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ASSESSMENT OF THE EFFICIENCY OF PROTECTION OF THE INFORMATION SYSTEM OF ENTERPRISES

Abstract. The paper evaluates the effectiveness of the use of functionally stable generalized information system of the enterprise. Diagnosis of the system in general. The following definition-assumption was used in the diagnosis: the amount of diagnostic information is the number of test results accumulated by the module before the execution of the algorithm, recorded during the mathematical modeling of the diagnostic procedure.

It is illustrated that the reliability of the diagnosis does not change due to the expansion of the system. This is due to the property of adaptive self-diagnosis - the ability to diagnose with a given reliability. Values of reliability significantly depend on the number of failures. As the number of failures increases, the reliability of diagnosis decreases, due to the peculiarities of the algorithm of analysis of test results, in which the whole set of modules is divided into two subsets - possible good and possible bad modules. It is the power of many possible faulty modules that influences decision-making, i.e. the reliability of diagnosis. Dependence of reliability on a priori probability of working condition of modules shows insignificant increase of reliability with increase of value of probability of working capacity that is also caused by features of algorithm of analysis of diagnostic information in which the decision on failures of modules is made directly taking into account value of probability of working capacity. The amount of diagnostic information is the number of test results accumulated by the module before executing the algorithm.

The property of adaptive self-diagnosis, in contrast to the existing ones, is considered in the work due to the increase in the time of diagnosis and the acceptable decrease in the reliability of the diagnosis. At the same time, the time of diagnosis is predictable and is within acceptable limits, which allows to detect failures in time, roll back the computational process and ensure the insensitivity of the computational process to failures of system modules.

Keywords: functional stability, graph model, graph-transitions, information system restoration, diagnostics, evaluation.

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ОЦІНКА ЕФЕКТИВНОСТІ ЗАХИСТУ ІНФОРМАЦІЙНОЇ СИСТЕМИ ПІДПРИЄМСТВ

Анотація: У роботі оцінено ефективність використання функціонально стійкої узагальненої інформаційної системи підприємства. У діагностиці використовувалося таке визначення-припущення: кількість діагностичної інформації – кількість результатів тестування, накопичених модулем до виконання алгоритму, зафіксованих під час математичного моделювання діагностичної процедури.

Проілюстровано, що достовірність діагностики не змінюється через розширення системи. Значення надійності істотно залежать від кількості відмов. Зі збільшенням кількості відмов достовірність діагностики знижується. Потужність багатьох можливих несправних модулів впливає на прийняття рішення, тобто на достовірність діагностики. Залежність надійності від апріорної ймовірності працездатності модулів показує незначне підвищення надійності зі збільшенням значення ймовірності працездатності. Обсяг діагностичної інформації – це кількість результатів тестування, накопичених модулем перед виконанням алгоритму.

Властивість адаптивної самодіагностики, на відміну від існуючих, розглядається в роботі за рахунок збільшення часу діагностики та допустимого зниження достовірності діагнозу.

Ключові слова: функціональна стійкість, графова модель, граф-переходи, відновлення інформаційної системи, діагностика, оцінка..

1. Introduction

The development of modern society requires the intensive development of information technology with a high degree of autonomy. This problem is especially acute for manufacturing enterprises that operate under the influence of extreme factors [1]. Among such enterprises are enterprises of metallurgy, energy, chemical industry and more. The functioning of production units of such enterprises is provided by information systems of various types. These systems are used to plan and control all processes [2,3]. They work autonomously under the influence of external and internal destabilizing factors [4,5]. With the help of information systems it is possible to increase the productivity of all production centers while reducing the number of people employed in production and significantly reducing the share of manual labor [6,7]. The systems are constantly being modernized due to the intensification of investments in the production process.

We emphasize that the information systems of enterprises operate under the influence of external and internal destabilizing factors. Under negative effects, system modules may fail. However, the systems must operate offline for a specified time. This operating condition can be met by providing functional stability properties. Functional stability is the key to the functioning of the information system, possibly with a decrease in quality, during this time under the influence of external and internal destabilizing factors [8,9]. External and internal destabilizing factors are failures, system module failures, mechanical damage, thermal influences, errors of service personnel. The main stages of ensuring functional stability are the detection of the module that failed during the control, diagnosing the module that failed and the restoration of the information system of the enterprise.

