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EWDTS 2011 CONTACT INFORMATION

Prof. Vladimir Hahanov
Design Automation Department
Kharkov National University of Radio Electronics,
14 Lenin ave,
Kharkov, 61166, Ukraine.

Tel.: +380 (57)-702-13-26
E-mail: hahanov@kture.kharkov.ua
Web: www.ewdtest.com/conf/

9th IEEE EAST-WEST DESIGN & TEST SYMPOSIUM (EWDTS 2011)

Sevastopol, Ukraine, September 9-12, 2011

The main target of the IEEE East-West Design & Test Symposium (EWDTS) is to exchange experiences in the field of design, design automation and test of electronic circuits and systems, between the technologists and scientists from Eastern and Western Europe, as well as North America and other parts of the world. The symposium aims at attracting attendees especially from the Newly Independent States (NIS) and countries around the Black Sea and Central Asia.
We cordially invite you to participate and submit your contribution(s) to EWDTS'11 which covers (but is not limited to) the following topics:

- Analog, Mixed-Signal and RF Test
- Analysis and Optimization
- ATPG and High-Level TPG
- Built-In Self Test
- Debug and Diagnosis
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- Object-Oriented System Specification and Design
- On-Line Test
- Power Issues in Testing
- Real Time Embedded Systems
- Reliability of Digital Systems
- Scan-Based Techniques
- Self-Repair and Reconfigurable Architectures
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- CAD and EDA Tools, Methods and Algorithms
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- Thermal, Timing and Electrostatic Analysis of SoCs and Systems on Board
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- Digital Satellite Television

The EWDTS'2011 will take place in Sevastopol, Ukraine. Sevastopol is a port city, located on the Black Sea coast of the Crimea peninsula. The city, formerly the home of the Soviet Black Sea Fleet, is now home to a Ukrainian naval base and facilities leased by the Russian Navy and used as the headquarters of both the Ukrainian Naval Forces and Russia's Black Sea Fleet.
The symposium is organized by Kharkov National University of Radio Electronics in cooperation with Sevastopol National Technical University and Tallinn University of Technology. It is technically co-sponsored by the IEEE Computer Society Test Technology Technical Council (TTTC) and financially supported by Virage Logic, Synopsys, Aldec, Kaspersky Lab, DataArt Lab, Tallinn Technical University, Cadence.

CONTENTS

Competence as a Support Factor of the Computer System Operation

Krivoulya G., Shkil A., Kucherenko D.
Design Automation Department, Kharkov National University of Radioelectronics,
14, Lenin Ave, Kharkov, 61166, Ukraine,
E-mails: krivoulya@i.ua, shkil@opentest.com.ua, d_zin@ukr.net

Abstract

In this paper the issue of the computer systems users' competence analysis as one of its failing causes was considered. For this purpose the competence model for the analysis of witch it is necessary to carry out the diagnostic experiments, where the qualifying tasks will be open form tasks with a detailed answer, was proposed. In order to evaluate these tasks the mathematical apparatus of fuzzy logic was proposed to use. In this paper a justification of the operating fuzzy inference algorithm was given, and the model of condition-action rules composition was proposed.

Keywords: ICT-competence, diagnosis experiment, qualifying task, fuzzy logic, condition-action rule.

1. Introduction

In the past two decades, computer systems (CS) has been extensively implemented to the management of the complex technical objects, such as process control systems and power plants control systems, environment control systems and object detection systems, vehicles control systems, power distribution systems, etc. Regardless of the technical control object complexity human remains the main link in the man-machine systems (MMS). He defines the goal, plans, directs and controls of the whole process of the MMS's functioning. The correctness of the CS operation which characterizes the faultless (accuracy) of decision problems faced by CS's users depends on his activity.

One of the main reasons of CS falling is user errors which depend on the level of their professional competence in the information and communication technologies (ICT - competence). ICT competence can be defined as the specialist capacity to make the best use of the available hardware and software of the information and communication technologies. At the same time user performs a specific professional function (or several functions), which directly represents one of the components of the overall specialist qualification and is reflected in the developed standards, qualifying requirement, etc. [1].

