

e-Xaminer: Electronic Examination System

A. ANDREATOS and N. DOUKAS

Div. of Computer Engineering & Information Science
Hellenic Air Force Academy
Dekeleia, Attica, TGA-1010
GREECE

Abstract: -This paper presents an automated examination system called e-Xaminer which is being developed as a pilot system supporting education at the Hellenic Air Force Academy. The exam agent composes personalised tests (html pages with forms) for each student, based on parametric problems and questions set by the instructor. Students submit their answers, which are marked via automatically generated scripts; a marking report is generated that can be reviewed by the course organiser, should this be necessary or desired. The above system is currently used to aid the educational tasks of the Hellenic Air Force Academy. It is our purpose to incorporate it to the continuing education pilot program developed by our Division for the officers of the Hellenic Air Force (HAF), on Computer and Telecommunication Networks. This program is to be administered by the Hellenic Air Force Academy and offered via the Internet to HAF officers.

Key-words: e-Xaminer, electronic examination, e-Learning, Domain Specific Languages, Computer Networks.

1 Introduction

In previous papers [1]-[3] we have described the design of an e-Learning system for continuing education on Computer Networks, for the officers of the Hellenic Air Force. In this paper a pilot electronic examination system is presented, called **e-Xaminer**, intended for use in our e-Learning system but also in regular exams of our Division at the Hellenic Air Force Academy.

Although one can find a lot of information about e-Learning, CBL and distance education systems in the bibliography (see for instance [4], [5], [6]), not all of them contain student evaluation (exam) modules, and even less discuss them in depth [7], [8]. However, a research by Guidorzi and Giovannini about the users' opinions on e-Learning tools, has shown that the capability of exam support was found to be the most appreciated feature among other features [9]. This is due to its practical usefulness.

e-Xaminer is a pilot program automating exam taking and grading in electronic form. The program was developed by the Division of Computer Engineering & Information Science of the Hellenic Air Force Academy in order to facilitate the examination of our courses. The exam questions and problems must be written in a specific manner; a plethora of questions and problems is supported.

Key features of the e-Xaminer are:

- Automatic test generation
- Automatic test grading
- Supports a variety of question types

- Easy to use
- Personalisation of problems via random number generation of specific problem parameters.

The structure of this paper is as follows: in section 2 we present the types of problems and questions accepted by the e-Xaminer so far; in section 2 we present the structure of the e-Xaminer itself; in section 4 we discuss the problems which arose from the initial tests of the e-Xaminer; in section 5 we discuss the next extensions of the e-Xaminer and its integration in our pilot e-Learning system; finally we conclude in section 6.

2 Structure of the tests

In order to facilitate automatic correction, specific types of questions are used. These may be classified as shown below.

1. True/false questions [type=1]
2. Multiple choice questions [type=2]
3. Questions with many correct-wrong options [type=3]
4. Questions with Short answers (textual or numerical); enumeration / quotation of few terms [type=4]
5. Simple problems with arithmetic results [type=5]
6. Simple theoretical questions from the textbook where the answer is a phrase [type=6]
7. Parametric problems with arithmetic results [type=7]

8. Questions of correspondence [type=8]
9. Composite Questions; a combination of one or more of the above types [type=9].

Let us now examine each type. The examples are taken from our Computer Networks course [10], [11].

1. In multiple choice questions the examinee has to select one among 3 to 5 answers. Example 1: "IP address 130.50.4.1 belongs to class: A B C D E".
2. In true/false questions the examinee has to check whether a proposition is true or false. Example 1: "In a datagram subnet, routers do not hold state information; TRUE FALSE". Example 2: Concerning distance, laser is a better source of signal than LED: TRUE FALSE.
3. In type 3 questions the examinee has to tick all answers which are correct. Example 1: "Which of the following are physical medium dependent sublayers of 802.16? QAM-32 QAM-64 FHSS OFDM". Example 2: "Which of the following media may be used at the physical layer of Ethernet? Coax UTP STP fiber air".
4. In type 4 questions the user is prompted to give a short textual or numerical answer such as "switch" or "4". In simple problems with arithmetic results the answer is a particular number which comes out after calculations. An arithmetic error here, or even a typing error, is fatal. Example 2: "What networking devices operate at the DLC layer?" Example 2: "If a probability of any bit being in error is $p=10^{-5}$, what is the probability of receiving a full Ethernet frame correctly?"
5. In type 5 questions the examinee has to perform simple arithmetic calculations in order to find the answer. Example 1: "What is the expected number of retransmissions in an ALOHA channel, when $G=0,4$?" Example 2: "The sequence numbers of a selective repeat protocol at the DLC layer are 6 bits long; What is the maximum sliding window size at the receiver?"
6. In type 6 questions the examinee has to write a phrase in a textbox; then e-Xaminer checks its correctness by scanning for