Therefore, one of the most important prerequisites for ensuring the functional stability of the information system of the enterprise [9]. A very effective approach is to use a method of ensuring the properties of functional stability of the enterprise information system, by presenting the functioning of the system in the form of a formalized process, in which the main types of procedures are accumulation of tests, analysis of test links, diagnosing systems.

2. Literature review and problem statement

The presence of a set of criteria for the effectiveness of MoD determines the multi-criteria nature of the task of its design and significantly complicates the development of formal methods. To simplify the design task and its practical solution, the efficiency indicator to be optimized is determined, and others are classified as constraints. Depending on the main indicator of efficiency (optimization criterion) distinguish the following options for setting the synthesis of computer networks [10]:

-synthesis of the network by the criterion of the minimum average delay time of messages in the network at a given reliability and cost;

-synthesis of the network by the criterion of minimum cost at given reliability indicators;

-synthesis by the criterion of maximum reliability at a given total cost.

Determination of functionally stable MoD. The main requirement proposed for computer networks is that the network performs its main function - providing network subscribers with the potential to access distributed information resources combined in the MoD. All other requirements - performance, reliability, compatibility, manageability, survivability, etc. - are related to the quality of this basic task.

Accordingly, the urgent scientific task is to increase the efficiency of information systems. Many scientific works are devoted to the solution of this problem [11–14]. However, in our opinion, the main attention is paid to the solution of partial problems, namely - the construction of redundant information and control systems, fault-tolerant control computer systems, adaptive control systems.

In this regard, of particular interest is the construction of functionally stable MoD, which allow to solve problems under the influence of the flow of operational failures, intentional damage, interference in the exchange and processing of information, as well as errors of staff [15,16]. In fact, the functional stability of a complex technical system combines the properties of reliability, fault tolerance and survivability and characterizes the ability of the object to restore serviceability through the use of redundancy. To solve the problem of rational introduction of redundancy, the problem of synthesis of the optimal structure of MoD is solved.

3. Formulation of the problem

In the process of information protection, the task of identifying threats and blocking channels of information leakage arises. One of the methods of unauthorized leakage of information is the means of obtaining information, which is used as information transmission radio channel. Probable detection of covert means of obtaining information using a radio channel is a very difficult task. Therefore, the question of developing new methods and techniques for detecting the means of covert receipt of information use radio channel to transmit the received information is very relevant.

The purpose of this article is to illustrate the results of mathematical modeling of the process of diagnosing a generalized information system of an industrial enterprise.

4. The main section

4.1 Basic provisions and assumptions of mathematical modeling

To confirm the correctness of the developed scientific and methodological apparatus, mathematical modeling of the process of diagnosing the information system of the enterprise was carried out. At the same time, the information system was divided into several subsystems, which contain a number of modules. It is assumed that the division into subsystems can be carried out on any principle: functional, spatial, etc. The number of modules in each subsystem is important for the division into subsystems - it should not exceed 30 modules. This limitation is due to the limited computing power of modern microprocessor technology when solving a class of complete problems. When limited to 30 modules, the diagnostic system can within a reasonable time to give a diagnosis - the technical condition of the modules of the subsystem.

The technical condition of the subsystem is given in the form of a binary vector:

$$S = \{s_i\} = \{0,0,0,1,0,1,0,...,1,0,0\}, \quad i = 1,2,...,N, \tag{1}$$

$s_i=0$ – indicates the working state of the computing module M_i;

$s_i=1$ – indicates the non-working state of the computing module M_i;

Mathematical modeling was performed to determine the main indicators of diagnosis:

1) D - reliability of diagnosis;

2) $t_д$ – diagnostics time - the time from the moment of failure of some module to the moment of issuance by the algorithm of analysis of the technical condition of modules *S*.

However, other key indicators of diagnosis have not been modeled, due to the following judgments:

1) Π – completeness of diagnosis - the percentage of hardware and software computing module to be tested at the time of diagnosis. This characteristic is completely due to the test task, which is sent to each module during the basic test. Depending on how much all the equipment will be covered by the test, this will be the completeness of the diagnosis;

2) Γ – depth of diagnosis - characterizes the scaling of the troubleshooting procedure «to the typical replacement element», «to the board», «to the element», etc. In this case, the depth of diagnosis is completely determined by the method of diagnosis, which determines the inoperable computing module.

