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The main target of the **IEEE East-West Design & Test Symposium** (EWDTS) is to exchange experiences between scientists and technologies of Eastern and Western Europe, as well as North America and other parts of the world, in the field of design, design automation and test of electronic circuits and systems. The symposium is typically held in countries around the Black Sea, the Baltic Sea and Central Asia region. We cordially invite you to participate and submit your contributions to EWDTS'14 which covers (but is not limited to) the following topics:

- Analog, Mixed-Signal and RF Test
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- ATPG and High-Level Test
- Built-In Self Test
- Debug and Diagnosis
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- Design for Testability
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- Digital Satellite Television

The symposium is organized by Kharkov National University of Radio Electronics, National Pedagogical Dragomanov University and Science Academy of Applied Radio Electronics http://anpre.org.ua/ in cooperation with Tallinn University of Technology.

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Expert evaluation model of the computer system diagnostic features

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Abstract

In this paper, the expert diagnostic system (EDS) is suggested to be used for the analysis of the computer system's technical state. The mathematical apparatus that allows to operate the expect assessment of the diagnosis object's state (hardware, software or staff) is fuzzy logic. In the preparation stage of the diagnostic experiment (DE) it is proposed to describe the diagnostic features of the computer system in terms of linguistic variables, which makes it possible to use the knowledge and experience of the expert in their familiar form.

1. Introduction

Any modern computer system's (CS) information processing and management, regardless of the scope of its use, can be represented by a set of hardware, software (SW) and staff. Failures in hardware can lead to the generation of a false signal, which is fed to the input of software components. This can lead to the failure of the software. In such critical (emergency) situations the staff also often makes mistakes. The incorrect actions of the latter, in turn, can provoke failures and errors in the hardware or software. Thus, an error, occurring in a single component, can lead to the failure of the entire CS.

2. Problem definition

The functioning quality of the CS is determined by its technical state and is directly dependent on the state of all three components. The process of determining the system state, called the technical diagnosis, applies the construction of a mathematical model of the diagnosis object (DO). This model is a set of the mathematical object descriptions and all of its incorrect modifications. The set of incorrect technical states of the DO, in turn, is determined by the dictionary of defects – a list of physical defects, leading to the disruption of the CS functioning. In this case, diagnostic experiment (DE) requires the presence of the binary standard of the DO correct functioning. This approach is traditional for structural-functional diagnosis of the digital device's components. However, in the case of the CS, such approach is only partially applicable to the hardware [1], its use in the software diagnosis is almost impossible [2] and it absolutely doesn't apply in the diagnosis of the staff's qualifications [3].

Thus, the aim of this work is to develop a unified model of the expert evaluation of the technical state for any CS component (whether hardware, software or staff) to further quantify evaluation of the functioning quality of the entire system in whole.

3. Expert diagnostic system

Due to the complexity and variety of the CS components and the lack of binary standards of their correct functioning, evaluation of the CS technical state often uses expert diagnosis [4]. The expert diagnosis method implies the definition of the DO state, based on the qualitative information from the experts. In this case the dictionary of defects is replaced by a set of diagnostic features (DF), which describe the technical state of the CS components. Then, some critical values of the DF are considered as models of the failures. For example, if the speed of data transmission in a local area network (LAN) with a nominal value of 100 Kbit/s is considered as DF, then the speed drop below 50 Kbit/s can be regarded as a sign of a faulty state of the LAN.

Thus, the model of the failure is replaced by the model of the DF evaluation, which, in turn, depends on the following factors:

– physical (logical) characteristics of the DF;
– the level of expert knowledge about the evaluated DF;
– tools of the decision making support about the diagnosis result.

The model of the DF evaluation shouldn't require from the expert unnecessary details what will not give benefits but will complicate the work of the expert. This approach allows to use fuzzy logic and fuzzy inference procedures using linguistic variables (LV) as a mathematical apparatus of the expert diagnosis. In this case it is necessary to strive for unifying of the models (terms) of the LV for various DF of the CS components.

