AUTHORING AND AUTOMATIC GENERATION OF CIRCUITRIES AND DRAFTS IN DISTRIBUTED E-TESTING CLUSTER (DETC)

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The insufficient volume of testing questions and lack of question classes, which test one area of knowledge, is a primary problem in most systems for electronic testing. The Distributed e-Testing Cluster (DeTC) provides services to learners in the processes during learning, self-preparation and self-testing, and during real testing examination of groups of learners. This paper describes the authoring and automatic generation of circuitries and drafts in the DeTC. This enables automatic generations of questions, which test one area of knowledge. Once a circuitry is already drawn, the dialog-based graphic editor allows automatic generation of new circuitries and drafts when possible. The authors of testing questions must determine which of the primary and marking graphic primitives contained are static, and which dynamic. The authors define connection ranges for each primitive, describe the admissible connections between primitives and generate circuitries.

1. INTRODUCTION

With the modern technologies for education and assessment there are used a variety of methods and resources, which contribute to the successful achievement of the goals, set during the educational process. Testing assessment is one of the most widely used and well-developed instruments in the web-based education.

In web-based education emphasis is increasingly put on how to facilitate the work of lecturers by providing modern methods and resources, one of which is parameterization of testing questions [2].

Most of the already created web-based systems for education contain databases with static questions, created by lecturers and used to create tests for self-assessment and examinations after defined criteria, both during the learning process and during final course examinations. Usually those systems have insufficient amounts of testing questions, especially when large numbers of learners are involved. Parameterization of testing questions is essentially a model of an authored question, whose parameters are replaced with random values from a defined set or interval during presentation. Each question model is capable of producing (generating) large and even unlimited number of different testing questions.

A number of web-based systems for education like CAPA [4, 5], WebAssign [13], EEAP282 [6], Mallard [3], SDG [1], DeTC [10] do parameterize testing questions mostly in areas like Mathematics, Informatics, Physics, Chemistry and others, where answers can be calculated after a parameterized formula. Parameterization of testing questions in various contexts is one of the most perspective run of work to facilitate the work of lecturers [12].

The contemporary educational and testing systems contain many circuitries and drafts, which authors have to draw themselves or use already created ones. In [11] there is described a multi-language graphical editor for authoring circuitries, drafts and graphics in those subject areas, where it is possible to predefine the composing graphical primitives. The graphical editor is created as an extension of Dynamic Test Development Tool (DTDT) in the Distributed e-Testing Cluster – DeTC [8, 10].

This paper describes how circuitries and drafts are generated automatically in the Distributed e-Testing Cluster (DeTC), which significantly facilitates authors in creating new testing questions, in parameterization of testing questions and in creating classes of testing questions, which assess same areas of knowledge.

DeTC [7-11] is being developed as a joint project of the ECE Department at the University of Limerik – Ireland, the Humboldt University in Germany, the Laboratory for Electronic Trade (ECL), the departments of Computer Technologies and Computer Systems at the University of Plovdiv, Bulgaria, and the department of Informatics and Statistics at the University of Food Technologies, Plovdiv, Bulgaria.

2. AUTOMATED GENERATION OF CIRCUITRIES AND DRAFTS

The dialog-based graphical editor enables automatic generation of circuitries and drafts in subject areas, where it is possible to predefine the composing graphical primitives. Authors of circuitries for electronic test-based assessment in DeTC have to perform the following sequence of actions:

1) Select the primitives from the database for the future circuitries;
2) Select the type of each selected primitive – stationary or dynamic. Stationary composing elements (primitives) do not change their location in the generated circuitries, while dynamic elements (primitives) can change it;
3) Describe the range of the admissible number of links for each selected primitives by entering the lower and upper boundaries (MinLinks, MaxLinks) of the range. Some primitives may have no links (the lower and upper boundaries are zero), others can have a fixed number of links (the lower and upper boundaries are equal) and for some the two boundaries can be different. In every generated circuitry the number of links between the selected primitive and the other primitives will be within the defined range. The dialog-based graphical editor provides facilities to edit the defined range of admissible number of links;
4) Define the potentially possible links between the selected primitives according to physics meaning of the composing elements (primitives) in the corresponding subject area. For each link authors have to define which

primitives it links and the type of the link (the type of linking graphical primitive). The described links are stored in a matrix of admissible connections between primitives, with the primary diagonal containing 0 for standard primitives and 1 for dynamic primitives. The dialog-based graphical editor provides facilities for editing the described connections and for visualization and straight editing of the matrix of admissible connections;

5) Finally, actual generation has to be started. The system will warn about the number of potential circuitries to be generated. If this number is too large, the author can decrease the number of potentially possible connections for one or more of the selected primitives, decrease the range of potential links, or even decrease the number of selected primitives. The actual generation is carried out after the author confirms the number of circuitries to be generated. Authors are provided with facilities to preview, edit, save and delete newly generated circuitries. Each stored circuitry can be used as a newly created graphical primitive and be later used to create manually or automatically new (more complex) circuitries.