Other assumptions made in the work during the simulation:

- it is assumed that *all computing modules that are part of the subsystem are connected to other modules of the subsystem.* That is, there is at least one route of information transfer between any pair of subsystem modules;
- all *subsystem modules are not completely reliable*. It is assumed that at the beginning of the diagnostic procedure, each module has a certain a priori *probability of operational condition*, which is denoted by *p* and varies during modeling in the following values:

$$p = \{0{,}80; 0{,}85; 0{,}90; 0{,}95\}, \quad (2)$$

- the *algorithm for analyzing* diagnostic information (test results) *sets the specified level of reliability of diagnosis* $D_{зад}$, which acts as a sign of cessation of accumulation of test results in the memory of the module that will perform the specified algorithm. The specified reliability varies during modeling with the following values:

$$D_{зад} = \{0{,}80; 0{,}85; 0{,}90; 0{,}95; 0{,}98\}, \quad (3)$$

- the current *simulation time and the diagnosis time* were determined in *conventional units of time*, for which several machine cycles of the processor at the natural clock frequency were taken.
- computational modules *operate on a cyclic scheme* and perform basic tasks for a certain period of time $T_{пер}$. During modeling, it is assumed that each module has a random value of $T_{пер}$, which is distributed according to a uniform distribution law within the following limits:

$$T_{пер} = [8; 10]; \quad (4)$$

- *part of the period of solving the main tasks is devoted to solving service tasks*, processing interrupts and performing diagnostic tasks. It is during this time that the basic test is performed: the examiner sends to the module that is being tested the test task; the module being tested executes it and sends back the result of the test task, the test module compares the result with the reference and gives the test result r_{ij}. This time is called - *pause time* $T_п$, which is set for each module also randomly within:

$$T_п = (15...25) \cdot T_{пер}; \quad (5)$$

- the accumulation of diagnostic information is modeled in accordance with the method of conditional transmission of information. In the case when the test result is r_{ij} = 1, this result complements the matrix of results of the *i*-th module. And replenishment is carried out by replacement of the previous result. In the case when r_{ij} = 0, the accumulation of results is performed in two stages: 1) a similar replenishment of the matrix of results of the *i*-th module; 2) sending the updated matrix of results of the *i*-th module to the *j*-th module with the subsequent addition and updating of the matrix of results of the *j*-th module. Moreover, any element of the old matrix R is updated as follows: if the old value r_{ij} = 0, and the new - 1, then write the new value r_{ij} = 1; if the old value of r_{ij} was 1 and the new value was 0, 0 remains;
- after the accumulation of information (replenishment of the matrix of test results), *each*

module calculates the probability of issuing the correct result, which serves as a sign of completion of the accumulation of results. If the value of this probability is higher than $D_{зад}$, then this module stops performing tests and begins to perform the algorithm of analysis of test results;

- *the number of test results* accumulated by this module is denoted as $K_{пер}$;
- *essence of the algorithm for analyzing the results of tests is to calculate the a posteriori probabilities of serviceability of all modules and determine the current technical condition of the modules of subsystem* $S=\{s_i\}$. And the module that could accumulate faster than all other tests this module;
- at this point *the diagnostic procedure ends and the correctness of the diagnosis* is determined by comparing $S=\{s_i\}$ with the specified technical condition at the beginning of the simulation;
- *the calculation of the reliability of the diagnosis D* is carried out by performing 100 times the diagnostic procedure with a specified number of inoperable modules and random distribution of inoperable modules;
- *errors of the first and second genera* P_I *and* P_{II} were not calculated. This is due to the inability to distinguish between missed and incorrect failures, if the subsystem specifies several inoperable modules.

The simulation was performed on a personal computer Intel ® Celeron ® CPU J3455, 1.5 GHz, 8 Gb with Windows 10 Pro operating system in the programming language Jawa SE 8. The average simulation time of one diagnostic procedure did not exceed 2.5 minutes, which is acceptable for modeling of the specified procedures with dimension of a subsystem N<30 modules.