specific keywords. Example 1: In an 802.11 frame, what is the role of bit «O»? Example 2: "Why in the 802.16 frame the CRC is optional?"

7. Type 7 deals with parametric problems with arithmetic results; the data of the problem are parameterized according to the examinee's registration number or username. One or more parameters of the problem are changed in order to produce a different arithmetic answer. This is also a measure against cheating. Example: "How much time is needed for the transmission of a picture 12x20 cm by a 14400 bit/sec fax machine via a 64 Kbit/sec line? The resolution of the image is 60 pixel/cm & the colour depth is 6 bit/pixel." In this problem we may change one or more of the following parameters: picture size, fax speed, line bandwidth, image resolution and colour depth. Random number generators and look-up tables are used in combination with the examinees' identification elements. No partial credit is given for semi-correct solutions with wrong results. A solution to this is to have many intermediate questions.
8. Questions of correspondence: Two sets of terms are given and the examinees have to connect the corresponding terms one to one. Example: "Connect the following networking devices to their corresponding layer:"

| Device | Layer |
|---------------------|--------------|
| Router | Application |
| Switch | Transport |
| Hub | Network |
| Application gateway | DLC |
| Transport gateway | Physical |

Type 9 covers composite questions consisting of a combination of one or more of the above types. This type is used in complex problems with many questions. Example: "A modem used the following constellation; a) What kind of modulation does it use? b) if the baud rate is 2400, what is the final bit rate in bit/sec? c) Is it faster or slower than a V32bis modem?". Question (a) is a type 4 question (the answer may be "QPSK"). Question (b) belongs to type 4 but it may also be parameterized and then it belongs to type 7. Finally, question (c) is a type

1 question (true/false), but if we ask the examinee to justify his/her answer, then it will become a type 1 question. Table 1 below

summarises the question and problem types used by the e-Xaminer.

TABLE 1 – Types of questions suitable for the automatic correction

| TYPE | QUESTION TYPE | HTML FORM TYPE | COMMENTS |
|------|---|----------------------------------|--|
| 1 | True/false questions [2 options] | Radio buttons [12],[13] | True/false; [one answer excludes others] |
| 2 | Multiple choice questions [many options] | Radio buttons | One correct from many options; [one answer excludes others] |
| 3 | Multiple correct questions | Checkboxes | Questions with many correct or wrong options; [one answer does not exclude others] |
| 4 | Short answers, enumeration / quotation of few terms | Textbox | Answer is alphanumeric; [no calculations] - theoretical questions |
| 5 | Simple arithmetic calculations | Textbox | result is arithmetic Examinee must perform calculations |
| 6 | Simple questions from the textbook ANSWER=PHRASE | Textarea | Answer is scanned for specific keywords |
| 7 | Parametric problems with arithmetic results | Textbox | E-Xaminer generates different parameters for each examinee & also the corresponding answer |
| 8 | Correspondence Questions | Textbox | Examinee must connect terms from set 1 to terms of set 2 |
| 9 | A combination of the above types | A combination of the above forms | Problems with many questions which allow for partial credit |

3 Structure of the e-Xaminer

The implementation of the e-Xaminer uses the concept of Domain Specific Languages (DSL) [14] to produce the code necessary for running the tests. This approach implies that neither the examiner (the author of the test) nor the examinees need to have any experience in Software Engineering. The examiner writes the test using a simple interface (e.g. a limited subset of the capabilities of an html editor such as MS Front Page or a simple text editor such as Notepad). Automated scripts then

create the examination and the marking agent routines. The examinees submit their answers via a web form (a task that is considered trivial by virtually anybody attending a course at university level). The marking processes is also masked by a web interface and the examiner need only read and review an automatically produced, web based, marking report. The concept of the e-Xaminer is illustrated in Fig 1.

