Generating Dynamic Questions in Distributed eTesting Cluster - DeTC

Olga D. Rahneva[1]

Abstract – **This paper describes how dynamic questions with engineering and mathematical contents are being created, generated and applied into practice at a Distributed eTesting Cluster – DeTC. As a result, the learners receive unique testing questions, while the database with tests does not grow significantly in size, and the size of the information transferred is minimized.**

Keywords – **Electronic Testing, eTesting, DeTC, Dinamic Question, Free Answer**

I. Introduction

Testing examination is one of the most popular and well-developed assessment instruments in higher education [1]. The classic test is a sequence of precisely defined questions, with each question suggesting a simple answer, which can be easily checked and assessed as correct, incorrect or partially correct (for example, incomplete).

Questions are often split in types, according to the expected answer:
- classic type of question – with a "yes/no" answer;
- multiple-choice question – one answer (MC/SA, Multiple-Choise/Single-Answer);
- multiple-choice question – more than one correct answer (MC/MA, Multiple-Choise/Multiple-Answer);
- free-type questions- with the answer being a number or a text;
- others.

Most of the existing Web-based systems for testing and assessment provide technologies and tools for creation, submission and assessment of questions of the first three types [2-6]. A certain number of systems process all types of questions [7,8].

However, most of the latter support materials with insufficient mathematical contents. The tests authors have to create the formulae and equations with a separate tool and convert them into a GIF/JPEG format and include them in the testing system as a graphic, when more complex mathematical or engineering content is required.

[1]Olga D. Rahneva is with the department of Informatics and Statistics at the University of Food Industries, 26 Maritza blv., Plovdiv, Bulgaria, E-mail: rahneva@yahoo.com.

This approach significantly increases the size of the database, which stores the testing questions, as well as the size of the information transferred to the learners, because of the large number of images.

On the other hand, it does not provide a solution to the problem for dynamic creation of questions, which forces the development of a large set of test versions, in order to prevent the test from being learned by heart.

It is described below how dynamic free-type questions with engineering or mathematical contents are created, generated and applied in practice at a Distributed eTesting Cluster – DeTC. Learners are given unique testing questions by generating random values for the variables in the question. This does not increase the number of the preliminary created questions, decreases the size of the database with tests, and minimizes the size of the transferred information.

DeTC [9-11] is being developed as a joint project of the University in Limerik – Ireland, the Laboratory for Electronic Trade, and the department of Computer Technologies at the University of Plovdiv, Bulgaria, and the department of Informatics and Statistics at the University of Food Industries, Plovdiv, Bulgaria.

II. Example Questions

Fig. 1 shows a sample multiple-choice (MC/SA) question in Electrical engineering.

The resistance R of a conductor, which dissipates an amount of heat Q, for time t, with amperage I, is determined with the following formula:

$$R = \frac{Q}{I^2 \cdot t}$$

Determine the resistance R in ohms (Ω) of the conductor, which dissipates heat of 10 000 J for a time of 2 seconds, at amperage of 10A.

a) 10   b) 20   c)50   d)100

Fig.1 Sample question MC/SA

In order to provide the learners with different questions, the authors must create many versions of such as question with different values for Q, t and I. Of course, they have to perform a lot of calculations to mark the correct answers.

This disadvantage can be overcome if the question is redefined as dynamic, a free answer is requested from the

learners, and the answer is automatically analyzed for being correct or not by the system.

Fig.2 demonstrated how the sample question from fig. 1 can be transformed into a dynamic free-type question.

The resistance *R* of a conductor, which dissipates an amount of heat *Q*, for time *t*, with amperage *I*, is determined with the following formula:

$$R = \frac{Q}{I^2 \cdot t}$$

Determine the resistance R in ohms (Ω) of the conductor, which dissipates heat of 10000J for a time of 2 seconds, at amperage of 10A.

$$R = \boxed{\text{I}}$$

Fig. 2. Sample dynamic question

III. System details

At DeTC, each dynamic question is described in a number of sections.

The first section describes the dynamic variables in use. In the example from fig. 2, those are Q, I and t. Each variable receives a name, a type (integer or real) and one or more ranges of possible values, which are dynamically set by a random generator. In the same example, the variable t is of type integer and its value is set in the range (0,12). The value is an integer or real number with specified precision and depends on the type of the numeric variable.

The second section defines the dynamic answers. Each answer is given a name, a type (integer or real), a formula for calculation and a method for comparison with the correct answer. The formula can contain only the dynamic variables, defined in the first section, numeric constants and arithmetic functions.