4.2 Results of system modeling with N = 15 modules

The results of modeling the procedure for diagnosing an information system consisting of N = 15 modules are given in table. 1 - 4. During the simulation the diagnostic parameters were recorded: reliability D, amount of diagnostic information $K_{пер}$, diagnosis time $t_д$ under varying the number of failures in the subsystem $N_{від}$, values of the specified diagnostic reliability $D_{зад}$ and a priori probability of serviceability of modules p.

Table 1. The results of modeling the procedure for diagnosing a subsystem with N = 15 modules under the condition p = 0.80

		$D_{зад}$ = 0,80	$D_{зад}$ = 0,85	$D_{зад}$ = 0,90	$D_{зад}$ = 0,95	$D_{зад}$ = 0,98
$N_{від}$=0	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	42	48	56	62	67
	$t_д$	121	138	151	164	182
$N_{від}$=2	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	45	52	64	70	78
	$t_д$	122	140	163	181	196
$N_{від}$=4	D	0,99	0,99	0,99	1,00	1,00
	$K_{пер}$	49	61	74	83	96
	$t_д$	126	146	182	206	221
$N_{від}$=6	D	0,97	0,97	0,98	0,99	1,00
	$K_{пер}$	58	72	88	100	111
	$t_д$	137	163	206	242	264
$N_{ві}$	D	0,94	0,94	0,97	0,98	0,99

		$D_{зад}$ = 0,80	$D_{зад}$ = 0,85	$D_{зад}$ = 0,90	$D_{зад}$ = 0,95	$D_{зад}$ = 0,98
	$K_{пер}$	70	90	104	124	137
	$t_д$	149	192	238	294	328
$N_{від}=10$	D	0,89	0,91	0,94	0,97	0,99
	$K_{пер}$	89	110	128	151	162
	$t_д$	178	228	281	360	417
$N_{від}=12$	D	0,81	0,85	0,91	0,95	0,98
	$K_{пер}$	116	136	161	185	198
	$t_д$	222	290	360	481	559

Table 2. The results of modeling the procedure for diagnosing a subsystem with N = 15 modules under the condition p = 0.85

		$D_{зад}$ = 0,80	$D_{зад}$ = 0,85	$D_{зад}$ = 0,90	$D_{зад}$ = 0,95	$D_{зад}$ = 0,98
$N_{від}=0$	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	37	42	49	56	61
	$t_д$	103	119	133	148	163
$N_{від}=2$	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	39	46	58	66	74
	$t_д$	105	124	143	163	178
$N_{від}=4$	D	0,99	0,99	0,99	1,00	1,00
	$K_{пер}$	42	54	69	82	94
	$t_д$	109	132	163	190	204
$N_{від}=6$	D	0,97	0,97	0,98	0,99	1,00
	$K_{пер}$	49	65	83	101	112
	$t_д$	119	150	188	226	244
$N_{від}=8$	D	0,94	0,94	0,97	0,98	0,99
	$K_{пер}$	59	81	100	126	138
	$t_д$	132	177	222	276	306
$N_{від}=10$	D	0,89	0,91	0,94	0,97	0,99
	$K_{пер}$	74	100	124	154	165
	$t_д$	159	213	267	341	391
$N_{від}=12$	D	0,81	0,85	0,91	0,95	0,98
	$K_{пер}$	95	124	155	188	199
	$t_д$	201	270	340	453	525

