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Logic-probabilistic Model of Survivability of Information Systems

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The logical-probabilistic models of survivability of information systems (IS) are studied, on the basis of the models method of analysis of survivability with drawing logical dependencies of the system from the adverse impacts is offered; it is demonstrated that survivability feature significantly differs from the reliability, durability and other properties of the known individual features of the reliability.

Key words: Survivability, Survivability analysis, Survivability model, Logical dependence.

The concept of survivability is known in a science for a long time and practically used in the creation of information technology systems for various applications, but it is still no a developed theory, which would contain the general technical results, allowing us to investigate this property, evaluate it quantitatively, and to develop practical recommendations.

Survivability is defined as the property of the IS to save and restore the ability to perform basic functions in a given volume and for a given operating time when the structure of the system and (or) algorithms and the conditions of its operation are changed due to unforeseen adverse impacts of regulations (AI). Main functions and predetermined operating time can be determined for both single and multiple, different severity AI, and in the general case they can be different for different levels[1-3].

Formulation of the model

Logical-probabilistic models are the simplest type of survivability models. They assumed a two-valued logic and behavior of the elements of the system as a whole, i.e. elements and system have only two sets of conditions; workable and unworkable[4-7]. The result of the perturbation is also evaluated on a binary scheme. The second major assumption of the model is the independence of system events that have occurred at different times. This enables the use the description of the system with a static model which does not contain time in the number of independent variables. Functional dependence between variables can be fully reflected by using algebra and logic functions. Elements of the system are the point objects interconnected by invulnerable

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links. AI impulse-type sequence forms a stream of independent events. Secondary effects of AI are absent, so the steady state of the system is known immediately after the AI. Means of the ensuring of the survivability control necessary disconnections and switches in the technical and functional - algorithmic structure in order to ensure the efficiency of IS using the remaining functional elements based on their interchangeability. Other assumptions of the model will be updated throughout the article[5].

Method of analysis of survivability.

In describing the elements we assume that each element can be in one of three states: e0 – element is workable and put into operation; e1 - element is unworkable and disconnected from the system for different reasons; e2 - element is unworkable. Transition from state to state is determined by four groups of factors: natural failures of the elements, restoring functionality, disconnections when triggered means of emergency protection and reconfiguration actions of external perturbations works. Connections between the elements are defined and stationary in time, so that at any time the state of the element can be set on the functionality of this element and the state of other elements. Signs of system functionality are unchanged over time and allow you to uniquely identify the state of the system at the aggregate state of its elements.

Descriptions of the elements and drawing logical dependencies.

For each element, we introduce two logic variables: x_i - functionality indicator of the i-th element ($x_i = 1$ if it is workable and $x_i = 0$ otherwise), y_i - the status indicator of the workable element ($y_i = 1$ if the item works and $y_i = 0$ otherwise). To reflect the effects of perturbations on the elements indicators z_{ij} and $z_i = V_{(j)} z_{ij}$ are introduced, where $z_{ij} = 1$ if the perturbation j-type influences on the i-th element, $z_{ij} = 0$ otherwise. Now it is possible to express the states of the three indicators:

$$ui1 = 1[e0] = xi\, yi\, zi \;;\; ui1 = 1[e1] = xi\, yiz$$

$$ui2 = 1[e2] = xi\, V x_i\, z_i$$

Based on the preliminary analysis of dynamic models of physical processes taking into account the actions of means of emergency protection, reconfiguration and control logical equations for the unknown states of the workable elements are made up:

$$yi = fyi\,(xk, yj, zk, k = 1,\ldots,N; j\text{”}\, Mi),\; i = 1,\ldots,N \quad ..(1)$$

where N is a number of the elements in the system, Mi - the set of the elements adjacent to the i-th element. The set of expressions as type (1) forms a closed system of logic equations presented in the vector form like

$$Y = fY(X,Y,Z) \quad ...(2)$$

The advantage of this recording is that by the description of the state of the workable element is used only its direct surroundings and there is no need to consider the whole system. In the future of these private and fairly simple dependencies an explicit dependence of the state of the workable element of the functionality of other elements and characteristics of the AI can be found by mathematical methods.

The functionality of the system is determined by the functionality of its elements and dependencies (2). For many systems, the main one is the state of a relatively small group of the output elements. However, due to the presence of the indirect links reflected in (2), the functionality of the system is defined by the state of all other elements. For single-function system logical function of the functionality is written as

$$F = f\,(X, Y, Z) \quad ...(3)$$

In the multi-functional system dependence of the form (3) is made for each function separately. If the simultaneous execution of all functions is required, so

$$F = \&(i)\, f_i\,(X, Y, Z) \quad ...(4)$$

where f_i - logic function, the progress bar of i-th function of the system. Expounded here a method of describing states of the system does not require a combinatorial search of all states of the elements, and the functions f_i are found formal from systems of logic equations.

Conditions of uncertainty, in which the equipment of geographically distributed information systems works, are characterized by the complexity of the system, impossible or impractical to describe the system by the conventional methods, the lack of qualitative information for taking control actions. To create logical and probabilistic models of survivability of such information systems may also be used methods of the theory of fuzzy games and fuzzy integral calculus, which is proposed to implement by a neural network[8-10].

CONCLUSIONS

Relatively simple models of survivability (point, static, without resistance of the elements and the secondary effects of perturbations) are considered. However, on the results of analysis of these models can be concluded that the survivability feature differs substantially from the reliability, durability and other properties of the known individual features of the reliability. It is become in the composition of indicators, models involved for the evaluation of these properties, and methods of the analysis.

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