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Secure Online Testing System for LMS Moodle

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Abstract

In recent years e-learning systems have widely been used, which raised some security issues. One of these issues is the problem of providing secure online testings, quizzes and exams. Usually such problems are resolved with specially equipped exam-rooms. In Armenia providing such exam-rooms to large number of students is an expensive solution. In this paper an application of new environment is proposed and described, which will make possible to use other computers. The idea is to lock down the students' computers, so during the exam they have no opportunity to use the internet, external memory cards, files located on computer's HDDs or other sources of information. There is no need to have big test-rooms with expensive equipment, when using this environment. An online exam environment is developed, which ensures secure online testing from the students' computers, so that no local program or information can be used during the exam. The system operates independently of computer's operation system, without making any program changes.

Keywords: E-learning security, Online exam, Learning management system (LMS).

1. Introduction

E-learning is an inclusive term that describes educational technology, which electronically or technologically supports learning and teaching. Bernard Luskin, a pioneer of e-learning, advocates that the "e" should be interpreted to mean "exciting, energetic, enthusiastic, emotional, extended, excellent, and educational" in addition to "electronic". Developments in internet and multimedia technologies are the basic enabler of e-learning, with consulting, content, technologies, services and support being identified as the five key sectors of e-learning industry [1].

Using the traditional examination methods, the lecturer faces a number of time-consuming activities, such as compilation of nonrepeating examination cards out of a specific list of questions, changing of the order of right answers and estimation of results. International scientific-educational center at the National Academy of Sciences of the Republic of Armenia (ISEC NAS RA) suggests people to get e-learning education, due to which the trainings are available to students who live in different regions of Armenia and even beyond the republic (http://vle.sci.am/, http://isec.am/).

As an e-learning environment, the LMS Moodle is used in International scientific-educational center at the National Academy of Sciences of the Republic of Armenia (ISEC

NAS RA). Usage of testing modules included in LMS Moodle considerably simplifies the compilation of examination cards. Random selection of questions from a database of questions, compilation of examination cards and estimation of examination results is automated. While using e-learning systems, some security issues arise. One of these issues is the problem of providing secure online testings, quizzes and exams.

Main solution in organizing secure online examinations is creating specially equipped testing rooms. However, in the case of a significant number of exam takers, the specially equipped rooms are associated with a lot of expenses. To avoid that kind of expenses, a system was developed, which will make possible to use the students' computers for taking online exams. This system we called "Online Exam Environment" (OEE). Usage of the participants' computers during online examination is leading to a number of problems, such as data disclosure, the opportunity to use the information stored in the computer, the opportunity to use the internet, etc. [2]. The purpose of this investigation is to create a secure environment, which will provide the exam takers an access to using necessary softwares during testing, meantime blocking the opportunity to use any other softwares, sources of information, internet, etc. While using the students' devices, security problems may occur during online testing, which will be presented below [3].

2. Risks of Online Testing

During the analysis of security risks of online exams using students' devices the following major threats may occur [4]:

- Mismanagement: A lot of tools and services are used for preparation, compilation, realization, taking, estimation, preservation and security of online tests. Probability of mismanagement is quite high. With literate usage of LMS tools and resources, it is possible to reduce risks and to conduct online exams without problems. Test management system includes not only online software tools, but also defines procedures for lecturers, exam takers and those carrying out maintenance.

- Impostors: Such risks could be prevented by means of face-to-face checking. Technical checking might be done only by means of biometric measurements, which is not available in all systems. Combination of login and password of the user may be a solution, but the students could give a wrong information, if someone else takes the exam instead of them.

- Computer Misuse: This risk is the main obstacle related to students' computers in exams. The developing of the OEE ensures that no local program or information can be used during the exams.

- Using unauthorized materials: After prohibiting the use of local information, the use of other materials such as notebooks, references and copybooks is prevented by individual control during the exams.

- Conspiring: The attempts of assisting the exam taker can only be prevented by individual control. The regulations concerning the exchange of notes, going out etc. are the same as for written exams.

