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Strategy of Adaptive Diagnosing of Memory Modules

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Abstract: A strategy of diagnosing of memory modules implemented using expert system with indistinct rules raises the degree of automation of choice procedure of the effective tests from allowable set. The process of diagnosing adapts for features of tested object, thus the most probable types of malfunctions are taken into account and the most effective tests are applied to their covering.

Keywords: Memory, Diagnosing, Test, Graph Malfunction

1. Introduction

The modern operative storage devices (RAM) of computers are consisting from memory modules, which consist from very large integrated circuits (VLIC). The high characteristics of reliability VLIC are determined by a level of automation of technological processes and observance of conditions and rules at their manufacturing. At assembly phase of memory modules the new malfunctions can be added which frequently are caused by the human factor and result in short circuits or breakage of trunks of the address, data, managements and synchronization, turned microcircuits or installation of computers inappropriate to the specifications.

Most frequently failures of memory modules arise at an early stage of life cycle (ESLC), which three months usually proceed. To reduce ESLC duration, the leading firms of manufacturers will carry out tests of memory modules within 24 hours at increase intense of the power supplies and environment temperature of 100^{oC}. On the expense of an establishment of severe constraints of memory modules tests; the manufacturers aspire to ensure aging microcircuits at least for three months.

The large duration of tests on ESLC expands a set of tests ensuring effective diagnosing of microcircuits and memory modules. Great success was gained by March tests family, beginning from March A, March B up to March Y, March FD [1-3].

The purpose of the given work is to develop a strategy of adaptive test diagnosing on ESLC, ensuring release of high quality products.

To achieve the given purpose it is necessary to solve the following tasks:

- Development of process's models of localization of memory modules malfunctions;
- Development of criterion of the tests choice of approaching achievement of the purpose;
- Collecting of new and additional information for process's adapting diagnosing of used modules.
- Choice and modernization of means for diagnosing modelling process.

The solving of the given tasks will allow adapting process of testing in time that will ensure a prize of time and cost reduction on memory modules testing.

2. Problem of Tests Choice for Memory Modules Malfunctions Covering

The high expenses of time to performe the diagnosing test VLIC RAM of large capacity determine a task of a choice of the effective tests covering the most probable malfunctions. In the formalized kind the problem of a tests choice can be presented as the following functional [4]:

$$F = < T, P, M>,$$

Where:
T − duration of testing;
P − Probability of malfunctions covering;
M− Number of the tests.
Given functional allows to generate seven tasks, which

have practical meaning and are given in tab. 1.

Table 1. *Tasks of diagnosing of memory modules.*

№	T	P	M	Function
1	var	var	var	P=f(T,M)
2	var	const	var	M=f(T,P=const)
3	var	const	var	T=f(P=const,M)
4	const	var	var	P=f(T=const,M)
5	const	var	var	M=f(T=const,P)
6	var	var	const	T=f(P,M=const)
7	var	var	const	P=f(T,M=const)

Let's consider more in detail description of the given tasks.

1. P = f (T, M) – is a task of definition of probability of a covering of malfunctions without restrictions on time and quantity of the tests. It has not the formalized solution, as there are a large number of combinations of various sequences of the used tests.

2. M = f (T, P = const) – determines the optimized set of the tests ensuring achievement of given probability of a covering of malfunctions. The time of testing thus is not limited.

3. T = f (P = const, M) – determines the minimal time, for which the most favourable sequence of the tests provides the given probability of a covering of malfunctions.

4. P = f (T = const, M) - the greatest possible probability of a covering of malfunctions determines at restriction of duration of testing at surplus of all possible sequences of performance of the tests.

5. M = f (T = const, P) – determines the minimal set of the tests ensuring the greatest possible probability of the covering of malfunctions at restriction of duration of testing.

6. T = f (P, M = const) – determines number of recurrences of the tests M, that will ensure the greatest possible probability of a covering of malfunctions. Usually such strategy of testing is wiped at tests on reliability of memory modules.

7. P = f (T, M = const) – determines the greatest possible probability of a covering of failures, which is possible to reach at repeated recurrence M of the tests. If the new malfunctions do not come to light, the testing should be stopped.

At performance phase of test diagnosing of memory modules on VLIC it is expedient to apply two strategy of testing performance:

a) Choice of the optimized sequence of the tests on the basis of knowledge of the experts of diagnosing;

b) Minimization of a test set at the expense of application of heuristic and indistinct algorithms.

