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CONTENTS

POSTER SESSION

COMPUTER SYSTEM EFFICIENT DIAGNOSTICS WITH THE USAGE OF REAL-TIME EXPERT SYSTEMS

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Abstract

The application of the modern methods of evolutional modelling for the efficient diagnostics of computer network on the basis of real-time expert systems is considered in the given article. The usage of Petri network apparatus for the purposes of expert system structure simulation is proposed. The limited Petri nets are considered to be the most effective way of simulation of processes with the binary logic.

Keywords: *Computer Network Diagnostics, Expert System, Fault, Idle Time, Recovery Time, Reliability.*

1. Introduction

During the previous two decades the complexity and operating speed of computers have increased thousands times. The problem which demanded the year of calculations in 1983 can be solved in an hour now, and modern pocket PC is much more powerful than the desk-top one of those days. But we are to pay for the progress and computer systems (CS) improvement. The more complex computer systems become the less steady and reliable they operate. Personal computers buzz regularly, internet sites stop working rather often.

New software which was designed to achieve CS productiveness frequently worsens the situation from the point of view of reliability. As a result, the annual costs on the support and the repairs of CS exceed software and hardware worth for the individuals and for the corporations as well.

The group of Stanford and California Universities (USA) collaborators has elaborated new approach. They assume operator mistakes and operational system faults to be a necessity in the process of complex system functioning. Instead of the attempts to get rid of the defects the developers concentrated on the development of the system being able to restore quickly after emergency. Such an approach was called "recovery oriented computing" (ROC).

By the example of the functioning of the number of Internet sites the possible reasons of their defects were investigated. The mistakes of the operators appeared to be the first reason of the system halt. Traditional measures of software and hardware reliability improvement are figured on the operators' correct actions.

But now in often happens that the system falls out due to their negligence and the time of the system standstill is longer than the idle time caused by the other troubles with hardware and software.

The diagram 1 illustrates the percentage of the typical faults in the work of program-apparatus complexes which provide Internet sites functioning.

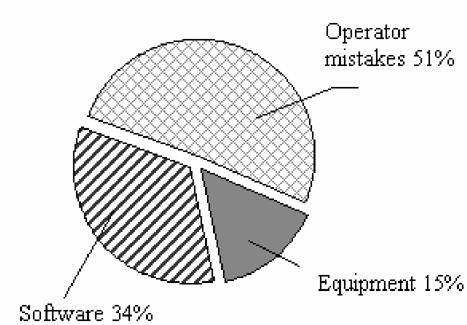

Diagram 1. The Reasons of Web-Sites Faults

2. Problem Statement

Idle time of the CS costs a lot, besides sometimes it is simply inadmissible. The complex possessing the reliability of 'five nines' works 99,999% of time without faults, that means that it stands idle 2 hours during 25 years. Instead of the attempts of errors elimination, ROC adherents try to decrease system recovery after faults. The transition from two ‘nines’ to five allows to keep about 90 hours of working time per year.

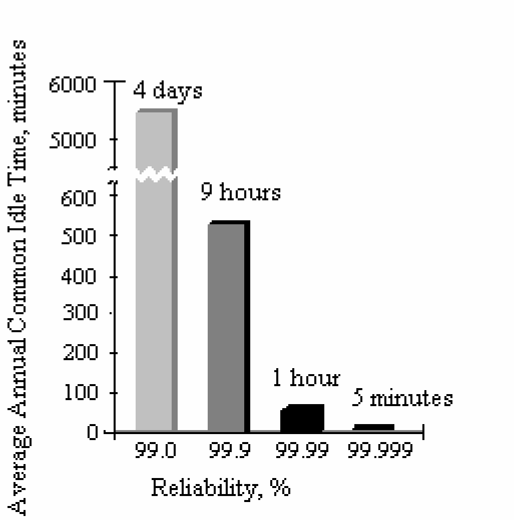

Diagram 2. Complexity in ‘Nines’

Four principles of the ROC – oriented computer system can be formulated on the basis of the complex systems analysis:

– the efficient diagnostics of the current state of the CS which allows detecting fault reasons and location in the automated mode;

– the efficient recovery of the CS operability with the usage of program and hardware-based means provided during the process of CS design;

– while developing new software the programmers are to make provision for the possibility of cancellation of the actions (as it is done in the text editors) to give the operators the opportunity of correction of their mistakes.

– test errors are to be inculcated to the program complex. This will allow to foresee system behavior and teach operators.

So, the first and the most important task is the automated diagnostics of the current state of the computer system fulfilled on the basis of the newest information technologies.

The aim of the present work is the application of the modern methods of evolutional modeling in the purposes of efficient diagnostics on the basis of the real-time expert systems.