- Disclosure of Test Data: The disclosure of Test Data poses a real risk to every exam, especially if there are several examination rooms. No one can prohibit the students from remembering the exam tasks, nevertheless the great number of tasks and the high possibility of confusing the answers may reduce this risk [5].

- Hacking: In this case, the main threat is the stealing of information from the Test System. There is no system absolutely safe from hacking. It is only possible to increase the time required for entering the system and stealing the information.

- Test leakage: An acute risk is test leakage, especially for the same time tests [6]. Although testes can (try to) memorize (some of) the closed test's content, at least they should not be able to compromise it at test time.

- Cheating: While many studies have been conducted to determine the state of cheating in traditional courses, few have focused solely on online classes. Many believe that an online class lends itself more easily to cheating due to the lack of face-to-face contact between the students and the instructor [7].

3. Organizational Matters

For the development of OEE, it is necessary to collect organizational requirements and general terms.

Test Preparation: One of the important phases of an online-examination is Test Preparation. The lectures should be transmitted to the Department of Education. At the preparation of online-examinations, several parameters are considered: not only the type and structure of tasks should be taken into account, but also the number of test takers. There are several ways of confusing the tasks and answers, so that viewing other students' laptops cannot be useful. Many lecturers use question databases, which can be applied during an exam. Moodle provides an opportunity for random selection of 30 tasks from 100 tasks available on the database. Some special tasks can be inserted into all tests, so that there will be 30 randomly selected tasks and 5 tasks selected by students. If the lecturer decides to mix the questions and answers, five special questions could appear any time among 30 tasks. It is recommended to insert maximum two questions on each page.

Availability problems during the exam: The most serious problem at an online-examination is the computer breakdown. On Moodle there is a "save without confirming"-icon on each page. Because of the students' stress during the exam, they usually forget to click that icon, which will result in loss of their work in case of a computer breakdown. This failure can be prevented by placing one question on each page. Before going to the next or previous page it is necessary to press the "save without confirming"-icon. In this way students automatically save their answers when going from one page to another. This would be impossible if all questions were on the same page.

Possible Misuse: In order to prevent possible misuse there should be an individual control. Invigilators should verify that the number of students corresponds with the request number. The verification of students can be conducted with the aid of a register. This method of verification can prevent the possible misuse except for impostors. The latter can be revealed only by individual control.

Test Accomplishment: This phase requires most of the resources. The OEE system

should be booted from external drives, such as USB, DVD or PXE (Preboot Execution Environment). The students should register themselves and get computers, unless they do not want to use their own laptops. If the examination takes place in a lecture room, the cables should be connected before the start of examination and removed after it. The most difficult part of an examination in technical terms is booting from PXE, USB and DVD drives. For OEE the students can register their laptops in advance. At the registration place they get assistance about how to install the system properly and whether the program functions normally on their computer or not. Tool requirements are rather low, but a memory of 1.5 GB RAM is needed to prepare OEE. However, 1 GB memory is enough; in that case, both the boot process as well as the usage speed of the third party programs of the OEE will slow down.

After examination: If all the questions could be checked and estimated automatically, the lecturer may decide to announce the results as soon as they will be approved. Moodle gives different opportunities to publish the results. For example, the students can only see their scored points and/or all the answered questions. The classification of questions can show what questions could possibly be answered right.

Immediately after the examination, the technical support team collects the computers, USB and DVD drives, after that the students must be deregistered from the exam.

4. The Online Exam Environment

There are many solutions, which will help to block the system so that it will allow using only some programs or web sites. Such solutions might be undesirable, and the installation of any program to the personal computer of the student might cause some problems. Besides the legal problems, the number of personnel required for technical maintenance should be more than they usually work in the IT department of any organization.

After studying the existing blocking systems, it was decided to design such a system, which will operate independently of computer's operating system, without making any program changes in the current operating system. This system could operate (Boot) from USB flash drive, DVD disk or RXE server. The system will block access to the information saved in the computer. Software SEB (Safe Exam Browser) is integrated in the system designed for safe operation.