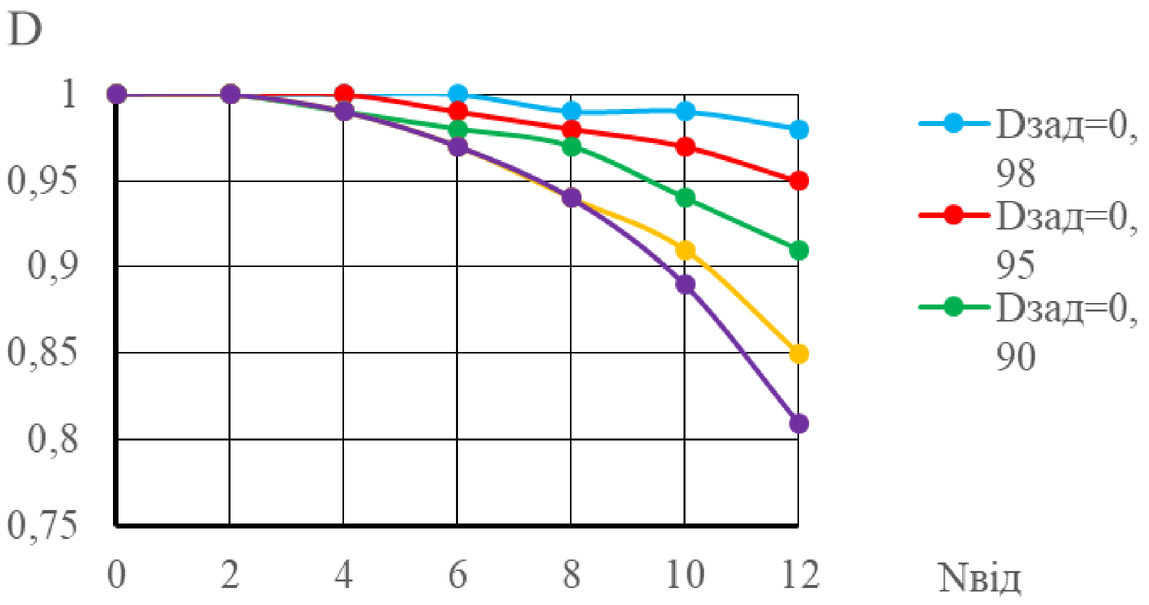
Table 3. The results of modeling the procedure for diagnosing a subsystem with N = 15 modules under the condition p = 0.90

		$D_{зад}$ = 0,80	$D_{зад}$ = 0,85	$D_{зад}$ = 0,90	$D_{зад}$ = 0,95	$D_{зад}$ = 0,98
$N_{від}$=0	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	33	37	43	49	55
	$t_д$	86	101	114	131	143
$N_{від}$=2	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	34	40	52	62	71
	$t_д$	88	109	156	144	161
$N_{від}$=4	D	0,98	0,99	0,99	1,00	1,00
	$K_{пер}$	36	47	63	81	93
	$t_д$	93	118	144	173	186
$N_{від}$=6	D	0,96	0,97	0,98	0,99	1,00
	$K_{пер}$	39	58	78	101	113
	$t_д$	102	136	171	210	224
$N_{від}$=8	D	0,94	0,95	0,97	0,98	0,99
	$K_{пер}$	47	73	97	129	140
	$t_д$	115	163	207	259	283
$N_{від}$=10	D	0,90	0,92	0,95	0,97	0,99
	$K_{пер}$	58	90	121	157	168
	$t_д$	140	197	252	322	364
$N_{від}$=12	D	0,82	0,86	0,91	0,96	0,98
	$K_{пер}$	73	111	150	191	201
	$t_д$	179	249	321	426	492

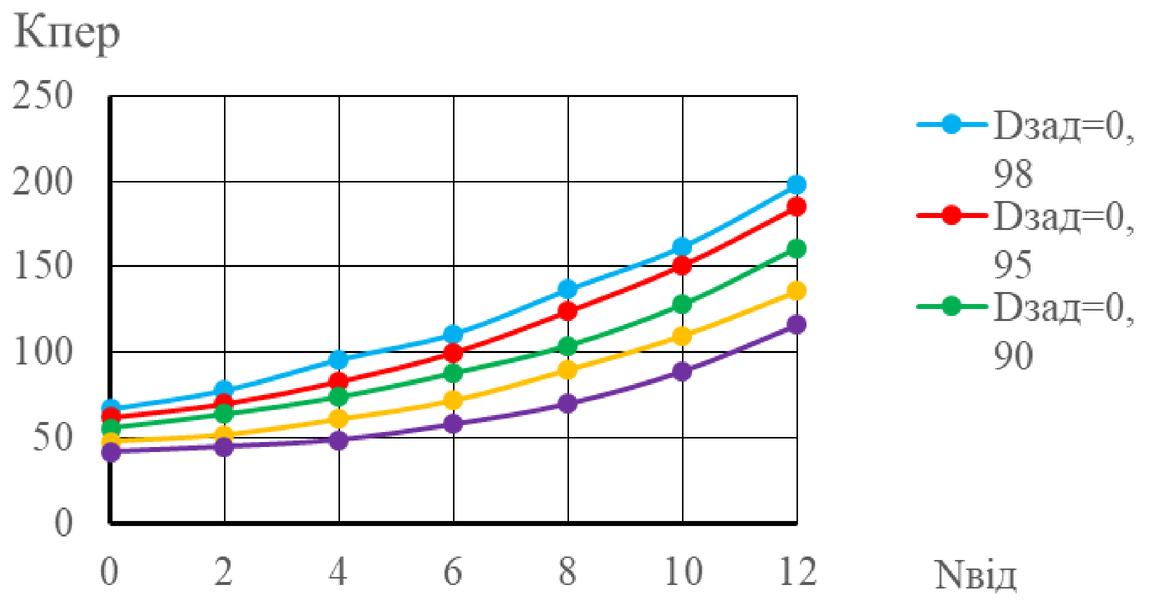
Based on the simulation results, graphs of the dependence of diagnostic reliability D, the number of tests $K_{пер}$ and the time of diagnosis $t_д$ on the number of failures in the subsystem $N_{від}$ under different values of the specified diagnostic reliability $D_{зад}$ and a priori probability of operational modules p, for a subsystem consisting of N = 15 modules (Pic. 1 - 3)