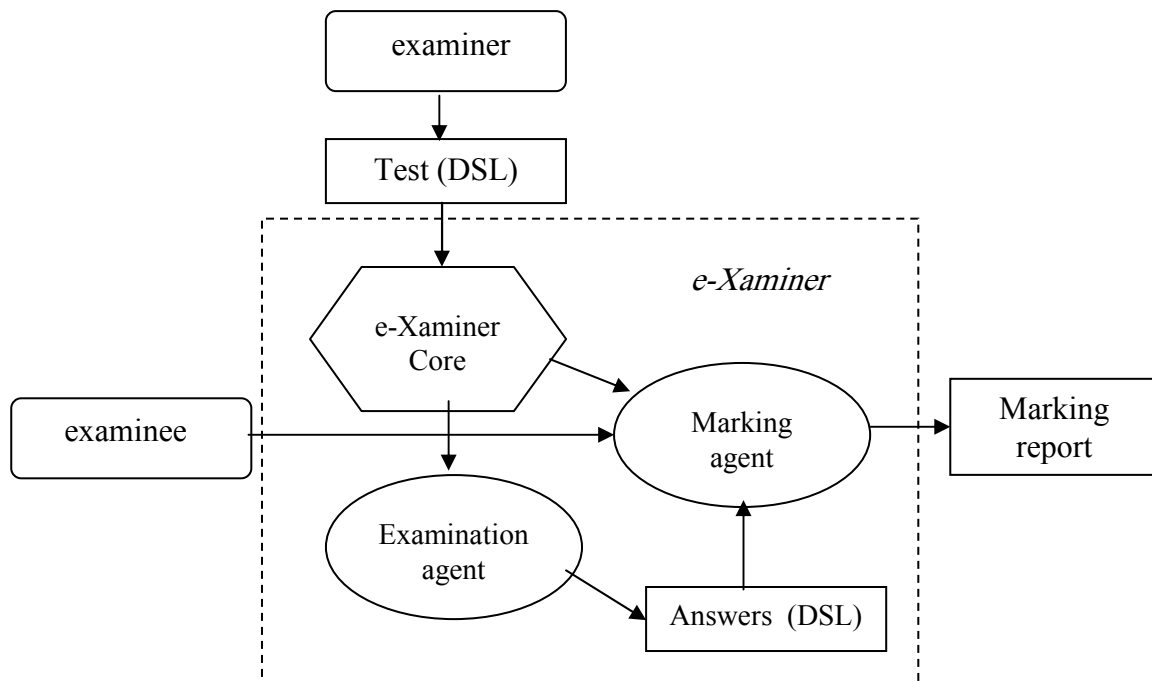


Figure 1: Structure of the e-Xaminer

The e-Xaminer is implemented using two independent functions for each test. The first one implements the examination agent and the second one the marking agent. The two agents operate in physically separate servers in order to avoid any possibility of the students gaining access to the correct answers.

The examination agent is implemented as an active page that uses standard html forms and Perlscript in order to validate and collect the student's answers. The page may contain specific html form objects, namely text boxes, text areas, check boxes and radio buttons. The pages are required to use only standard html features, so as to ensure portability between browsers. The exams included in this study where tested in both Microsoft Internet Explorer 6 and Mozilla 1.7.12 had worked without problems. Currently the tests are not allowed to include interaction with non-textual objects (e.g clicking or selecting items from an image). This feature will be added in future versions of the e-Xaminer. As measures against possible exam-time cheating, the agent allows (a) the insertion of unique random arithmetic parameters in each test and (b) the random, unique re-ordering of examination questions.