Stand-alone OEE system is designed based on Debian Linux Distribution. Debian Live operating system boots from USB flash drive, DVD disk or RXE server. The software and abilities available in Debian Live operating system were fitted to the requirements of OEE with the tools provided by The Live System Project (live.debian.net).

5. Security Concepts and Limitations

As it is known cheating, rewriting, copying are the biggest problems of classical examination. The organizers must prevent the direct contact between the students during the examination, and using of pre-installed information in the computer and USB flash drives must be prevented applying technical means. Except the online examination, Moodle has an opportunity of chat and instant messaging, but SEB browser blocks them by default. Therefore, OEE system, constructed by us, has the following security providing features:

- Customized Debian live CD provides recognition of almost all the computers and block of using data existing in computer.
- Student's entrance to internet and other systems in the same network, except the Moodle server, is blocked by firewall existing in Debian Live CD. Applying SEB browser integrated into Moodle, which limits using of services provided by Moodle.
- There are installed free softwares in the system such as Foxit Reader, Libre Office etc.

To start the exam the student must complete the following steps:

- Connect the computer to the LAN of exam-room.
- Boot Debian Live CD from USB, DVD or PXE from server.
- After testing of system elements and validation of network connection Debian automatically boots up virtual windows XP. Windows XP runs SEB and interconnects with scientific-educational Moodle server.
- Student inserts his login and password, then chooses the corresponding examination.

The Debian firewall concepts:

- All incoming traffic is blocked by default.
- All outgoing traffic is blocked by default.
- Only HTTP traffic is allowed to the Moodle server of scientific-educational center.
- Ping packets are allowed to the Moodle server of scientific-educational center.

Before connecting to virtual XP, OEE system checks interconnection of student's Computer and Moodle server for checking network connections. This process is accompanied with corresponding precautionary records showing on computer screen. If OEE is connected with Moodle server, the operation system will execute XEN virtual machine and the latter will execute Windows XP. Windows XP integrated in OEE system is also adapted to the OEE requirements, to reduce its volume and to make it work as faster as possible. After starting of Windows XP, SEB system starts and immediately is connected with the Moodle server. General construction of OEE system is depicted in Figure 1.

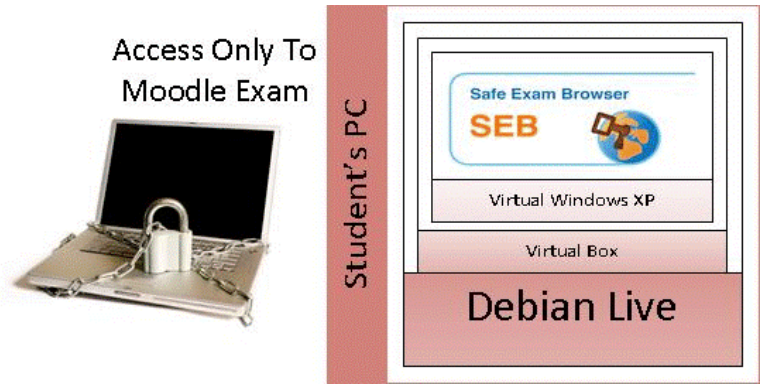

Fig. 1 Infrastructure of OEE PC.

OEE system includes varied tools that enable lockdown of the desktop, operating system, and Web Browser. The idea is to flexibly restrict or completely disable the testees' access to the compromising functionalities of these resources. Besides the access to the test questions and use of authorized files or tools (e.g., word processing, spreadsheet analysis), the OEE system secures the testing PC by preventing print, capture, copy, or access to other locally stored or Web accessible files and programs.