2. Diagnostic experiment

The process of computer systems users' competence analysis can be considered as a diagnostic experiment (DE) in the MMS, during which special qualifying tasks (QT) are used to test the level of the knowledge, skills and abilities of CS's user, as well as its ability to adequately respond to the various situations that appear on-stream of the CS. The DE of the competence analysis consists of the special QT preparation and the reference (right) reactions of users, the process of testing and responses (decisions) comparing with the standard, and then making a decision about the test result (Fig. 1).

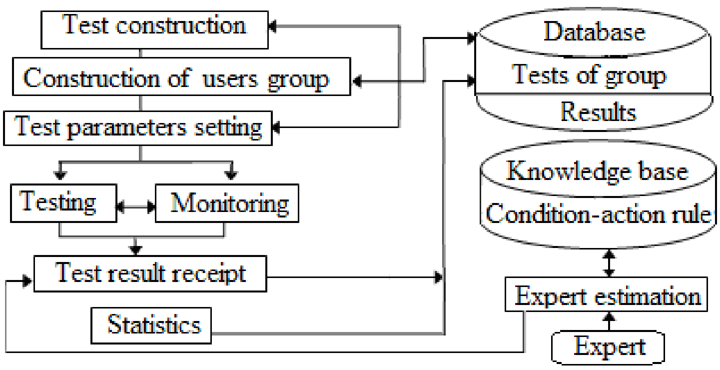

Fig. 1. The structure of the diagnostic experiment for the competence test

If leave out of account the possibility of the natural experiment using the real hardware, and limit oneself to modeling MMS, then this DE on the face of it looks like a classic testing. But the DE of the competence analysis at the same time has significant differences from the classic testing:

1. Generally testing checks the level of received and assimilated knowledge. The competence analysis is a wider process and checks the user's ability to apply their knowledge, skills and abilities in many academic disciplines to the standard and non-standard modes of CS operation.

2. The special forms of test tasks are used for testing [2], while for the competence analysis, except test tasks, examination tasks for the general and specific skills and abilities can be used. It is difficult to attribute such tasks to one of the most common forms of the test tasks. These tasks by their form and didactically load similar to the open form tasks with a detailed answer, which are used in the modern external independent assessment in Ukraine [3].

3. The formal procedures which are used for the test tasks assessment can be easily automated, but for the tasks assessment for the competence check it is impossible to manage without an expert (an expert systems), because it is very difficult to assess the open form tasks with a detailed answer by the formal matter.

3. Competence model

In accordance with the paradigm of competency-based education, each form of key competences, in particular ICT-competence, has three dimensions: subject dimension (what you need to know), activity dimension (what you should be able to) and practical dimension (in particular, how to use the acquired knowledge and skills during CS operating) [4].

The following structure of the ICT-competence categories is proposed:

1. Subject dimension: information, technical, technological, algorithmic competences, network and telecommunication competences, methodological and research competence, competence in the information security.

2. Activity dimension: algorithmic (S1), technological (S2), technical (S3) and research competences (S4).

3. Practical dimension: communicative (A1), interconnecting (A2), operational (A3) and diagnostic competences (A4).

Subject dimension is taken as a basic during the ICT-competence model composition and four-level hierarchical domain model, which defines the structure of the subject competence, is used for this: "the category of the competence" → "the name of the chapter" → "the name of the topic" → "tasks of the topic". In accordance with knowledge domain, a model of the test database of qualifying tasks in different shapes, which are used during the diagnostic experiment (a diagnosis session), is generated. The main form of the QT is open form tasks with a detailed answer.

In accordance with the ICT-competence structure, a set of the QT within the range of the single topic can be represented as a two-dimensional space of dimension {4x4} ({S1, S2, S3, S4; A1, A2, A3, A4}). According to this approach, each topic of subject dimension should be covered by minimum of 16 tasks (excluding various levels of the QT difficulty). The composition of such number of the tasks for each topic is extremely time consuming, and the size of a diagnosis session in the diagnostic experiment of the ICT-competence analysis will be prohibitive and practically impossible. In the diagnostic session for minimization of a tasks number, let's assume that each QT checks for more than one competence with the different degrees of the coverage (covers two or more point of two-dimensional space). To calculate the degree of the coverage, let's use fuzzy logic [5].