The structure of such EDS is shown in Fig. 1. As a model of knowledge representation is proposed to use a production model (PM), which has several advantages: visibility; modularity (individual production rules can be added to the knowledge base, removed or changed independently of the other, allowing to automate their design), ease of making additions and changes; ease of inference [5].

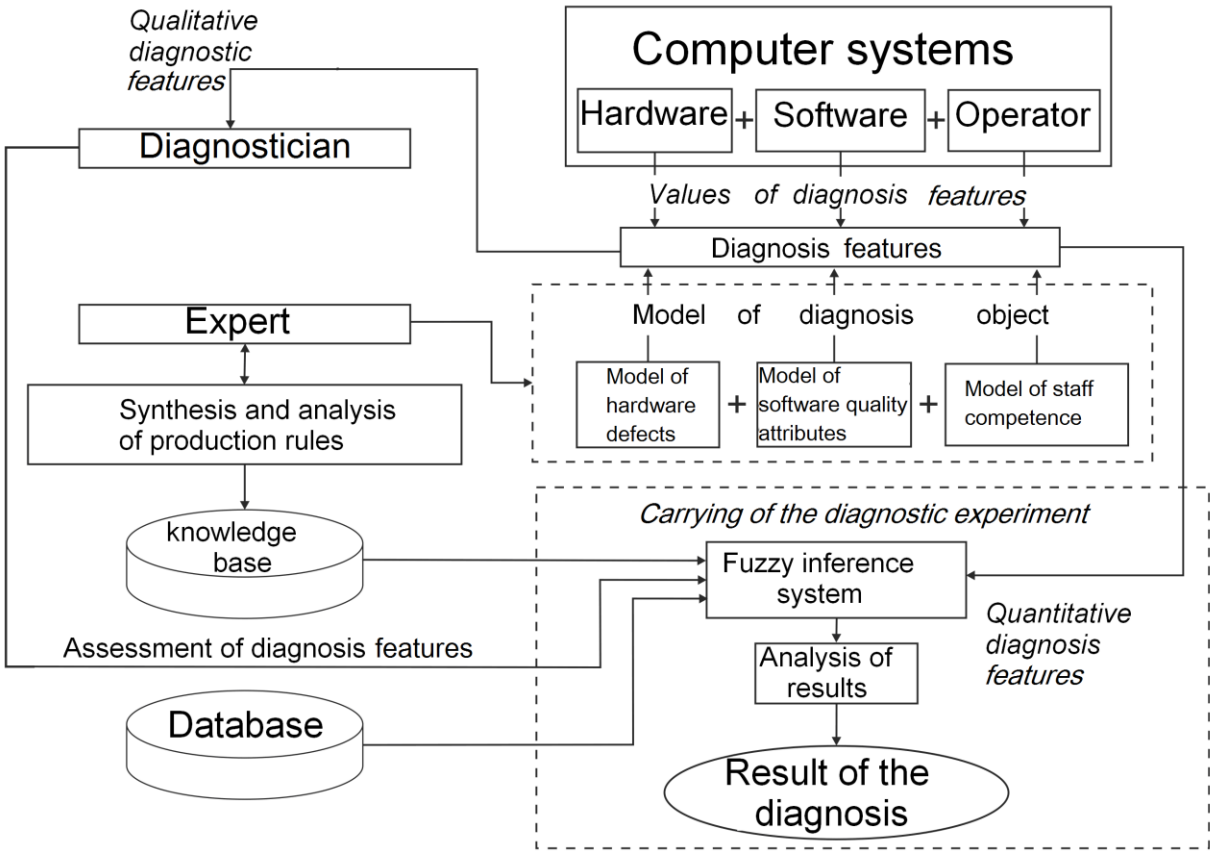

Fig. 1. Structure of the EDS

As can be seen from Fig. 1, to ensure the correctness of the entered knowledge EDS must contain an additional block of their synthesis and analysis.