OEE system disables (if not restricts) the following functionalities:

- Cut/copy/paste of data to/from the testing environment.
- Screen capture/printing functions Control/function keys/shortcuts Task/application start/access/switch Right-click menu options Menu options or icon activation Setting of PC date/time Pop-up windows (Don't you need to put commas between them?).
- Messaging, screen sharing, network monitoring.
- Searching/surfing the Web.
- Browser menu and toolbar options with possible exception for Back/Forward/Refresh/Stop.
- HTML source code viewing.
- Cache/store of pages in history/search listings.
- The test questions are displayed in a full-screen mode that cannot be minimized.
- Clearing of any cookies, caches, and temporary files at test session end.

6. Operational Stability and Safety

Classical examination processes do not depend on informational technologies and availability of systems. Nevertheless, in case of online examination, network connection and computer malfunction can be arisen. In case of malfunction of any subsystem, the answered questions are kept in Moodle system, and in case of any problem, the student can continue the examination by another system. The answers to the questions, given by the students, and their marks are kept in Moodle system and are not available for the other students. The connection between SEB and Moodle is made encrypted by HTTPS, which protects personal data from villains during network sniffing.

7. Network and Server Part

For applying SEB in OEE system, it should be held in certain conditions. Stating from Moodle 1.9 version SEB is integrated in Moodle and can be used without any additions. While creating an exam in Moodle system it should enable an addition "Require the Sale Exam Browser", which is one of the functions of ensuring security. By enabling this addition, the entrance to examination is blocked from the computers, in which SEB Software is not installed. As the time of exam is announced, any person who has SEB can enter into the digital system regardless of his location. It can use additional limits of entrance into

system and can be allowed from the certain IP addresses. In comparison with cable network connections, wireless technologies are not secure, that is why in order to provide high level security it is important to use cable connections. In the case of cable infrastructure all the IP addresses that are not allowed to be connected to the exam system, may be blocked. Only the computers, which are in the exam room, are connected to the cable network, in which SEB program is installed, can take part in the exam?. The lessons installed in the Moodle system can be available for everybody but the entrance into exam can be limited physically depending on the system demands and internal limitation of LMS Moodle.

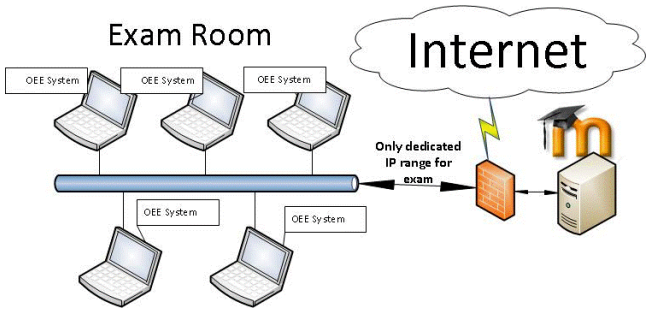

Fig. 2 Exam room network structure.

As it is introduced on Figure 2, the entrance into exam is possible if the following conditions are satisfied:

- Computer works in the OEE with SEB installed;
- Computer is physically connected to the cable network of exam room;
- During the exam Moodle system must answer to computers with dedicated IP addresses.

8. Softwares and Applications in Exam

Spreadsheet counting programs such as MS Excel, OpenOffice Calc and Libreoffice Calc are widely used during the lessons. It is impossible to check the skills of students operatively without using such programs during the written exams. It will be possible during the online exams if the demanded program is installed in the OEE system. As we know the existing software and data are not accessible in OEE environment execution, as they disallow the computer's unnecessary abilities. Therefore, all necessary software must be registered in OEE environment, which will be executed by students. For switching from Moodle test to another allowed and available software, ALT+TAB combination must be submitted, the function of which is the same as in Windows environment. The mentioned button combination in OEE environment will allow switching to another program, which has been chosen by the teacher beforehand.

According to the demand of lecturer Libre Office, Open Office, Java Runtime are integrated in OEE environment. Usage of additional programs by pressing ALT+TAB is blocked by default. Their usage becomes possible by the demand of lecturer after definite changes. When pressing ALT+TAB buttons, Popup window opens where accessible applications are shown.