Let's assume that the input coordinates of competence are fuzzy variables (8 variables S1, S2, S3, S4, A1, A2, A3, A4), each of which contains three terms {"low" (L), "average" (A), "high" (H)}. The range limit of the terms (values) in the terms of 100 - point scale will be: "L" – {0 - 40} points; "A"– {30 - 70} points; "H" – {60 - 100} points.

An expert (several experts) for each task assigns the appropriate values of the "material coverage" for all variables from the specified range ($C^{S}_{i,j}$ – for the activity dimension and $C^{A}_{i,j}$ – for the practical dimension). Thus, for each task a tuple (vector) of 8 values is formed, which characterizes each task in terms of the "material coverage". If the "material coverage" for the certain task is determined based on opinions of several experts, then the final coverage is determined by averaging (as arithmetic mean) estimates of various experts for the relevant fuzzy variables. This approach depends on the fact that an opinion of each expert is an independent event, and these assessments do not influence each other.

In addition to the integral "material coverage" estimate and according to each dimension each task has three statistical characteristics: difficulty (D), coefficient of differentiate ability (coefficient of discrimination K_D), and Pearson correlation coefficient (R_{xy}) between the results with respect to this task and to the test in whole [6].

Subject to the inserted parameters the integral estimate of the competence for each task and topic is calculated as $C_i^S = \bigcup_{k=1,4}^{rules} C_{i,\kappa}^S$, where $\bigcup_{k=1,4}^{rules}$ – condition-action rules, $C_{i,\kappa}^S$ – values of fuzzy variables of the competence coverage for the activity dimension. The similar formulas are also used for the practical dimension. The integral estimate for the topic as a whole for each competence variable is calculated $C^{S1} = \max_{i=1,M} \left| C_i^{S1} \right|$, where M – the number of tasks in the topic. The similar formulas are used for all 8 variables of the activity and practical dimension of the competence (Fig. 2). The expert "coverage" estimate presents difficulties for the subject component of the competence. It is caused by the reason that the topical breakdown of verifiable material inside the chapter is not fixed and can change from one DE to another. Therefore, with some degree of conditionality, let's assume that "material coverage" for the subject dimension of the competence depends on difficulty of the QT and has the following values for different difficulty levels: for hard tasks ($0{,}2 < T_i(H) \le 0{,}4$) $C_H^{Kn} = 70$, for intermediate ($0{,}4 < T_i(A) \le 0{,}6$) $C_A^{Kn} = 50$, and for easy – ($0{,}6 < T_i(L) \le 0{,}8$) $C_L^{Kn} = 30$.

The diagnosis session during the DE is formed so that from each topic of the subjective dimension tasks from three levels of difficulty (hard, intermediate and easy) with a maximum "verifiable material coverage" should be included to the diagnosis session. The structure of the diagnosis session for tasks of the j-th topic for the subjective dimension of the competence is shown in Figure 3. The developed methodology of the preparation and conduction of the DE for analysis of CS's user competence, enable to get onto the automation of this sufficiently complicated and informal process. The proposed "material coverage" estimation system by the QT of various forms allows shaping an optimal diagnostic session in terms of the "material coverage", difficulty and differentiating ability of the QT. This approach allows us to obtain not only a formal estimate of a diagnosis session, but also an estimate of the volume of the material on which a test of CS's user competence was conducted.