3. Problem solution

In general, the existing diagnostics systems (DS) based on the expert systems generally solve the problem of the detection of the fault and its appearance reasons in some CS or the process during information processing. During the process of diagnostics DS correlate the observed violations of the systems behavior with the reasons which caused these violations relying upon one of the following methods. In the first method the table of associative connections between behavior types and the diagnosis is used. In the second one the combined usage of knowledge about the system structure and its unreliable parts, device realization or usable details allows to suppose faults which are compatible with the observed data. The necessity of comprehension of the structure of the systems which are diagnosed is the important specific of such problems. This problem becomes more complicated by the fact that some faults can be masked by the other ones. Besides, it is important to notice that the diagnostic equipment can also distort the registered information. At last, the structure of the system being diagnosed can be unknown or can be represented by the set of not always coordinated particular models. Necessary for the diagnostic process data can be unavailable or expensive or they can be connected with the destruction of the system being diagnosed, and this is one of the main problems of DS creation. And it is necessary to choose the optimal strategy of diagnostic information receipt in each concrete case.

The reduction of down-time and the liquidation of the bottlenecks of the CS with the help of automatic identification of irregular effects and automatic generation of the methods of their decision are the main purposes of DS. The system of expert analysis renders the diagnostic information of three categories:

The symptom is the event in the CS which needs the additional attention of the administrator. (Physical error when addressing to the network node or the single-repeated file transmission, for example). The symptom doesn’t absolutely mean that the partial efficiency loss took place, but it requires administrator regard if the level of periodicity is high.

The diagnosis is the reiterated repetition of the symptom. It needs the compulsory analysis from the direction of the administrator of the network. As usual, the diagnosis describes the situations which characterize serious faults in the computer system (double network address, for example). At the diagnosis stage, the translation of the event leading to the partial loss of efficiency into the language which is understandable to the operator and the administrator takes place.

The explanation is the context-dependent expert conclusion of the analysis system for each diagnosis or symptom. The explanation contains the description of some possible reasons for the existing situation, the reasoning of such conclusion and the recommendations towards their elimination.

The possibilities of supplement of the existing knowledge base by the specific data obtained by the administrator of CS in the process of its usage exist in the system.

But the efficient diagnostics of computer systems requires the solution of the complex of problems in accordance with the qualifying standards of the real-time systems [3]:

1. To represent varying in time data which incomes from the external sources; to provide the storage and the analysis of the changing data.

2. To fulfill temporary argumentation about several asynchronous processes simultaneously (i.e. to plan the handling of the processes got into the system in accordance with the priorities).

3. To provide the mechanism of argumentation in the conditions of the limited resources (time, memory). The realization of this mechanism makes demands of the high speed of the system work and the possibility to solve several problems concurrently (that is, we can use such operational systems as UNIX, VMS, Windows NT, but not MS-DOS).

4. To provide the predictability of system behavior. This will guarantee that each task will be started and stopped in the strict compliance with the time limitations.

5. To model the environment considered in the given application, to provide the creation of its various states.

6. To record its actions and personal actions, to provide the recovery after fault.

7. To provide the filling of knowledge base for the application of real degree of complexity with the minimal costs of time and labour. (The usage of object-oriented technology, common rules and the modularity is necessary).

8. To provide system tuning to the solving problems (The problem or object directivity).

9. To provide the creation and support of user interfaces for different user categories.

10. To provide information security level (according to the user categories) and to prevent the unauthorized access

The construction of the argumentations in the expert system is a rather complex and ambiguous process. The problem becomes more complex if the unstructured sets of data are used as the source information. The construction of the high-speed knowledge base is one of the main problems in this process. The mechanism of Petri nets with some limitations is appropriate to be used as the instrument of modeling of the logical structure of the output procedure. Generally Petri nets (PN) are widely used for the purposes of modeling and investigation of the functioning of dynamic discontinuous systems and processes. It is essential for such problems that unlike other models, PN allow describing dynamic undetermined processes in the complex systems by the establishment of the local connections between the objects and the observation of the changes of the system states. This circumstance lets the expert system designer the means of modeling of the interactive element in the output procedure. At the same time, the classic apparatus of PN has a number of serious lacks, which limit the possibilities of practical problems solution. The problem of determination of some PN marking attainability concerns the tenth Gilbert problem, so it is impossible to tell if the problem of determination of the net liveliness is solvable. This is the most essential of PN lacks. Some specified limitations are imposed upon the solvable problems class to resolve the given situation and to simplify simulation mechanism. This allows distinguishing some subclass with the additional properties among the whole set of Petri nets.

In the work [4] the limited PN are proposed. They can be used in the real-time expert systems with the binary logic when the activity of any of the system component either influences on its state or not. The local structure of output procedure can be represented as the controlled system with the binary logic in the heterogeneous expert system.

To describe the limited PN the following determinations are used.

