INTERACTIVE INTERNET-SERVICE FOR COMPUTER TESTING IN MATHEMATICS

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Abstract. Mathematics testing Internet-system requirements, the system architecture and main components description are presented here. Peculiarity of the proposed method is the irrelevance of a user's answer to be congruent with an etalon. The user's answer analyzing is replaced with objectives to check the possibility to equivalently convert an answer to an etalon using symbolic mathematical software like Maple or MathCAD.

Recently, specialized interactive mathematics servers and Internet-systems of computer testing in mathematics have become most popular. Such systems should have built-in methods of knowledge assessment with a protecting security mechanism and virtual classes, which allow teachers to control student work as well as to create exercises, animated graphics, tools for entering mathematical formulas etc. [1]. These systems may be easily adapted to any other disciplines assuming the use of formalized notations, e.g. physics, astronomy, chemistry and such.

Within the project of a distance learning system at Yanka Kupala State University of Grodno we have been developing an Interactive Mathematics Internet-system. The main goal of the system is to provide a variety of interactive mathematics services such as examples and exercises, mathematical calculation domains, graphic visualization tools. An important place in like systems should be given to a computer testing subsystem.

Testing system requirements

There are many different methods for the solution of the computer testing system problems. Thus, there is a big variety of program systems created for being used in a local computer as well as in Internet/intranet. The overwhelming majority of such solutions propose a list of tasks where a user must choose one or more right answers. In many cases this is enough to evaluate the level of user's knowledge. However, this is not effective while testing in domains which request either answers to be in a free form or using elements of specialized notation languages such as ones that are used in mathematics, physics, chemistry etc.

When trying to realize a computer testing system oriented to system project notations of such domains, we meet a series of problems, which the most significant are:

- To make it possible for a user to enter an answer using notations that are traditionally accepted in this domain;
- To check the syntax of entered expressions on the client-side;
- To compare a user's answer with an etalon. An answer is considered to be correct not only if it's congruent with an etalon, but also when it may be brought (сведено) to an etalon by the way of equivalency conversions using corresponding axioms;

System architecture features

Main attitudes and aspects to be considered while realizing the architecture of an Internet-system aimed to resolve the above tasks of computer testing:

1. The system should be a client-server application that would allow carrying out distance testing in the scope of both higher and school mathematics.
2. None of additional software but a standard web browser should be used to interact a user with the system.
3. Users should be provided with tools for entering mathematical expressions with the use of standard notations. Before sending data to a server, users should have a possibility to check the syntax of their answers.
4. Mathematical software able to make symbolic calculations should be used to compare a user's answer with the etalon. That is, such software has to explore the possibility to equivalently transform a user's answer into an etalon. A client-side application interacts with mathematical software through an interface module, which must be created with a special data format transferring agreement.
5. Methods of making the instructions for Mathematical Software should be developed to check the equivalence of a user's answer to an etalon. The methods evidently vary depending on a type of problem.

By now we have realized the prototype of such the system for testing students in mathematics. The prototype functions within the on-line testing server of Computer Science department at Yanka Kupala State University of Grodno.

System functionality principles

We have chosen MathML as a standard of data exchange between system components. MathML [2] is an XML-based markup language for publishing mathematics on the Web. Many modern browsers like Netscape 6, Mozilla, Amaya, IE 6 can display the documents containing encoded MathML expressions. Furthermore, the latest versions of mathematical software – Maple 8, MathCAD 2001i, Mathematica 4.2 – use MathML as a standard for importing or exporting data.

When working with the system a user enters his answers by using a Java applet built in an XML-page, which serves for inputting mathematical formulas with the help of formula graphics editor. The editor provides a wide range of base notations for various mathematics sections: algebra, set theory, integral and differential calculus, geometry series etc. It is also reasonable to simplify the formula editor for the use of school students to make it be more oriented to their possibilities and skills. Since entered by a user, an answer has been encoded into MathML expression and transferred to a web server.

We have created a special module, realized as COM-server, to provide an interaction between a web server and Mathematical Software. Its mission is to get a user's answer from a web server, and an etalon from database, form a task for Mathematical Software, receive the result from it, interpret and send the result back to a web server.

A user, for his convenience, has the possibility to get the result in a MathML format from a web server. In such a way he may see it on the web browser in a usual standard mathematical form.

System architecture components description

Figure 1 illustrates the Internet-system architecture oriented to testing in mathematics. A prototype of this Internet-system is realized and integrated into an on-line testing server of Computer Science department at Yanka Kupala State University of Grodno.