3. IMPLEMENTATION IN PRACTICE

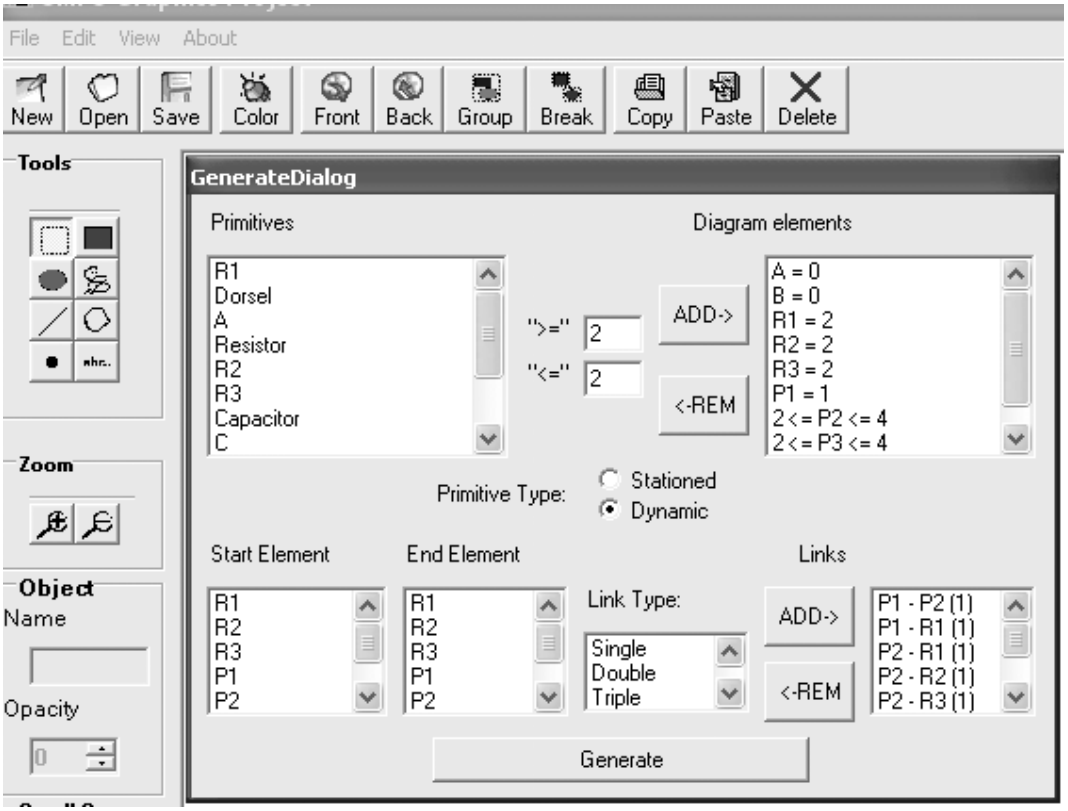

Fig. 1. Circuitry generation dialog

An author of testing questions would like to generate all possible circuitries for the following testing question: "Calculate the total resistance between points A and B

from the circuitry …", with the circuitry having four connection points P1, P2, P3 and P4, and three resistance elements R1, R2 and R3, and A and B marking endpoints P1 and P4 accordingly.

Figure 1 shows the dialog, with which the author will generate the schemes. The composing primitives are created and saved in advance in the database: marking – A, B, P1, P2, P3, P4; primary – resistance elements R1, R2, R3, etc.

The author selected the nine composing primitives and defines A, B, P1 and P4 as stationary, and R1, R2, R3, P2 and P3 as dynamic.

Afterwards one describes for each primitive the range of admissible links, as shown in figure 2: A and B have no links, R1, R2 and R3 have exactly two links each, P1 and P4 have exactly one link each, and P2 and P3 have from two to fours links.

Primitives	**A**	**B**	**R1**	**R2**	**R3**	**P1**	**P2**	**P3**	**P4**
MinLinks	0	0	2	2	2	1	2	2	1
MaxLinks	0	0	2	2	2	1	4	4	1

Fig. 2. Range of admissible number of links

Finally, the author defines the potentially possible links between the selected primitives and the system visualizes the matrix of admissible connections between the primitives (figure 3). Zero in the main diagonal marks the standard primitives, one marks the dynamic ones. Because of the symmetry of the matrix, admissible links between primitives are marked with one only above the main diagonal.