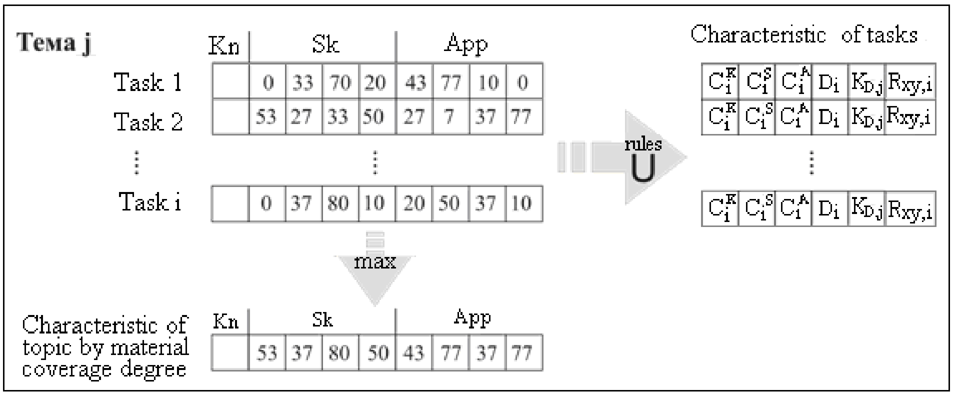

Fig. 2. The integral estimate "material coverage" for each task and for the topic

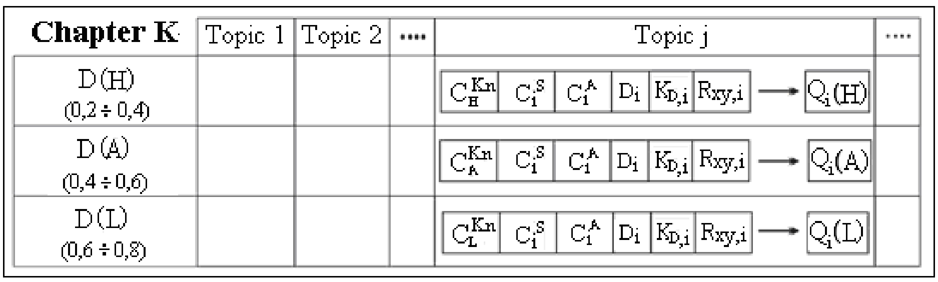

Fig. 3. The structure of the diagnosis session

4. Fuzzy logic for the qualification tasks assessment

The difficulty of the problem solving of the QT assessment as the open form tasks with a detailed answer is that the degree of the tasks performance correctness and the gradation of the implementation degree can determine only an expert (an expert's group). In addition, during the formation of the assessment scale there is a high fraction of a subjectivism, since it depends on a large extent on experience, intuition, expertise and professionalism of the expert. Experts, during the QT performance assessment, essentially, use the concepts of the natural language, which is also more understandable for users. In terms of the user fuzzy assessment of his competence as levels "high", "sufficient", "low" and etc. is clearer than crisp points which he scored as a result of the DE. It is precisely this fact that determines usage of fuzzy logic [7] as a mathematical tool during the results assessment of the QT performance.

The following models of fuzzy inference are the best known: Mamdani, Sugeno, Larsen, Tsukamoto. The fuzzy inference algorithms are differed in the view of using logical operations and defuzzification method, and the model selection is determined, essentially, by the nature of current tasks. In our case, the final assessment of user's competence will be assessed on the basis of the expert estimates of the separate criteria. In addition to that the assessments of all criteria are in the same range and don't require scaling (there is no need to apply the Larsen model), all membership functions are homogeneous (there is no need to apply the Tsukamoto model), the result of fuzzy rules computing is simple fuzzy set which elements are not computed using a special functional (there is no need to apply the Sugeno model). Thus, in this paper the algorithm of fuzzy inference Mamdani was adopted as the basic algorithm. It is necessary to take this into account at the stage of tasks formulation by separation of the appropriate criteria assessment and determination of the scores ranges for the criteria. In order to present expert assessment about the degree of the tasks performance correctness at one of the chosen criteria assessment, let's introduce the linguistic variable < CRITERIA ASSESSMENT > (<CA>), which contains three terms {"low" (L), "average" (A), "high" (H)}. The range of the linguistic variable values <CA> E = {0 - 100} points. The standard symmetric Gaussian function is used as the membership functions (the function *gaussmf* in the fuzzy inference package Fuzzy Logic Toolbox), which is given by $\mu(x) = e^{-\frac{(x-M)^2}{2\sigma^2}}$, where σ – the slope coefficient (standard deviation) , M – the center (average value). The parameters of the terms for this function are presented in the Table 1.

A graphical representation of introduced membership functions in the visual window of Fuzzy Logic Toolbox package of mathematical system Matlab 7.5 is shown in Figure 4.