Fig. 3 shows the formula for calculating the correct answer of the dynamic question from fig. 2.

$$R = \frac{Q}{I^2 \cdot t}$$

Fig. 3. Sample formula for the dynamic question

Two methods for comparison of the learner's answer with the correct answer are provided – by calculating an absolute or a relevant error.

The third section describes the body of the question – as a text with mathematical formulae. The body is a template, in which dynamic variables are defined by putting a "@" before their names.

Fig. 4 shows how the body of the dynamic question from fig. 2 is described:

The resistance *R* of a conductor, which dissipates an amount of heat *Q*, for time *t*, with amperage *I*, is determined with the following formula:

$$R = \frac{Q}{I^2 \cdot t}$$

Determine the resistance R in ohms (Ω) of the conductor, which dissipates heat of @Q J for a time of @t seconds, at amperage of @I A.

Fig. 4. The body of a Sample dynamic question

The fourth section describes the dynamic answer form for of the questions to the learner. For each answer, the name of the dynamic variable is defined, as well as the sign = (equals) and a form for the free answer with a certain number of characters allowed. It can be specified whether preliminary formal control will be exercised over the input.

The fifth section is not mandatory. It allows extended formatting of the questions screen with sound, pictures, animations, etc.

IV. Authoring tool

A syntactically oriented editor is created to facilitate the authors of tests – Dynamic Test Development Tool (DTDT), as an extension of the existing in DeTC editor Test Development Tool (TDT) [10]. DTDT features an easy and convenient dialog-based user interface for writing engineering and mathematical formulae; for defining the dynamic variables used; for defining the dynamic answers; for defining the body of the dynamic questions and for additional design of the questions screen.

DTDT saves each testing question in a file in XML (eXtensible Markup Language) format. The file contains the logical data as contained in the question – keywords, general information, the question type, question itself, variables, ranges, type of answers supported, possible answers, information about the correct answer, and extra information.

XML is chosen as a technology for storing the testing questions, because it allows the transformation of the basic data into virtually any other format by using XSL (XML Style-sheet Language) – HTML, MathML, XHTML, WML, PDF, Microsoft Word document, etc.

Fig. 5 shows a principal diagram for development and generating of tests with dynamic questions.
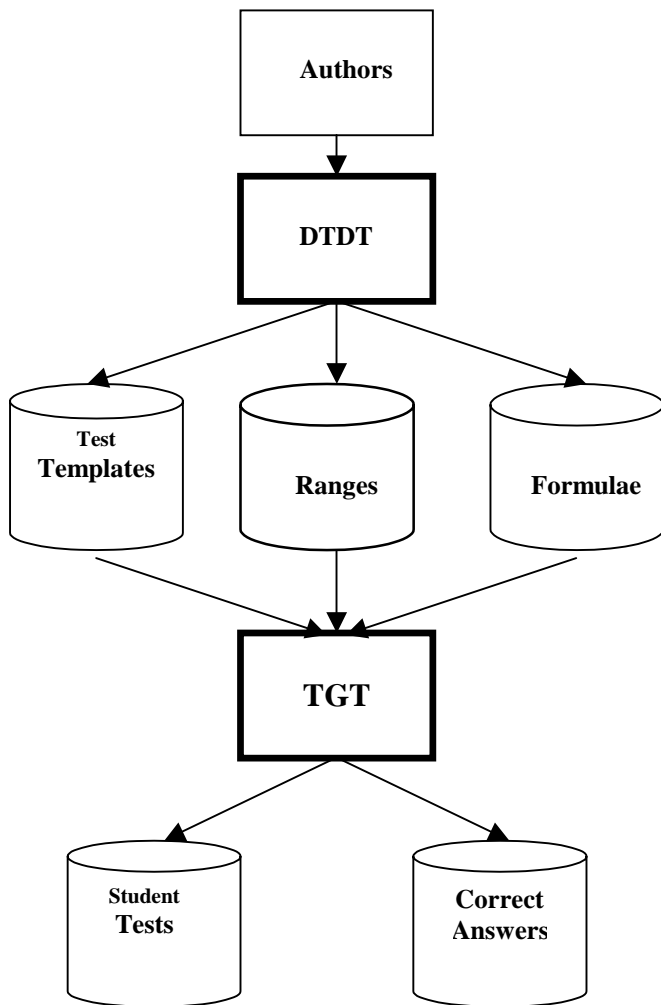
Fig. 5. Development and Generating of Dynamic Tests

DTDT is a multi-language editor – all its menus and buttons are parameterized and the dialog with the author of the test can be conducted in any one of the specified (and defined in the database, of course) languages – Bulgarian, English, French, even Macedonian.