3. Model of Malfunctions Covering Process of Memory Modules

The process of malfunctions covering process of memory modules is expedient for representing as the probable diagrams of the transitions represented as directed graphs.

Top graphs are the condition of process, when the condition corresponds uncertain condition of object of diagnosing, and top 1,2, …, j, …, m 2-nd corresponds to condition of failure detection 1-st, …, j, m-type accordingly. The arches of the graph correspond to probabilities changes of condition of process of diagnosing.

The process of detection of the first malfunction can be presented, as the column given on fig.1.

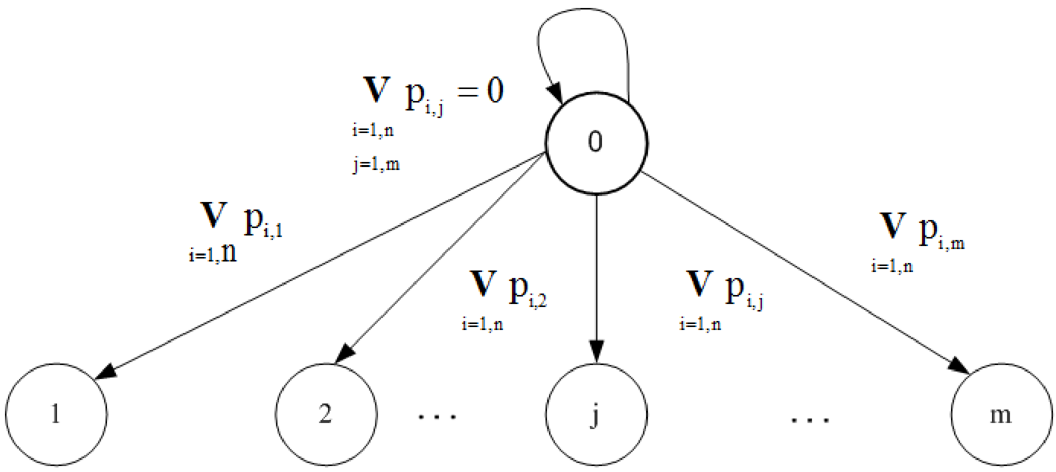


Fig. 1. *Detection of the first malfunction.*

After detection of the first malfunction $j \in \{1,2,...,m\}$ by the test, for example α, calculated the conditional probabilities of a covering of other malfunctions stayed by the tests p_i/p_α by $i \neq \alpha$ The graph of malfunctions of the process of a covering of malfunction of the second type is given on fig. 2.

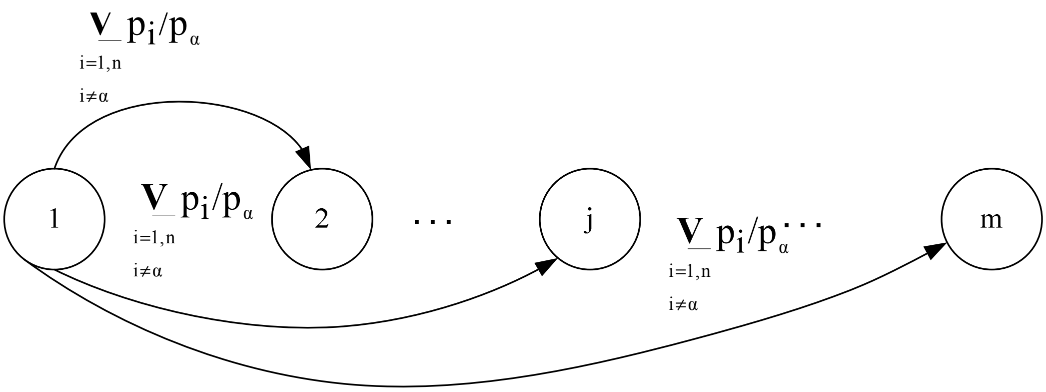


Fig. 2. Failure detection of the second type.

The graphs displaying process of a covering of malfunctions j-th and m-th of types are given on fig.3 and fig.4 accordingly.