Table 1. Uniform distribution terms over the range of E values

Terms	Ranges		Width	M	σ
L	0	40	41	20	10,25
A	30	70	41	50	10,25
H	60	100	41	80	10,25

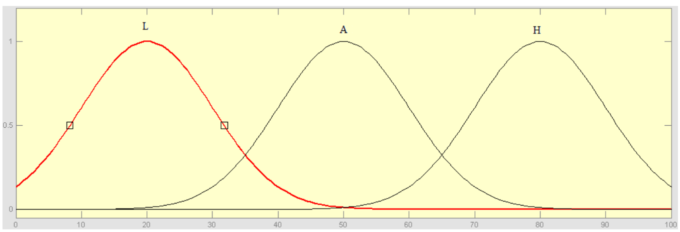

Fig. 4. The membership functions of variable <CA >

By analogy, let's introduce the output linguistic variable <TASK ASSESSMENT > (<TA>), and define for it five-level scales of the task performance correctness (five terms) {"very low" (VL), "low" (L), "average" (A), "sufficient" (S), "high" (H)}. The range of the linguistic variable values <TA> E = {0 - 100} points. The limits of the data values ranges of the terms can be fixed or determined by experts for each task and trial separately.

One of the key factors which influence on the final grade scaling is the shape of the distribution of primary diagnosis results over the range of the assessment scale. In carrying out of the educational measurement the frequency distribution of sign display over the certain interval (the number of users, who got the mark in the certain range) is considered as symmetrical distribution with a pronounced “central tendency”, which is mathematically described (approximated) by the normal law curve [8]. For the linguistic variable <TA> the limits of the ranges (terms) are also subordinate to the “central tendency” that is “width” of the terms are not equal and narrows to the center of the assessment scale. The limiting value of the “central tendency” is the quintile standardization of the normal distribution (5 parts, $M = 50\%$ and $\sigma = 16{,}7\%$). Three variants of the terms limits of the linguistic variable <TA> are given in the Table 2. Variant 1 correspond to the uniform distribution with parameters $M = 50$ and $\sigma = 7.75$, variant 2 – the normal distribution with parameters $M = 50$ and $\sigma = 25$, and variant 3 – the distribution with the parameters $M = 50$ and $\sigma = 18$. In our view it is preferable to use the variant 3, as the closest to the quintile standardization.

The membership function for the variant 3 of the limits of terms ranges of the linguistic variable <TA> is shown in the figure 5.

Table 2. The limits of the terms range for variable <TA>

Terms	Variant 1					Variant 2					Variant 3				
	Ranges		Width	M	σ	Ranges		Width	M	σ	Ranges		Width	M	σ
VL	0	25	26	12,5	6,5	0	30	31	15	7,75	0	35	36	17	9
L	15	45	31	30	7,75	20	45	26	33	6,5	27	47	21	37	5,25
A	35	65	31	50	7,75	40	60	21	50	5,25	44	56	13	50	3,25
S	55	85	31	70	7,75	55	80	26	67,5	6,5	53	73	21	63	5,25
H	75	100	26	87,5	6,5	70	100	31	85	7,75	65	100	36	83	9

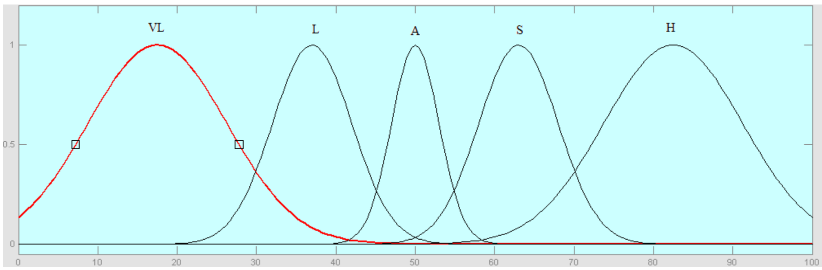

Fig. 5. Variant 3 of the membership functions of the variable <TA>

In the Mamdani model the relationship between inputs $X = (x_1, x_2, \dots, x_n)$ and output y mathematically is determined by the fuzzy rule base on the following format (4.1):

