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EFFECT OF ULTRA-SHORT PULSE SIGNALS ON INFORMATION SYSTEM SURVIVABILITY

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Here, the problems dealt with a survivability simulation of information systems under destabilizing electromagnetic effect have been considered. Proposed was the graph-analytic model of the information system and the electromagnetic surrounding, which presumes its structure evolution by reconfiguring links between its parts. A model complexity evaluation was carried out taking into account a cardinal number and an entropy. Such an evaluation made it possible to allow for a variety of component parts included into the system. The quantitative measure of model complexity has been obtained. It allowed us to evaluate a level of complexity of information systems in the course of their reconfiguration or degradation as well as to develop methods for making the system simpler and at the same time keeping safe their most essential features and characteristics.

A wide radiation spectrum reducing the stable band operation of information system to a high degree is a distinctive feature of high-power ultra-short pulse signals. Failure to maintain working capacity of such a system often leads even if not to disastrous effects, causes substantial economic losses. So, to provide effective operation of the system, it should be endowed with certain survivability feature. Survivability of an information system therewith implies a system feature which is capable of compensating detrimental effects of internal and external actions on its proper operation, either totally or partially, by using a structural organization and an operative algorithm.

Hence, the system operating in real-scale time and featuring survivability should be capable of localizing failures of functional elements caused by their insufficient reliability and an ill environmental attack in case the system functions in conditions different from specified. In doing so, the system should be capable of changing its properties and characteristics to neutralize effects of external actions as well as to influence on an environment in an active manner for decreasing the ill environmental attack to the system. At the same time the system should provide a gradual degradation of quality parameters of the system under operation with invalid functional elements progressively added.

Survivability of information system can be provided by introduction therein different redundancy types relative to a minimum configuration which is necessary for the system operation.

It is obvious therewith that the information systems are of survivability not only to external actions but to internal ones either. The latter is dictated by insufficient reliability of functional components and structure and algorithm features of system operation. At the same time the information system that displays the survival capability should reveal the faulty functional components and localize their failure effects in the system before it proves to be in faulty state due to component defects.

The systems, which are best suited to achieving the goal comprise as a part thereof functional diagnostic means. In this case, there is no need to have time redundancy and diagnostic software connected with interruption procedure for entry of testing commands and analysis of results, i.e. when a system directly realizes the operative algorithm prescribed to it. Irredundant information systems contain a minimum apparatus needed for the up system to perform the prescribed functions. At the same time dynamic redundancy systems assume that the apparatus being in a backup state is put into operation only if it is necessary to replace the parts of the system under operation in case they give rise to a malfunction.

Accordingly, it is always possible to change both the number of devices included in the system and the links between them.

To evaluate such a change in the system complexity level in its reconfiguring and taking decisions for a transfer from one complexity level to another (evolution of the system), it is necessary to have a complexity quantitative criterion both for the system and for the model reflecting the system adequately as a whole. Thus, determination of complexity level is an important and pressing problem without solving thereof it is impossible to elaborate the system reconfiguration methods for the aim of increasing its survivability and keeping most essential features and characteristics.

Irrespective of a system type the complexity should be proportionate to the scope of information required for description of this system. One of the description methods reduces to evaluation of the number of component the system involves and variety of interconnections there between. At the same time the models representing survivability aspects of information system can be best shown as graphic analytic multiple structures wherein nodes are the system elements and ribs map a variety of connections there between. At that, the challenge formally arises of evaluating the graph complexity. So, one should find the function:

$$C = f(n, t, m, k, p), \quad (1)$$

where

$n -$ is a number of graph nodes;
$t -$ is a type number of graph nodes;
$m -$ is a number of ribs;
$\varphi -$ is a number of rib types;
$p -$ is a number of different graph degrees of vertexes.

This function should meet a set of conditions. One of the conditions is that the range of function values should coincide with a set of nonnegative numbers. At the same time the function should increase monotonically depending on a number of nodes, ribs and their type number. At that, one should consider that one undirected edge is equal to any two directed edges. Besides, the function should have a set variety measure of information.