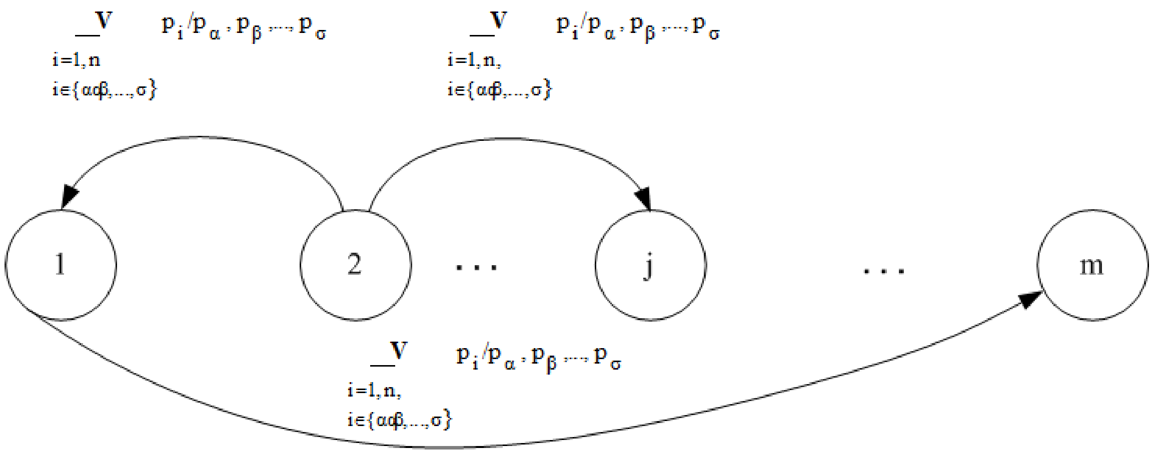


Fig. 3. Failure detection of j-th type

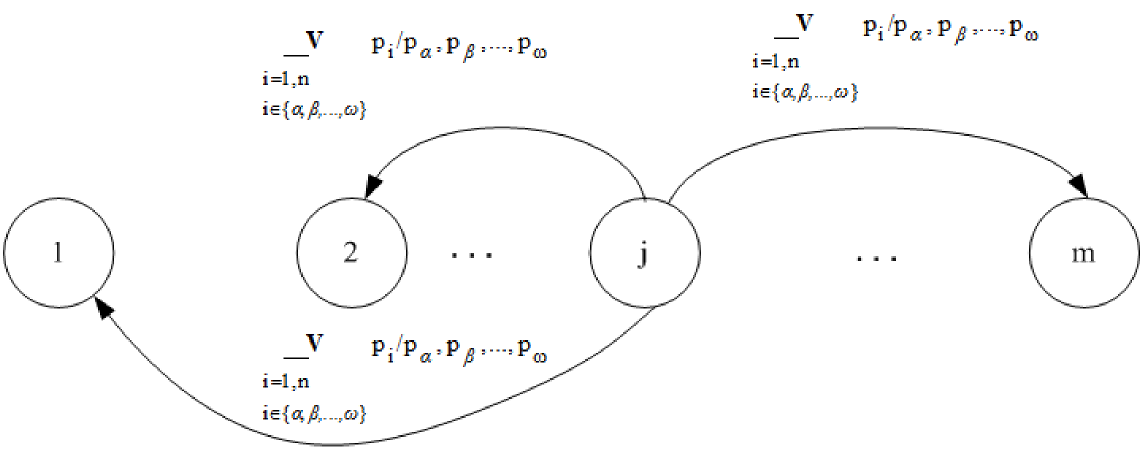


Fig. 4. Failure detection of m-th type.

The account of conditional probabilities of the covering of all possible malfunctions demands the presence of large file of the initial used tests, given about diagnostic abilities. Application of such data is long and expensive procedure, therefore it is expedient to apply to a choice of the optimized set of the tests indistinct algorithms, which can be realized through the tool fuzzy logic.

4. Choice of the Tests Via Indistinct Algorithm Sugeno

The set of terms t = {l, lm, m, hm, h} indistinct variable probability of display of malfunction and probability of a covering of malfunction, resulted in a fig. 5.

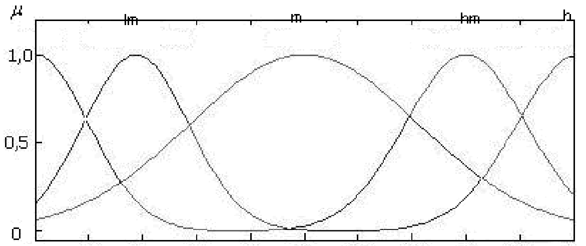


Fig. 5. *Function of accessory of indistinct variables: l – low; lm – below medium; m – medium; hm – is higher medium; h – maximum.*

The functions of accessory of indistinct terms of display and covering of malfunctions can set by Gauss functions of:

$$\mu^t(x) = \exp[-\frac{(x-z)^2}{2c^2}],$$

Where $\mu^t(x)$ - function of an accessory of the factor to x indistinct number t;

z and c – coordinate of a maximum and factor of concentration of function of an accessory.