1. The system A is called the controlled system with the binary logic if it is the set of components with $P = \{p_i\}, i = \overline{1,n}$ various characteristics; each of the components can be in one of the two states: it can be active or not. The set of transition functions from one state to the other is determined on the set $P = \{p_i\}, i = \overline{1,n}$ of components. Each of these functions depends on the number of active components and some system event (internal or external). If there are functions which depend on the interactive input action, the system A is called the interactive controlled system with the binary logic.

2. Component p_i, ingoing into system A is called active at some point of time t if is has an essential influence on the system reaction. Component p_i, ingoing into system A is called inactive at some point of time t if is its presence in the system is inessential while changing the state.

3. The state S_i at some point of time t or the scenario S_i of the system A is a set of active components $S_i = \{p_i{}^k, p_i{}^{k_2}, ..., p_i{}^{k_r}\} \subseteq P$, if is $p_i{}^k$ active and $S_i = \{p_i{}^k, p_i{}^{k_2}, ..., p_i{}^{k_r}\} \subseteq P$, if $p_i{}^k$ isn't active. The transition from the state to a

state is accomplished stepwise by the activation of the other set of components. The process of functioning of such system is undetermined because it is impossible to foresee which set can be activated at I point of time beforehand. This process can be formalized in the view of conceptual model, constructed on the base of Petri net theory.

4. Limited Petri net is a Petri net with the limited marking, i. e. the cortege $N = \{P, T, F, H, M_0\}$, where $P = \{p_i\}, i = \overline{1,n}$ is the set of positions, $T = \{t_i\}, j = \overline{1,m}$ is the set of transitions and $P \cap T = \varnothing;$ are reflections $F : P \to T; H : T \to P,$ assigned by the incidence matrixes $F : P \times T \to \{0,1\}$ and $H : T \times P \to \{0,1\}$, that is $F(p,t) = 1$, if the transition t is incident to the position $p, H(t,p) = 1$, and $p, H(t,p) = 1$, if the position p is incident to the transition $t; M_0 : P \to \{0,1\}$ – the initial marking.

5. The scenario S_i is a marked set of vertexes from the set $P : S_i = \{p_i^{\ 1}, p_i^{\ 2}, ..., p_i^{\ k_r}\}$, where $p^j{}_i \in P$, $S_i \subset P, m^j{}_i(p^j{}_i) = 1$. The scenario S_i is determined by the marking $M_i = \{m_i^{\ 1}(p_1), m_i^{\ 2}(p_2), ..., m^n{}_i(p_n)\}$, which represents the binary set of n bits where the vertex $p_j \in S_i$, if the marking is $p_j \in S_i$, and the vertex $p_j \notin S_i$, if vertex marking is $m^j{}_i(p_j) = 0$.

6. The scenario S_i is called connected by the transition t_k with the scenario $S_j(S^{t_k}{}_i \to S_j)$, if some subset $S^k{}_i$ which consists of the vertexes containing in the scenario $S_i : S^k{}_i = \{p^{k_1}{}_i, p^{k_2}{}_i, ..., p^{k_r}{}_i\} \subseteq S_i$, initializes the activation of some subset of vertexes which go into the scenario

$$S_j : \{p^{m_1}{}_j, p^{m_2}{}_j, ..., p^{m_s}{}_j\} \subseteq S_j, .$$

7. The net which was produced by the transition t_k of the scenario Si with the scenario Sj which are determined on the set of all available scenarios, is called the primitive limited Petri net. It is described by the statement $P = S_i \cup S_j, T = \{t_k\}$. Incidence functions form in the following way:

$$F : P \times T \to \{1\} \forall p \in S_i, P \times T \to \{0\},$$

$$\forall p \in S_j \setminus S_i \cap S_j, H : T \times P \to \{0\},$$

$$\forall p \in S_i \setminus S_i \cap S_j, T \times S \to \{1\}.$$

The initial mark is $M_0 : P \to \{0,1\} : m^k{}_0(p_k) = 1$, if $p_k \in S_i$, and it is $m^k{}_0(p_k) = 0$, if $p_k \in S_j$.

8. Limited Petri net is a Petri net produced by the set of symbols – transitions T on the set of scenarios S.

4. Conclusion

The offered mechanism of limited Petri nets is one of the possible methods of modeling of dynamic undetermined structures and processes, as it possesses the following properties: the possibility of definition of the set of operations over the class of distinguished nets; the liveliness and the finiteness of the constructed structure with the help of input operations.

Generally the limited Petri net allows constructing the algebra for the adequate logic simulation of processes with the binary logic. It is expeditious to distinguish the given class of nets possessing some special features which are essential for the considered problems. These features allow to define the set of operations for the construction of the nets out of the subnets and the primitives and to fulfill the preliminary analysis of the obtained nets. This gives the basis for the design of the mechanism of the logical structure simulation and the controlling of the processes in the dynamic undetermined systems of CS diagnostics.

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