$$
\begin{array}{ll}
 & \{x_1 = a_{1,j1}\}\ \text{AND}\{x_2 = a_{2,j1}\}\ \text{AND} \cdot\cdot \text{AND}\{x_n = a_{n,j1}\}\quad \text{OR} \\
 & \{x_1 = a_{1,j2}\}\ \text{AND}\{x_2 = a_{2,j2}\}\ \text{AND} \cdot\cdot \text{AND}\{x_n = a_{n,j2}\}\quad \text{OR} \\
\text{IF} & \dots\dots\dots\dots\dots\dots\dots\dots\dots \quad \text{OR} \\
 & \{x_1 = a_{1,jk_j}\}\ \text{AND}\{x_2 = a_{2,jk_j}\}\ \text{AND} \cdot\cdot \text{AND}\{x_n = a_{n,jk_j}\} \\
\text{THEN} & y = d_j, j = \overline{1,m},
\end{array}
\tag{1}
$$

where $a_{1,jp}$ – the linguistic term, which is evaluated by the variable x_i in the line with the number $jp\,(p = \overline{1,k_j})$; k_j – the quantity of the lines-conjunctions, in which output y is evaluated by the linguistic term d_j; m – the quantity of the terms, which is used for the linguistic estimation of the output variable [9].

By means of the operations $\cup$ (OR) and $\cap$ (AND) a fuzzy rules base can be rewritten in the more compact form (4.2):

$$
\bigcup_{p=1}^{k_j} \left(\bigcap_{i=1}^{n} \{x_i = a_{i,jp}\} \right) \rightarrow y = d_j, j = \overline{1,m}. \tag{2}
$$

Suppose that five criteria assessment and, accordingly, five input linguistic variables <CA> and one output linguistic variable <TA> for the expert assessment of some QT are identified.

To obtain the integral assessment let’s use condition-action rules for the fuzzy variables. During its composition the biggest challenge is to make the complete and consistent condition-action rules. Totally for the given conditions of the task expert assessment there is 243 ($3^5 = 243$) condition-action rules.

To formalize the condition-action rules compilation, let's use the principle of the weight fixing for each term of the input linguistic variable <CA>, notably, to the term L assign weight equal 1, to the term A – weight equal 2, and to the term H – weight equal 3. In the same time it is necessary to take into account that the weight of each criteria assessment in the final score has to be the same.

With a glance of the condition-action rules representation for the terms of the output variable <TA> in the form (2), each conjunction has its own weight. For example, the conjunction $\{H \wedge H \wedge A \wedge A \wedge L\}$ has a weight (3+3+2+2+1) = 11. Hence, the minimum weight equal 5 will have the conjunction $\{L \wedge L \wedge L \wedge L \wedge L\}$, and the maximum weight equal 15 will have the conjunction $\{H \wedge H \wedge H \wedge H \wedge H\}$. For each of the five terms of the output variable let's define the weight range equal 2 points ($(15-5)/5=2$), and taking into account the overlapping of the fuzzy ranges the weight range of each term will be equal 3.

Thus, the formal condition for the condition-action rules compiling in the form (2) will be the next: the conjunction of the input variable terms determines to the corresponding term of the output variable, if it belongs to the weight range which specified for that term. The limits of weight ranges are determined by the number of input variables terms and the number of the conjunctions variants – by the number of the evaluated criteria.

The model of the condition-action rules for each of the five terms of the linguistic variable <TA> can be represented as a set of 5-bit vectors, taking into account of the universe X = {L, A, H} for the linguistic variable <CA>. The coordinate of each 5-bit vector corresponds to the number of the criterion. The weight range (5 – 7) defines a set of the conjunctions for the term VL $\rightarrow$ {LLLLX(5)}; the weight range (7–9) defines the term for L $\rightarrow$ {LLAAX(30), LLLHX(20)}; the weight range (9 – 11) defines the term for A $\rightarrow$ {AAAAX(5), AAHLX(60), HHLLX(30)}; the weight range (11 – 13) defines the term for S $\rightarrow$ {HHHLX(30), HHAAX(20)}; the weight range (13 –15) defines the term for H $\rightarrow$ {HHHHX(5)}. In this model, each vector (the variant of the model) contains a set of the conjunctions defined by a combination of the expert scores of different criteria.