As it is known, Moodle system does not give opportunity to download any file during the exam. If the lecturer demands to use any file from Moodle system during the exam,

the student must download it before the exam. First, it is important to execute OEE environment, to enter the Moodle system, download the needed file and save it on the desktop of computer. During the exam in order to use the downloaded file, the student must press ALT+TAB button, choose the suitable software from the opened popup window, which can use the mentioned file. This mechanism is applied for pdf, xls, xlsx, java, javac and for files, having another extension.

Foxit Reader and Cool PDF Reader softwares are installed for using files, having a PDF extension.

9. Conclusion

An online exam environment is developed, which ensures secure online testing from students' computers, so that no local program or information can be used during the exam. The system operates independently of computer's operation system, without making any program changes. The OEE system is implemented in e-learning system of International scientific-educational center at the National Academy of Sciences of the Republic of Armenia. The OEE can operate within LMS Moodle and LMS ILIAS.

References

[1] A. Nagy, P. Bruck, A. Buchholz, Z. Karssen and A. Zerfass, "The impact of e-Learning", *Technologies and Perspectives for the European Market*, Berlin, Springer-Verlag, pp. 79-96, 2005.

[2] E. Weippl, *Security in E-Learning (Advances in Information Security)*, Springer, 2005.

[3] D. Bartram and R. Hambleton, *Computer-Based Testing and the Internet: Issues and Advances*, John Wiley & Sons, 2008.

[4] J. Frank, "Dependable distributed testing - Can the online proctor be reliably computerized?," *ICETE 2010 Intl. Conf. on e-Business and Telecommunications, ICE-B Track*, 22-31, July 2010.

[5] G. King, R. Guyette and C. Piotrowski, "Online exams and cheating: An empirical analysis of business students' views", *The Journal of Educators Online*, vol. 6, no. 1, pp. 1-11, 2009.

[6] L. Stanculea and E. Marin Popa, "What is good e-Learning?", *International Journal Economics and Research*, vol 3, no. 4, pp. 1-9, 2012.

[7] L. McNabb and A. Olmstead, "Communities of integrity in online courses: faculty member beliefs and strategies", *MERLOT Journal of Online Learning and Teaching*, vol. 5, no. 2, pp. 208–221, 2009.

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Անվտանգ առցանց քննություն LMS MOODLE համակարգում

Վ. Առաքելյան

Ամփոփում

Մշակվել է առցանց քննական միջավայր, որը ապահովում է անվտանգ առցանց քննությունների անցկացումը ուսանողների համակարգիչների միջոցով: Համակարգչում գտնվող ոչ մի տվյալից կամ տեղադրված ծրագրային ապահովումից հնարավոր չէ օգտվել քննության ընթացքում: Քննական միջավայրը գործարկվում է համակարգչի օպերացիոն համակարգից անկախ, համակարգչում առանց որև է փոփոխություն կատարելու: Առցանց քննական միջավայրը կարող է կիրառվել LMS Moodle և LMS ILIAS համակարգերի հետ:

Безопасный онлайн экзамен в среде LMS MOODLE

В. Аракелян

Аннотация

Последние годы широко используются системы э-обучения, что приводит к возникновению некоторых проблем безопасности. Один из таких проблем является обеспечение безопасных онлайн тестирований. Обычно такие проблемы решаются с помощью специально оборудованных экзаменационных комнат. В Армении, предоставление таких экзаменационных комнат при большом количестве студентов является дорогим решением. Идея заключается в том, чтобы заблокировать компьютеры студентов, чтобы во время экзамена они не имели возможности использовать интернет, внешние карты памяти, файлы, хранящиеся на жестких дисках компьютера или другие источники информации. Нет необходимости иметь большие экзаменационные комнаты с дорогим оборудованием, при использовании этой среды. Разработана среда, которая обеспечивает безопасный онлайн экзамен с компьютеров студентов, так что никакая информация или местная программа не могла использоваться во время экзамена. Система работает независимо от операционной системы компьютера, без каких-либо изменений программы.