x_j \to (x_i \& x_j))],$$

$$[((x_i \to x_k) \to (x_j \to x_k) \to (x_i \to x_j) \to (x_i \vee x_j) \to x_k))],$$

$$[((x_i \to (x_i \vee x_j)],[\neg\ x_i \to x_i],\ [x_j \to (x_i \vee x_j))],$$

$$[(x_i \to x_j) \to (x_i \to \neg x_j) \to \neg x_i)]\}.$$

The only output rule for these axioms, without taking into account the additional rules associated with the rules for analyzing timestamps, is the rule *MP*, written in the form:

$$MP : [(x_i \rightarrow x_j)\,\&\, x_i] \rightarrow x_j.$$

Conclusion. Thanks to the introduction of time components in L_i, it became possible to determine the occurrence of an event (anomaly) in the process of solving the problem and the possibility of its formal definition.

Thus, the suggested model of a distributed dynamic information system can be used in designing a new or improving the existing systems that operate in the information and telecommunication environment.

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МОДЕЛЬ РОЗПОДІЛЕНОЇ ДИНАМІЧНОЇ ІНФОРМАЦІЙНОЇ СИСТЕМИ НА ОСНОВІ ВИКОРИСТАННЯ ЛОГІЧНИХ ЗАСОБІВ

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У статті запропоновано новий підхід до побудови моделей розподілених інформаційних систем на основі логічних засобів. Даний підхід базується на формальному математичному описі логічних зв'язків між компонентами розподілених інформаційних системи та їх задачами в процесі функціонування системи в цілому.

Ключові слова: *логічна модель, інформаційна система, рухомі об'єкти.*

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