V. Assessment tool

Tests are assessed with the Dynamic Test Assessment Tool (DTAT), which analyzes the free-form answers, given by the learners and determines whether they are correct or incorrect. DTAT parses the answer, evaluates it and compares it to the author specified answer.

Depending on the chosen approach, DTAT will seek zero or close to zero difference between the learner's answer and the author's answer, to mark a question as correctly answered. The error tolerance level can be specified with the definition of the question (for example, tolerance level is 10^{-5}).

The lecturers, instructors and assessors can receive various reports on the results of the conducted tests. Apart from that they can follow the performance of each learner and check his knowledge and skills, to measure up his progress. DTAT allows the creation of various personal, local and global (for the cluster) statistics of the results of the tests.

That feedback is very useful for the lecturers, so that they can estimate the success rate of each test and each question. In this way they can modify the tests or the questions in them or just the difficulty level of one or more questions.

Fig. 6 shows a principal diagram of the assessment process of dynamic questions.
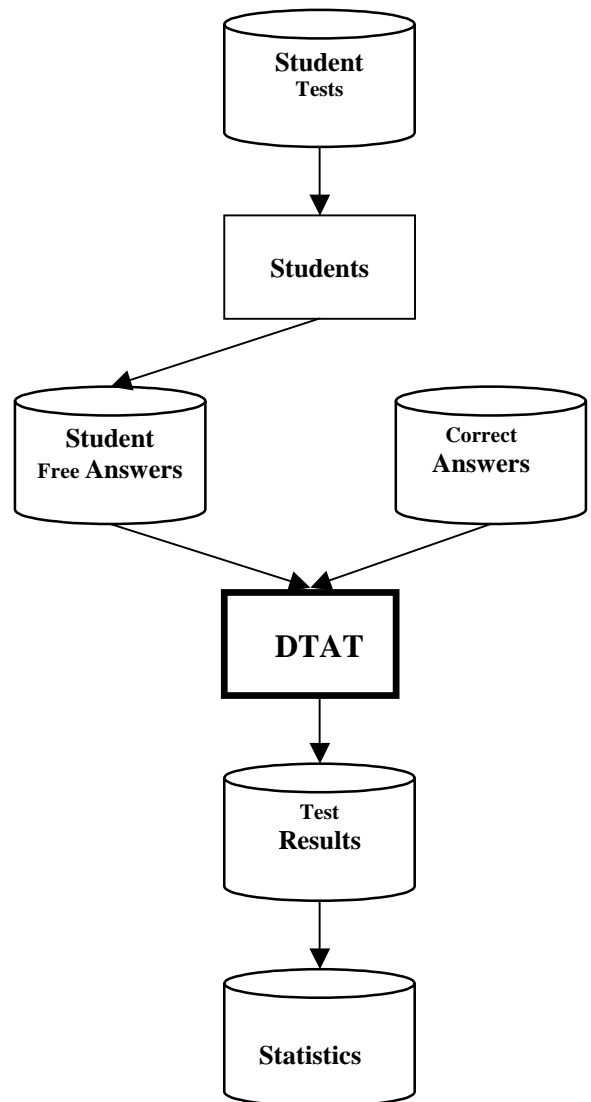

Fig.6. Assessment of Dynamic Tests

References

[1] Peter Brusilovsky, Philip L. Miller, "Web-based Testing for Distance Education", WebNet 1999, pp. 149-155.

[2] http://wdo.uni-svishtov.bg.

[3] http://estudy.iccs.bas.bg.

[4] http://www.nbu.bg.

[5] http://www.infoguard.net/education/test/.

[6] Gusev M., G.Armenski, "A New Model of On-line Learning", Proceedings of SSGRR Advances in Infrastructure for Electronic Bussiness, Education, Science and Medicine. Roma, 2002.

[7] http://arcade.fmi.uni-sofia.bg:8080/arcade/index.jsp

[8] Maomi Ueno & Keizo Nagaoka, "Web based Computerized Testing System for Distance Education", Proc of ICCE 2001, pp. 547-554, (2001), Korea.

[9] Rahneva, O., DeTC – Distributed Electronic Testing Cluster, Scientific and Practical Conference "New Technologies in Education and Professional Learning", Sofia, 16-17 May 2003, pp. 84-91.

[10] Rahneva O, eTesting Tools, First Bulgarian-Irish E-learning Workshop, Plovdiv, August 2003.

[11] Rahneva, O., Testing and Assessment in Distributed Electronic Testing Cluster - DeTC, 12th International Conference Electronics '2003, Sozopol, 24-26 Sept. 2003, Conference Proceedings, v. 4, pp. 214-219.