The target data of expert system with indistinct rules is the set of probabilities:

F = {f1, f2, …, fj, …, fm}.

And set of probabilities of a covering of the given malfunctions by the used tests:

$D_1 = \{d_{1,1}, d_{1,2}, \dots, d_{1,j}, \dots, d_{1,m}\}$,

$D_2 = \{d_{2,1}, d_{2,2}, \dots, d_{2,j}, \dots, d_{2,m}\}$,

….

$D_n = \{d_{n,1}, d_{n,2}, \dots, d_{n,j}, \dots, d_{n,m}\}$,

Results of work of knowledge-based expert systems is the expediency Yi of inclusion i-th of the test in the tests program.

The indistinct logic conclusion of algorithm Sugeno is carried out on indistinct base of rules [5]:

$$\bigcup_{p=1}^{k_j}\left(\bigcap_{k=1}^{m(n+1)} x_k = a_{k,ip} \text{ with weight } w_{ip}\right)^i \rightarrow$$

$$y_i = b^i_{r,0} + b^i_{r,1} \cdot x_1 + b^i_{r,2} \cdot x_2 + \dots + b^i_{r,k} \cdot x_k;$$

where $k = \overline{1,m(n+1)}$ - number of variables of entrances;

$r = \overline{1,s}$ - number of approval.

The base of knowledge of Sugeno is founded on the base of rules d^i_r which are set linear function from entrances:

$$d^i_r = b^i_{r,0} + \sum_{k=1}^{m(n+1)} b^i_{j,k} \cdot X_k.$$

Weight of rules on each step of a choice of the optimized set of the tests will be determined by functions:

$$W^i_{ip} = \frac{1}{\log_{t_{min}} t_i},$$

where t_{min} – the minimal duration of an examined set of the tests, accepts meaning more than 1 at the expense of change of a scale of measurement;

t_i – duration i-th of the test.

Then the rules, which choose the test with the minimal duration, will have a weight W^{max}_{jp} = 1, and other rules will have a weight less than 1.

For each test covering malfunction of a certain type, the base of rules is offered, which is made on the basis of seven functions:

Then the rules, which choose the test with the minimal duration, will have a weight W^{max}_{jp} = 1, and other rules will have a weight less than 1.

For each test covering malfunction of a certain type, the base of rules is offered, which is made on the basis of seven functions:

mf1 = 25f + 25d + 50;

mf2 = 22.5f + 22.5d + 45;

mf3 = 20f + 20d + 40;

mf4 = 12.5f + 12.5d + 25;

mf5 = 5f + 5d + 10;

mf6 = 2.5f + 2.5d + 5;

mf7 = 0.

where f – probability of malfunction display;

d – probability of malfunction covering by the researched test.

Using the given functions, about 25 rules of tests choice are formulated which are given in tab. 2.[6-7]

Table 2. *Rules of expediency of tests inclusion in the program of tests.*

Probability of display of malfunction	**Function of a choice of the test of terms for a variable covering of malfunctions**				
	l	**lm**	**m**	**hm**	**h**
l	mf7	mf7	mf6	mf5	mf4
lm	mf7	mf6	mf5	mf4	mf3
m	mf6	mf5	mf4	mf3	mf2
hm	mf5	mf4	mf3	mf2	mf1
h	mf4	mf3	mf2	mf1	mf1

The structure of expert system for a choice of the optimized set of the tests through indistinct algorithm Sugeno is given on fig. 6.

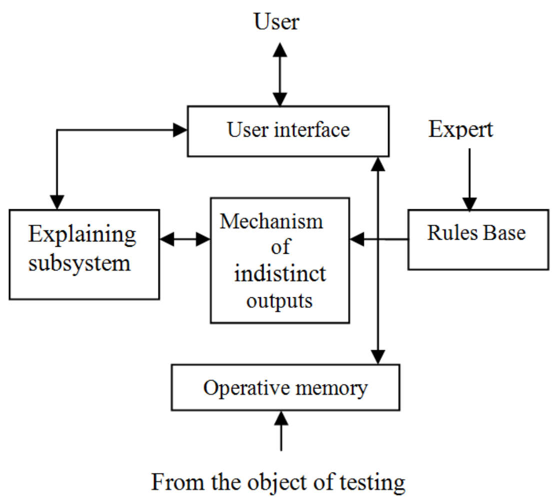


Fig. 6. *Structure of expert system.*

The following sequence of operations for choice of the tests is offered through expert system.