The number of the conjunctions in each variant will be $n!/R_H!R_A!R_L!$, where n – the number of the variables, R_H, R_A, R_L – the number of recurring levels (letters) H, A and L in each term. For example, for the term LLLLX the number of variables $n=5$, the number of recurring letters $R_H=4, R_A=0, R_L=0$, so the number of the conjunctions will be $5!/4!0!0!=5$. The number of the conjunctions is denoted in the brackets next to the variant of the model. Altogether in the condition-action rules for this set of criteria it will be 205 conjunctions. The proposed model of the condition-action rules can be represented in the form (1), which makes these rules record more obvious and usable for the fuzzy inference package Fuzzy Logic Toolbox. For example, for the term VL $\rightarrow$ {LLLLX} the rules:

$$
\begin{array}{ll}
 & \{CA_1=L\}\ AND\ \{CA_2=L\}\ AND\ \{CA_3=L\}\ AND\ \{CA_4=L\}\ OR \\
 & \{CA_1=L\}\ AND\ \{CA_2=L\}\ AND\ \{CA_3=L\}\ AND\ \{CA_5=L\}\ OR \\
IF & \{CA_1=L\}\ AND\ \{CA_2=L\}\ AND\ \{CA_4=L\}\ AND\ \{CA_5=L\}\ OR \\
 & \{CA_1=L\}\ AND\ \{CA_3=L\}\ AND\ \{CA_4=L\}\ AND\ \{CA_5=L\}\ OR \\
 & \{CA_2=L\}\ AND\ \{CA_3=L\}\ AND\ \{CA_4=L\}\ AND\ \{CA_5=L\} \\
THEN & TA=VL,
\end{array}
$$

where $CA_1,..,CA_5$ – an expert scores based on the five criteria respectively; TA – value of the linguistic variable <TASK ASSESSMENT >.

Figure 6 shows a demonstrable structure of the fuzzy inference system, which is necessary to assess some QT. This system contains five input variables (the assessment criteria $CA_1,..,CA_5$), each of which has three terms (L, A, H), output variable (task assessment TA), which has five terms (VL, L, A, S, H), the number of the condition-action rules – 205.

It should be noted that this model of the condition-action rules can be used for any types of criteria and tasks, that indicating of its versatility and minimizes the expert subjectivity during the condition-action rules base preparation.

All fuzzy subsets which obtained for the output variable (at all rules) are combined together to form a single fuzzy subset for each output variable (a stage of the aggregation or composition). Two types of operations can be used for such aggregation: max operation (maximum) and the sum operation (boundary sum). In MAX composition, the combined output fuzzy subset is constructed by taking the pointwise maximum over all of the fuzzy subsets (fuzzy logic "OR")

$$\mu_{\Sigma}(y) = \bigcup_{i=1}^{M} \mu_{B_i}(y) = \max_{i=1}^{M}(\mu_{B_i}(y)), \qquad (3)$$

where through «$\cup$» the logical operation of the maximum (MAX) is denoted.

In SUM composition, the combined output fuzzy subset is constructed by taking the pointwise sum over all of the fuzzy subsets assigned to the output variable by the inference rule:

$$\mu_{\Sigma}(y) = \mathop{\oplus}_{i=1}^{M} \mu_{B_i}(y) = \min\left(\left(\sum_{i=1}^{M} \mu_{B_i}(y)\right), 1\right), \quad (4)$$

where through «⊕» the operation of the boundary sum (SUM) is denoted.

After analyzing two types of the fuzzy sets aggregation, we did the conclusion that in the capacity of the aggregation method we will use the SUM method which, by-turn, allows to take into account the influence of each condition-action rule on the output fuzzy set.