On generating start, the system warns that fourteen circuitries will be generated, the author agrees and the circuitries are created.

	A	B	R1	R2	R3	P1	P2	P3	P4
A	0	0	0	0	0	0	0	0	0
B	0	0	0	0	0	0	0	0	0
R1	0	0	1	1	0	1	1	1	0
R2	0	0	0	1	0	0	1	1	0
R3	0	0	0	0	1	0	1	1	1
P1	0	0	0	0	0	0	1	0	0
P2	0	0	0	0	0	0	1	0	0
P3	0	0	0	0	0	0	0	1	1
P4	0	0	0	0	0	0	0	0	0

Fig. 3. Matrix of admissible connections

A close look at the circuitries shows that all of them are correct, some of them have one and the same answer to the posted testing question, but the primitives in the circuitries are positioned in different ways, i.e. circuitries look different. With the

current testing question the fourteen different circuitries have seven different answers. It has to be noted that four of the fourteen circuitries can mislead the learner when solving the testing question.

If the author desires to decrease the number of generated circuitries, it is enough to prohibit an admissible link between R3 and P4 by setting the cell on row R3 and column P4 to 0 in the matrix of admissible connections. In this case the system will generate "only" eight circuitries with different layout of primitives. In the context of the question above the eight different circuitries receive six different answers, and three of the eight circuitries can mislead the learner when solving the testing question.

On the other hand, the author can always increase the number of generated by the system circuitries by adding new links in the matrix of admissible connections, i.e. by replacing one or more zeros above the primary diagonal with ones. Of course, increase is not always possible.

4. CONCLUSION

DeTC saves those fourteen generated circuitries in its database and they can be used later as composing elements (primitives) to create other circuitries. Figure 4 shows some of the generated circuitries.

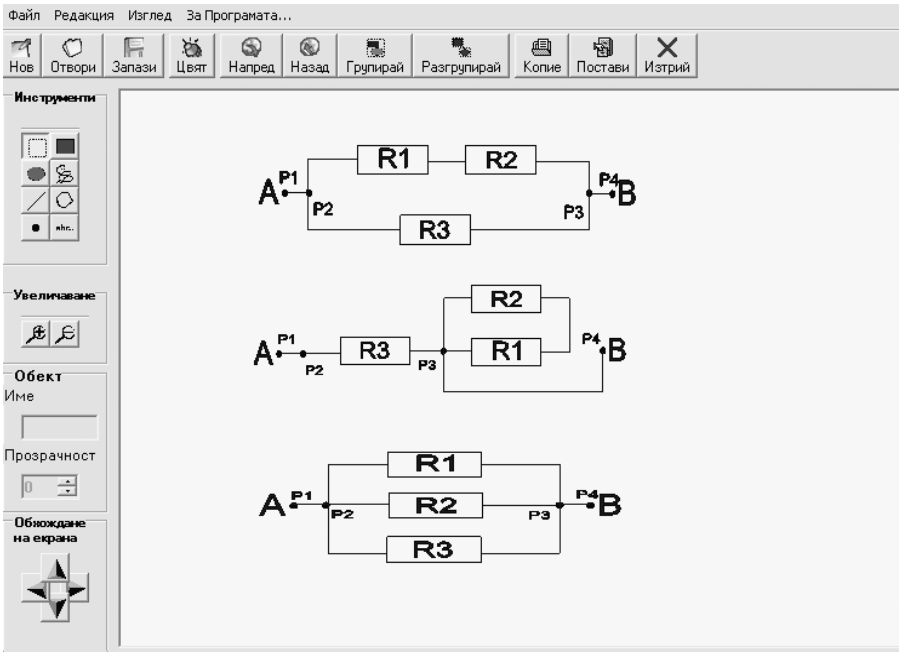

Fig. 4. Some of the generated circuitries

On the other hand, all or some of the fourteen circuitries can be combined with a parameterized testing question [10] with randomly selected values for resistance elements R1, R2 and R3. In this scenario even in a room of above two hundred seats each learner can receive a different question, testing the same knowledge.

The dialog-based graphical editor is a multilingual authoring tool, i.e. all the elements of the user interface (menus and buttons) are parameterized, with the actual texts of the supported languages stored in the database. Multilingual support may be observed in figures 1 and 4 – the language of the user interface in fig. 1 is English and in fig. 4 is Bulgarian.

This approach is experimented and is being successfully applied in preparation of tests for the education in Physics, Electronics, Electrical Engineering, Local and Global Area Computer Networks, Computer Systems and Architectures, etc.

5. ACKNOWLEDGMENTS

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