Table 4. The results of modeling the procedure for diagnosing a subsystem with N = 15 modules under the condition p = 0.95

1	2	3	4	5	6	7
$N_{від}=0$	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	28	31	36	43	49
	$t_д$	68	82	96	115	124
$N_{від}=2$	D	1,00	1,00	1,00	1,00	1,00
	$K_{пер}$	28	34	46	58	67
	$t_д$	71	93	103	126	143
$N_{від}=4$	D	0,98	0,99	0,99	1,00	1,00
	$K_{пер}$	29	40	58	80	91
	$t_д$	76	104	125	157	169
$N_{від}=6$	D	0,96	0,97	0,98	0,99	1,00
	$K_{пер}$	30	51	73	102	114
	$t_д$	84	123	153	194	204
$N_{від}=8$	D	0,94	0,95	0,97	0,98	0,99
	$K_{пер}$	36	64	93	131	141
	$t_д$	98	148	191	241	261
$N_{від}=10$	D	0,9	0,92	0,95	0,97	0,99
	$K_{пер}$	43	80	117	160	171
	$t_д$	121	182	238	303	338
$N_{від}=12$	D	0,82	0,86	0,91	0,96	0,98
	$K_{пер}$	52	99	144	194	202
	$t_д$	158	229	301	398	458

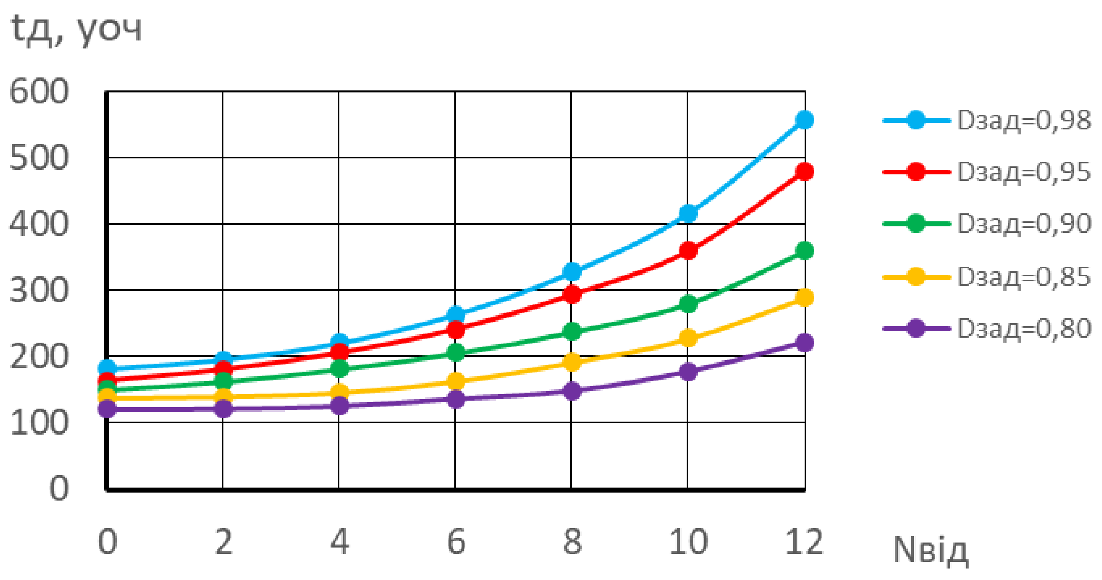


Pic. 1. The dependence of the reliability of the diagnosis of D on the number of failed modules, $N_{від}$ provided $D_{зад}$ = 0.8… 0.98, p = 0.80, N = 15