If we talk about models of faulty CS states (the results of the DE), they, as a rule, are determined by the values of the operation parameters of the CS, which are specified by the normative documents. In the process of the expert diagnosis these faulty states are transformed by the expert to the values of the output LV (or vice versa). And the result of the diagnosis is determined by the EDS, which is based on fuzzy inference (Mamdani algorithm).

4. Evaluation model of the CS technical state

Based on the goal, DF choice, describing the technical state of the DO (DE preparation), is the most important task during the expert diagnosis. Participants of the diagnostic experiment (DE) are not only expert and diagnostician, but also a man who is interested in the quality of its functioning. It can be the owner of the CS, operations duty officer, chief engineer, etc. We will call it the customer. Thus, each of the DE subjects is responsible for one or another of its stage.

1. Customer – initiates the DE, determines the frequency of the carrying, the order and nature of the results.

2. Judge – forms the knowledge base; creates a mathematical model that describes the technical state of the DO, by selecting the diagnostic features.

3. Diagnostician – evaluates the DF in terms of the model proposed by the expert, physically carries DE using tools to obtain results of the diagnosis for further transmission to the customer.

Thus, the evaluation model of the DO technical state is reduced to the following stages.

1. DF choice, their quantities and weights. Is defined by the customer together with the diagnostician.

2. The choice of the evaluation levels number (evaluation ranges) for the input DF and for result of the diagnosis. In a fact, it's model preparation of the CS technical state and methods of its evaluation. Is defined by the diagnostician together with the customer.

3. The choice of the numerical boundaries of the evaluation for each DF and the result of diagnosis. Is defined by the diagnostician together with the expert and the customer.

4. Normalization of the estimates in accordance with the adopted pattern of the evaluation, which takes into account all (universal within the linguistic variables) range of DF values. Is defined by the diagnostician together with the expert.

5. Assignment of the membership functions for given range (using fuzzy logic). Is defined by the expert.

6. Preparation of the evaluation models (base of the production rules) and production rules (PR) analysis for correctness. Is defined by the expert together with the diagnostician.

7. Creation of the evaluation pattern in the specified range for the expert. Is defined by the diagnostician together with the customer.

8. Decision making about the results of diagnosis using the tools of expert evaluation and knowledge base in the form of PR. Is performed by the diagnostician together with the customer.

Thus, in the framework of the chosen model of the DO the diagnostician must perform the evaluation, i.e. produce quantitative or qualitative measurement of the relevant features. Evaluation of the quantitative feature reduces to the indication of the corresponding numerical value or an interval in which, according to a diagnostician's opinion, the value of the evaluated feature lies.

Often the specific of the objects expert evaluation is such that for the diagnostician it is difficult to give quantify estimate for the values of the evaluated DF, and in some cases, these estimates don't provide sufficiently reliable expert information. In such situations, we are talking about quality DF, for expert evaluation of which verbal-numerical scales can be used. This scale represents names of gradations which have to be meaningfully described, and corresponding numerical values or ranges of numerical values for each gradation.

For preservation of the uniformity during quality evaluation of the all CS components functioning and the minimum load on the expert in terms of the evaluation results scaling, let's apply a minimum three-level quantile standardization of the DF evaluation results: "high", "medium (sufficient)" and "low". By analogy, let's define for diagnosis result evaluation five-level grading: "very low", "low", "medium", "sufficient", "high".

Let's consider examples of selecting diagnostic features during expert analysis of all three CS components.

5. DF selection during the analysis of the CS hardware state

According to [6], various types of the CS hardware failures are characterized by the following features which describe the state of the defect: the region of the failures occurrence, change the parameters during the failure, the nature of the failure existence in time, detection ability, conditionality by other failures (dependence), the ability to restore functionality after failure, the cause of the failure, the severity of the consequences.

Each of the failure characteristics can be qualitatively described by a three-level gradation of the values [7] within a 100-point scale. The distribution of the values on the scale is subjective with subsequent approximation of any known mathematical function.