If we abstract from quality of component elements, complexity C is proposed to measure by the number of its elements n and the element variety to take into account by the entropy formula used in statistical theory of information. In doing so, it is assumed that probability p_i of occurrence the i^{th} element is determined by the proportion:

$$p_i = n_\mu / n,$$

where n_μ is a number of elements of the μ – type, which i^{th} element is related to. Based on it one proposes the following quantitative measure of the graph complexity:

$$C = n\left(1 - \sum_{\mu=1}^{t} (n_\mu / n) \cdot \log_2 (n_\mu / n)\right), \quad (2)$$

At that the following conditions should be met:

$$n = 0 \quad \Rightarrow \quad C = 0;$$

$$m = 0 \quad \Rightarrow$$

$$C = n\left(1 - \sum_{\mu=1}^{t} (n_\mu / n) \log_2 (n_\mu / n)\right); \quad (3)$$

$$m = 0 \ \wedge \ t = 1 \quad \Rightarrow \quad C = n$$

With the assumptions taken in view, the quantitative measure of complexity of system (2) takes the following form:

$$C = n(1 - H_n^t - H_m^\varphi - H_n^k), \quad (4)$$

where

$H_n^t = \sum_{\mu=1}^{t} (n_\mu / n) \cdot \log_2 (n_\mu / n) -$ diversity entropy measure of the graph node names;

$H_m^\varphi = \sum_{\beta=1}^{\varphi} (m_\beta / m) \cdot \log_2 (m_\beta / m) -$ diversity entropy me measure of the graph rib names;

$H_n^t = \sum_{\mu=1}^{t} (n_\mu / n) \cdot \log_2 (n_\mu / n) -$ diversity entropy measure of the graph degree of vortexes.

Here n_μ is a number of nodes of one name; m_β is a number of one type ribs; n_λ is a number of nodes of one degree.

The data analysis obtained as a result of the experimental approbation of the criterion allows us to conclude that the proposed quantitative complexity criterion of the system graph model can be used both for the complexity evaluation of system external operation when one takes into account the number and diversity of the system links with environment objects and for comparison of systems deteriorated (evolution takes place) due to effect of ultra-short pulse signals.

ВОЗДЕЙСТВИЕ УЛЬТРАКОРОТКИХ ИМПУЛЬСНЫХ СИГНАЛОВ НА ЖИВУЧЕСТЬ ИНФОРМАЦИОННЫХ СИСТЕМ

А.А. Серков

Рассматривается задача моделирования живучести информационных систем под дестабилизирующим электромагнитным воздействием. Предложена графоаналитическая модель информационной системы и электромагнитного окружения, которая предполагает изменение структуры модели путем переконфигурирования связей между ее частями. Оценка сложности модели была произведена с учетом кардинального числа и энтропии. Подобная оценка позволяет принять во внимание разнообразие составных частей, включенных в систему. Получена количественная мера сложности модели. Это позволяет оценивать уровень сложности информационной системы в ходе ее переконфигурирования или деградации, а также развивать методы упрощения системы, сохраняя при этом наиболее существенные ее свойства и характеристики.

ВПЛИВ УЛЬТРАКОРОТКИХ ІМПУЛЬСНИХ СИГНАЛІВ НА ЖИВУЧІСТЬ ІНФОРМАЦІЙНИХ СИСТЕМ

О.А. Серков

Розглянуто задачу моделювання живучості інформаційних систем під дестабілізуючим електромагнітним впливом. Запропоновано графо-аналітичну модель інформаційної системи та електромагнітного оточення, яка припускає зміну її структури шляхом переконфігурування зв'язків між її частинами. Оцінка складності моделі була проведена з урахуванням кардинального числа та ентропії. Така оцінка дозволяє прийняти до уваги різноманітність складових частин, що включені до системи. Отримано кількісну міру складності моделі. Це дозволяє оцінювати рівень складності інформаційної системи у ході її переконфігурування або деградації, а також розвивати методи спрощення системи, зберігаючи при цьому найбільш суттєві її властивості та характеристики.