Pic. 2. Dependence of the number of tests $K_{пер}$ on the number of failed modules, $N_{від}$ on the condition $D_{зад}$ = 0.8… 0.98, p = 0.80, N = 15

Analysis of the graphs of the presented dependencies allows us to conclude that the procedure of self-diagnosis is convergent. For any random situation that was randomly determined, the diagnostic result was established for a limited time.



Pic. 3. The dependence of the diagnosis time $t_д$ on the number of failed modules, $N_{від}$ provided $D_{зад}$ = 0.8… 0.98, p = 0.80, N = 15

5. Discussion of experimental results

The peculiarity of the assessment is that, taking into account the acceptable time of diagnosis, there were cases of incorrect assessment of the negative situation. That is, as a result of simulation, 100% accuracy of the diagnosis was not obtained. This is due to the uncertainty in each result of the elementary test of each module, which in turn is explained not by errors in the algorithm of analysis of test results, and Bayesian estimation of a posteriori probabilities of working condition of each module. These a posteriori probabilities determine the reliability of the diagnosis as the probability of correct decision-making about the negative situation in the system.

Uncertainty of results of elementary checks is caused by the mathematical model (systems of estimation of the device) of result of elementary check accepted in work:

$$r_{ij} = \begin{cases} 0, & if\ v_i, v_j\ serviceable; \\ 1, & if\ v_i\ serviceable,\ v_j\ nonserviceable; \\ x = 0 \vee 1, & v_i\ nonserviceable, \end{cases} \quad (6)$$

where v_i – checking system module, v_j – system module being tested.

In this mathematical model, the result of the elementary test is taken as a Boolean variable 0 or 1. If the test module is faulty, the mathematical model assumes that the test module gives any random result $x = 0 \vee 1$ according to the uniform distribution law.

During an elementary test involving two modules, the test module compares the result of the test task performed by the module being tested with the reference value of the test. Based on the results of the inspection, the actual result of the inspection is issued:

$$r_{ij} *= \begin{cases} 0, & if\ the\ test\ result\ coincides\ with\ the\ reference; \\ 1, & the\ result\ does\ not\ match\ the\ reference. \end{cases} \quad (7)$$

It is these uncertainties that cause errors of the first and second kind when modeling the diagnostic procedure:

$$P_I + P_{II} = 1 - D \quad (8)$$

where P_I – probability of missed failure;

P_{II} – probability of «false alarm»;

D – reliability of diagnosis.

However, it should be noted that the procedure of self-diagnosis of the information system does not allow to identify errors of the first and second kind. As a result of the received diagnosis on a certain refusal situation if the number of failures in system $N_{від} > 1$, it is impossible to allocate the missed refusal from «false alarm». For example, in a real failure situation (5-th, 8-th modules are faulty), the diagnosis is received: 5-th and 9-th modules are faulty. For this example, it is not possible to identify errors of the first and second kind. Therefore, a conclusion is made about the incorrect definition of the negative situation. The probability of incorrect determination of the negative situation complements the reliability of the diagnosis, which is the main indicator of the effectiveness of the diagnosis.

According to the simulation results, the change in the reliability of the diagnosis from the number of modules that failed $N_{від}$ at different values of the specified level of reliability $D_{зад}$ and p was determined (see Pic. 1-3). Analysis of these graphs shows that in the absence of modules that failed $N_{від} = 0$, in all cases there will be 100 percent reliability $D = 1$. Given the small number of failures in the system $N_{від} < 5$, the reliability of the diagnosis is close to 1: $D \geq 0{,}98$. With a significant number of failures $N_{від} = 6 \ldots 12$ for a system with $N = 15$ modules, the reliability of diagnosis in any conditions is higher than $D_{зад}$. This confirms the main property of adaptive self-diagnosis - the ability to diagnose with a reliability not lower than specified.