The marking agent is implemented as a Perl script. It consists of three distinct parts: (i) the general purpose extraction routine, that retrieves the data from the form, without the need for prior

knowledge of the forms structure, (ii) the general purpose marking routine, that checks the answers given using each one of the supported html form objects and (iii) the specific marking routine that provides the answers to the specific test to the other two. The marking agent produces a marking report that contains both the students' answers and the automated comments and marks. For purposes of this study, this report was inspected and verified for each student by the instructor responsible for the particular course.

4 Pilot application of the e-Xaminer program

4.1 Problems detected

So far the e-Xaminer has been used to carry out exams on various classes of the Div. of Computer Engineering & Information Science, such as Microprocessors, programming Languages and Computer Networks. The results were encouraging. The pilot use has helped us correct some bugs, enrich the program to cover more types of questions and make it more robust. During the first tests, some unexpected problems were encountered:

- i. The e-Xaminer could not detect some specific keywords in the answer, because they were misprinted.

- ii. the e-Xaminer could not detect some specific keywords in the answer, because examinee used alternative words.
- iii. The approach of searching for keywords as a means of assessing the validity of answers, partially fails when the answer demands that a keyword appear more than once (e.g. an answer containing both the "connection" and "connection layer" keywords.)

4.2 Proposed solutions

In Greek there are often many different ways one can write a word, although only one of them is correct. This leads easily to misspelling. The solution proposed to problem no.1 above was to give guidelines to our students to check their spelling using an (electronic) dictionary.

Solution to problem no.2 was to enrich the model answers of the e-Xaminer with many alternative terms (synonyms). The pilot application of the e-Xaminer showed that as the examiners build up experience, they are able to set keywords that are successful with the entire range of students answers.

A solution to problem no.3 above could be to include:

- i. A keyword near keyword criterion
- ii. A multiple instance keyword criterion
- iii. Linguistic criteria,

for assessing answers. This problem will be one of the targets for future work of this research.

In any case, experience so far has shown that all possible problems can be overcome by the examiner's ability to review the marking reports and iterate marking process with new criteria.

5 Future extensions of the program

5.1 Further improvements

The e-Xaminer has been used for midterm examinations of 1st, 2nd, 3rd and 4th-year students of the Hellenic Air-Force Academy during the current academic year. The system will be further developed so as:

1. To improve the marking mechanism for keyword type answers.
2. To include a **timer**, which will automatically submit the test when a pre-specified time has elapsed. This module may also contain a timer applet for the examinee.
3. To enrich the marking agent so that it will automatically calculate **statistics** for each

test.

4. To tighten security so as to avoid having students gaining access to other students' answers [15].
5. To strengthen security and fight cheating attempts, we shall add a registration module; the user will first pass through a login and a logout process when he/she submits the form or an auto-logout process when the time expires.

The e-Xaminer will continue to be used for exams during the next academic year. It is intended that a GUI is built, which will make the introduction of questions easier.

5.2 Application in e-Learning

Continuing education is well established within the Hellenic Air Force Academy, but is currently implemented by conventional methods. These methods require officers to leave their posts (and homes) for months, creating various problems. The authors believe that the employment of e-Learning can solve many problems created by the conventional continuing education methods and also save a considerable amount of money for the Hellenic Air Force.

Computer and telecom networks are rapidly growing today. New applications, new services and new protocols are announced every month, creating new knowledge & outdated old stuff. For continuing education purposes, the Division of Computer Engineering & Information Science of the Hellenic Air Force Academy has developed a post-graduate course presenting a lot innovations on Computer Networks developed during the last nine years [1], [2]. It is our ambition to offer this course via the web site of the Hellenic Air Force Academy.

6 Synopsis

The aims of the pilot e-Xaminer program presented in this paper are twofold: first, to aid the educational tasks at the Hellenic Air Force Academy with automatic tests and grading, using our intranet; and second, to complete our pilot e-learning program for the continuing education of the Hellenic Air Force Officers in the area of Computer Networks. e-Xaminer supports a variety of questions and is easy to use. Experimental results are encouraging and have helped us to correct some bugs. Some more improvements are straightforward and have been programmed for the next months.

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