1. The base of rules given in tab. 1 is formed.
2. For each researched test its weight of rules is determined and the respective alterations of rules are carried out.
3. On the given probabilities of display of malfunction and its covering the expediency, inclusion of the test in the optimized set is defined.
4. Then the chosen test is excluded from researched set of the tests and the operations of items 1, 2, 3 repeat if doesn't step restriction on time of testing or the malfunctions of all known types will not be covered.[8]

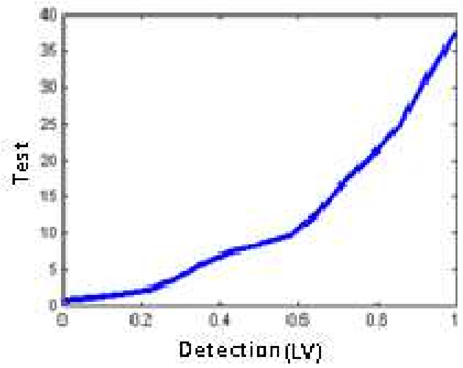
After performance of modelling with use of an indistinct logic outputs on algorithm Sugeno the following meanings in % the expedience of inclusion of the tests in the program of tests given in tab.3 are received.

Table 3. *expediency of inclusion of the tests.*

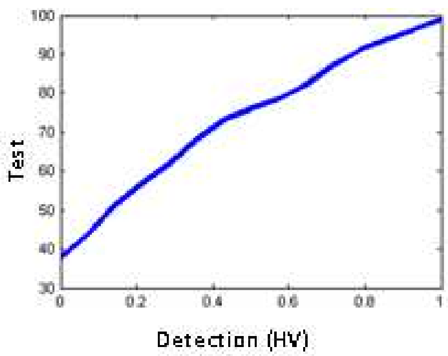
Probability of display of malfunction	Function of a choice of the test of terms for a variable covering of malfunctions				
	l	lm	m	hm	h
l	0.64	1.96	8.21	21.2	37.4
lm	1.96	6.05	15.9	37.5	55.7
m	8.22	16	37.5	63	76
hm	21.2	37.5	63	80.9	91.6
h	37.5	55.7	76	91.6	98.7

At high value of probability (HV) of malfunction display and high value of probability of its covering the expediency of inclusion of the test in the program of tests reaches 98.7%.

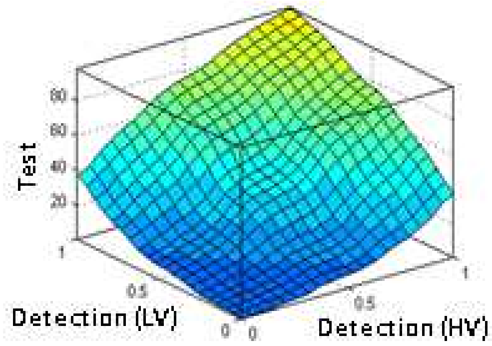
The results of a choice of the tests through expert system with indistinct base of rules are given on fig. 7.[9-10]



a



b



c

Fig. 7. *a – Dependence of expediency of inclusion j-th of the test in the program of tests from probability of display of i-th malfunction, which it covers with low value of probability of malfunction's display; b – Dependence of expediency of inclusion j-th of the test in the program of tests from probability of display of i-th malfunction, which it covers with high value of probability of malfunction's display; c – Dependence of expediency of inclusion of the test in the program of tests from probability of display of i-th malfunction and probability of its covering by the given test.*

5. Conclusions

The offered strategy of diagnosing of memory modules implemented via expert system with indistinct rules raises a degree of automation of procedure of a choice of the effective tests from allowable set. The process of diagnosing adapts for features of tested object, thus the most probable types of malfunctions are taken into account and the most effective tests are applied to their covering.

The expert system based on indistinct rules, is simple in operation and allows using experience of the experts on diagnosing remembering devices. It is recommended to be applied in development of manufacture of new types of microcircuits and memory modules or in changing the technological processes essentially influencing quality of made products.

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