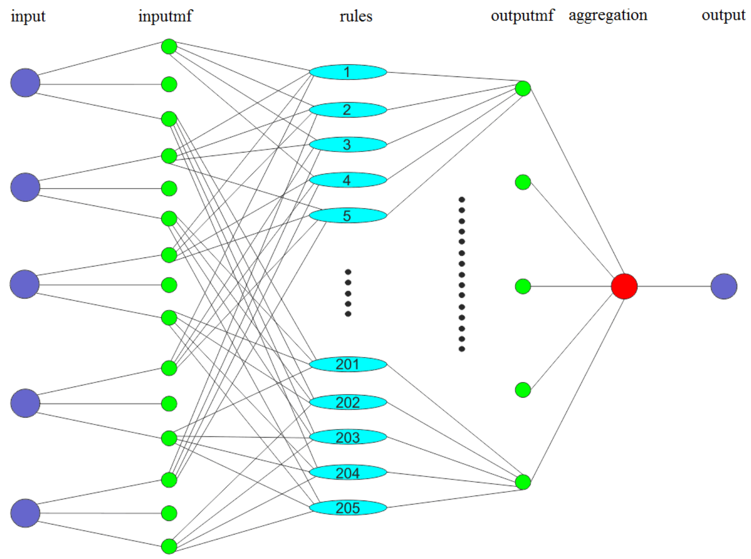

Fig. 6. Fuzzy inference system for the QT assessment

5. Example of the implementation and assessment of qualification task

For example, we choose the QT from the category "Network and telecommunication technologies", chapter "Local network", and topic "Wireless local area network". The task definition is following. "Select and configure the access point for Wi-Fi network which focused on the maximum service area. Network characteristics: the floor area – 30 sq.m., the number of workstation – 10, the rate for each client approximately have to be equal 2 Mbit/sec." Assume that the expert identified five criteria for the task assessment: the basis of the access point choice in terms of the quality-price ratio (CA_1), network scaling feature (CA_2), the correctness of the internal network parameters configuration (CA_3), the correctness of the network security configuration (CA_4), the network functionality with specified parameters (CA _5). The user gave a detailed response, which is not given in this article. He received the following expert scores for each of the criteria: CA_1 = 75 points, CA_2 = 55 points, CA_3 = 30 points, CA_4 = 45 points, CA_5 = 90 points.

To analyze the results of the diagnosis we used a special fuzzy inference package Fuzzy Logic Toolbox (system Matlab 7.5). The Mamdani model was used as the procedure of fuzzy inference, the Gaussian curve with parameters from the table 1 was chosen as membership functions for the input linguistic variables (CA_1, CA_2, CA_3, CA_4, CA_5), and for the output linguistic variable (TA) – the Gauss curve with parameters from the table 2 (the variant 3). The database of the fuzzy rules (condition-action rules) contains 205 rules, which were constructed on the basis of the proposed condition-action rules model. In the capacity of the composition (aggregation) method of the condition-action rules, Matlab allows to choose two methods: the method of the maximum (3) and the method of boundary sum (4). The output fuzzy set for the same model with the same input values (75, 55, 30, 45, 90), but with two different methods of the condition-action rules aggregation is shown in Figure 7. The difference between the results of the defuzzification is insignificant: by the MAX method – 57 points, by SUM method – 56,2 points.

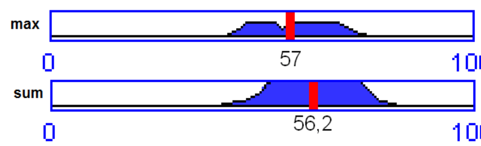

Fig. 7. Two variants of the finite fuzzy set

But the more the contributions to the rules activation, the better the difference between the results of the defuzzification with difference aggregation methods. This is confirms the necessity to use the SUM method. Thus, if the experts assessed the task CA_1 = 75 points, CA_2 = 55 points, CA_3 = 30 points, CA_4 = 45 points, CA_5 = 90 points, then the assessment of the QT will be equal 56,2 points, i.e. user has the sufficient level of the competence.

6. Conclusion

In this paper the approach of the computer systems users' competence assessment using open form qualification tasks with a detailed answer are proposed. The QT assessment is executed on the basis of the results expert estimate using rules and procedures of fuzzy logic. The formal procedures of the condition-action rules compiling and the final score scaling were developed. The simulation of developed procedures in the mathematic system Matlab showed its efficiency and effectiveness. In the sequel the proposed procedures of fuzzy logic can be implemented as a single program module to the knowledge testing system OpenTEST2.

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