This property is due to the applied information technology of accumulation of diagnostic information within the proposed method of adaptive self-diagnosis of the information system of the enterprise. This information technology consists in the accumulation by each module of the system of test results and in the assessment of the amount of diagnostic information (test results) by each module. If the amount of diagnostic information allows you to issue a diagnosis with a reliability not lower than the given, then this module decides to conduct an algorithm for analyzing diagnostic information.

The amount of diagnostic information is the number of test results $K_{пер}$, accumulated by the module before the execution of the algorithm, was recorded during the mathematical modeling of the diagnostic procedure. The following conclusions can be drawn from the graphs of the dependences of $K_{пер}$ on the number of modules that failed $N_{від}$ (see Pic. 2).

With a small number of failures $N_{від} \leq 2$, the diagnosis is based on the amount of diagnostic information $K_{пер}<50$ under a given reliability $D_{зад} \geq 0{,}80$. This amount of diagnostic information for a system with $N = 15$ modules is insignificant. It can be compared to the power of the set of edges of a fully connected graph in which $m = N \cdot (N-1) = 210$ edges. When the set reliability $D_{зад}$ increases to the level of 0.98, the amount of diagnostic information increases to $K_{пер} = 150 \ldots 200$. This is due to the fact that the system is tested until it is possible to issue a diagnosis with a given reliability.

The amount of diagnostic information characterizes the time of diagnosis $t_Д$ - the time from the beginning of the diagnostic procedure to the time of diagnosis. This parameter shows the time of «failure» in the system.

Analysis of the graphs of the dependences of the time of diagnosis $t_д$ on the number $N_{від}$ (see Pic. 3) allows us to draw the following conclusions.

As the number of failures increases, the time of diagnosis increases. And this growth is exponential. This is due to the peculiarities of the technology of accumulation of diagnostic results. With a significant number of failures $N_{від}$ >N, it is necessary to accumulate a significant number of test results in order for a subset of valid modules to test all modules included in the set of failed with as many tests as possible. In this case, it is possible to issue a diagnosis with a given reliability.

Analysis of the values of the diagnostic time allows you to calculate the number of operations that need to be rolled back in the computational process when detecting the failure of one or more modules. This must be done so that the failure of the module does not affect the computational process and does not lead to computational errors during the operation of the information system for its intended purpose.

That is why it is interesting to see how the increase in the number of modules in the system will affect the diagnosis. This may be the direction of further research.

6. Conclusions

The paper illustrates that the reliability of the diagnosis does not change due to the expansion of the system. This is due to the property of adaptive self-diagnosis - the ability to diagnose with a given reliability $D_{зад}$. Values of reliability significantly depend on the number of failures *N*. As the number of failures increases, the reliability of diagnosis decreases. This is due to the peculiarities of the algorithm of analysis of test results, in which the whole set of modules is divided into two subsets - possible good and possible bad modules. It is the power of many possible faulty modules that influences decision-making, ie the reliability of diagnosis. The dependence of the reliability on the a priori probability of the operational state of the modules p shows a slight increase in reliability with increasing probability value. This is also due to the peculiarities of the algorithm for analyzing diagnostic information, which decides on the failure of modules directly taking into account the probability value.

The number of tests is equal to the number of test results accumulated in the module that will perform the algorithm for their analysis. The number of tests characterizes the amount of diagnostic information. The amount of diagnostic information significantly affects the reliability of the diagnosis - with increasing number of tests increases the reliability of the diagnosis. The dependence of the number of checks on the number of failures in the subsystem is exponential. With a small number of failures, the number of inspections does not change. This indicates that for a small number of failures, the algorithm for analyzing the results of inspections allows you to make decisions with acceptable reliability.

The time of diagnosis, as well as the number of tests, depending on the number of failures in the subsystem varies exponentially. With a small number of failures, the time of diagnosis does not change. This indicates that for a small number of failures, the algorithm for analyzing the results of inspections allows you to make decisions with acceptable reliability.

Thus, the assessment of adaptive self-diagnosis, in contrast to the existing ones, is due to the increase in the time of diagnosis and an acceptable decrease in the reliability of the diagnosis. At the same time, the time of diagnosis is predictable and is within acceptable limits, which allows to detect failures in time, roll back the computational process and ensure the insensitivity of the computational process to failures of system modules.

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