Thus, the technical state of the CS hardware will be determined on a 100-point scale by the presence of the some force failure, which in turn depends on the values of the features listed above.

6. DF selection during the analysis of the CS software state

International Standard ISO/IEC 9126:2001 [8] for any class of software defined universal set of six quality attributes:

– Functionality is the capability of the software to provide functions which meet the stated and implied needs of users under the specified conditions of usage.

– Reliability is the capability of the software product to maintain a specified level of performance when used under specified conditions.

– Usability is the capability of the software product to be understood, learned, used and attractive to the user under specified conditions.

– Efficiency is the capability of the software product to provide appropriate performance, relative to the amount of resources used, under stated conditions.

– Maintainability is the capability of the software product to be modified. Modifications may include corrections, improvements or adaptation of the software to changes in environment, and in requirements and functional specifications.

– Portability is the capability of the software product to be transferred from one environment to another.

Selecting some attributes (DF) for farther analysis, it is necessary to construct a verbal-numerical scale, where the quality characteristics ("low", "medium", "high") are assigned a range of the numerical values. Boundaries of the values intervals for each DF are selected by experts on the basis of the feature semantic load, and then normalized to a 100-point scale. Thus, the quality of the CS software is determined by the set of DF estimates.

7. DF selection during the analysis of the CS user competence

Expert quality evaluation of the CS hardware and software will not give a complete picture of the quality of the whole system. This comes from the fact that, regardless of the complexity of the CS, the man remains one of the main elements of the system "man – machine". He sets goals for the system, plans, directs and controls the entire process of its functioning. Quality functioning directly depends on his activities, which in turn is characterized by infallibility (correct) solution of problems faced by the user of the CS. The last depends on the competence level of the CS staff in the field of information technology.

In the conditions of society informatization, a CS's user must possess not only a set of knowledge, skills and abilities, but also be able to apply them to solve a range of professional tasks, i.e. possess information-communication-technology competence (professional ICT-competence).

Professional competence is a combination of knowledge, skills and methods of their application, which allows the person to perceive and process information in his subject area, comprehend the nature of relationships between objects of professional activity and make appropriate decisions in a variety of standard and non-standard situations [9].

The analyzing process of CS user' competence can be considered as a diagnostic experiment with special qualification tasks (QT), which check the level of knowledge and skills of CS user, as well as its ability to respond to various situations that arise in the course of the CS work. DE of competence analysis consists of the preparation of special QT and reference (correct) reactions, a process of testing and comparing responses (decisions) with a standard and the ongoing decision about the test result.

During QT preparation, three-dimensional model of the ICT-competence, which consists of an object measurement (need to know), the activity measurement (which should be able to) and practical measurement (how to use the acquired knowledge and skills in the design and operation of CS) is used [10].

Tasks, which used during diagnostic experiment, can be of various shapes, some of them are difficult to accurately quantify (tasks with detailed answer). The evaluation of this type QT is difficult task, since the degree of the evaluation correctness and grading of the implementation degree – the characteristics to a greater extent subjective. They can only be determined by an expert (expert group).

Thus, the expert should select the appropriate DF (evaluation criteria) for each QT and EDS will determine the degree of task correctness.

8. Conclusions

As a tool for the analysis of the computer system's technical state as a combination of hardware, software, and staff proposed to use an expert diagnosis which bases on the rules and procedures of fuzzy logic. This EDS from the same position allows considering hardware failures, software error, and the competence level of the CS user for a comprehensive assessment of the functioning quality of the whole system.

A representation model of the diagnostic features for various components of the computer system in the form of linguistic variables was developed. Despite the different nature of the diagnosis objects, all diagnostic features are combined by a single space of the evaluation – the same number of terms for the inputs LV (three) and output LV (five), and 100-percent scale of its measurement. This is allows to use a unified approach to the knowledge base formation in the expert diagnosis system.

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