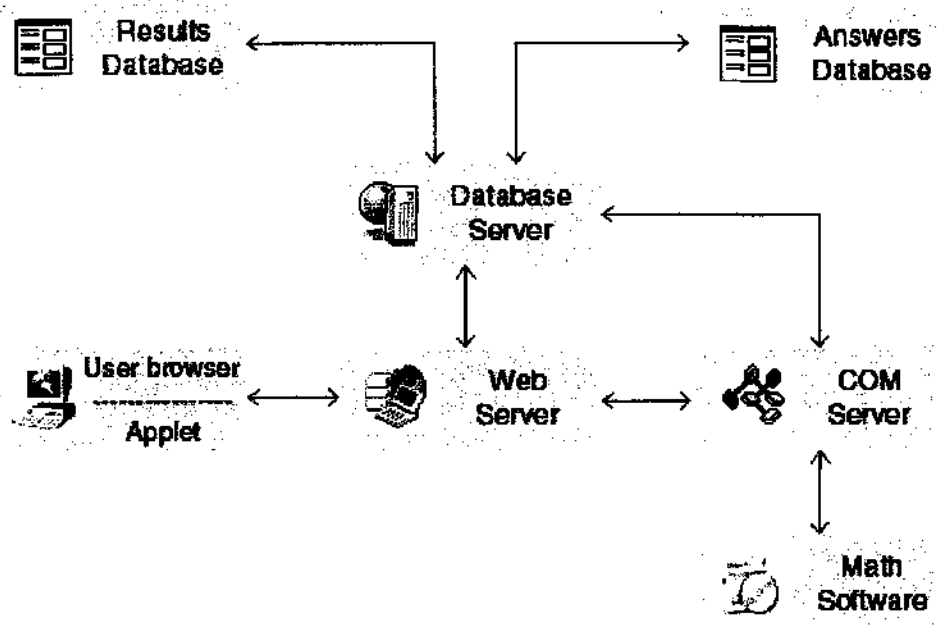

Fig.1 Internet-system architecture oriented to testing in mathematics.

Here is a brief description of modules and related data exchange processes, which are necessary for like system realization and functionality.

Remote user's computer, connected to the Internet or intranet, should have a web browser supporting Java- and XML- scripts. When working with the system a user enters his answers using a Java applet built in an XML-page, which serves for inputting mathematical formulas with the help of formula graphics editor. The editor functions in a style of WYSIWYG. Its interface and capacities are similar to Microsoft Equation settings of Microsoft Office software. While entering an answer, the applet generates MathML code corresponding to a user's entered data appearance. After answer entering is done, the applet starts transferring MathML code to a web server for further processing.

Web server holds a controlling CGI-program and XML-document templates, which are referred to a remote user's computer. A basic XML-document template is designed for getting a user's answer, and contains an imported type library and a Java applet.

The controlling CGI-program connects to a database server to get an exercise, afterwards, generates an XML-document using the basic template and sends it to a remote user's computer. Since a user's answer is received, the CGI-program dispatches it to a COM server. When a COM server returns the result of whether a user's answer is correct, CGI-program requests of a database server to save user's results.

The destination of a **COM server** is to organize a user's answer checking process as well as a connection with the mathematical software. COM server, using database server, retrieves an etalon for current test task. To form a task for Mathematical Software the server uses information about a type of a current problem, an etalon and a user's answer. After receiving a result from **Mathematical Software**, the COM server interprets and sends it to a web server to save results in database and/or send them to a user.

Database server provides structured and protected on-line testing system data storing, allows data managing using an SQL language and makes it possible to operate

with tasks, answers, and test results databases The server has a set of stored procedures for static data collection.

Here below is an example to make it easier to understand how all the testing Internet-system processes function. Let's assume that a user's task is to resolve the following integral $\int\sin(x)dx$, and his answer is $-\cos(x)+C$. The web server therefore receives an answer in a MathML format that looks like the following:

```
<apply>
  <plus/>
    <apply>
      <minus/>
      <apply>
        <cos/>
        <ci>x</ci>
      </apply>
    </apply>
  <ci>C</ci>
</apply>
```

COM server gets the above script and the type of a problem, which in our example is integral calculus. The server also gets an etalon from the database. Let's suppose that the etalon is $\sin(3\pi/2+x)+C$. Consequently, the server gives, according to the current problem type, the following instructions to mathematical software (here we use Maple 8):

```
user_answer := MathML[import]
("<apply> <plus/>
  <apply> <minus/>
  <apply> <cos/> <ci>x</ci> </apply>
  </apply>
  <ci>C</ci>
</apply>");
etalon := sin(3π/2+x)+C ;
result := etalon – user_answer ;
```

The first command imports a MathML code and translates it into $-\cos(x) + C$ expression. The last command makes mathematical software perform all necessary equivalency conversions and returns 0 if the user's answer proved to be correct. After the COM server receives the result, it sends it to a web server.

References

[1] WWW Interactive Mathematics Server - http://wims.unice.fr/wims/

[2] World Wide Web Consortium. W3C Math Home. http://www.w3c.org/MathML/