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## Dependable e-learning systems

Ali Al-Dahoud<sup>1</sup>, Marek Woda<sup>2</sup> and Tomasz Walkowiak<sup>2</sup>

<sup>1</sup>*Al-Zaytoonah University, Jordan, [aldahoud@alzaytoonah.edu.jo](mailto:aldahoud@alzaytoonah.edu.jo)*

<sup>2</sup>*Institute of Computer Engineering, Control and Robotics  
Wroclaw University of Technology, Poland, [Tomasz.Walkowiak@pwr.wroc.pl](mailto:Tomasz.Walkowiak@pwr.wroc.pl),  
[Marek.woda@pwr.wroc.pl](mailto:Marek.woda@pwr.wroc.pl)*

### 1. Introduction

Education in nowadays fast changing world is a very important aspect. The need of gaining more professional knowledge, shortening the time available for stationary methods of learning (esp. when somebody works) resulted in the development of distant learning methods [UNDP, 2002]. In a more widely usage of internet and development of internet based techniques for distributing multimedia materials a modern distant learning [M. Woda, 2006] is commonly known as e-learning.

E-learning is being more willingly and widely employed [W. Baranski W., Walkowiak T., 2003],[Ch. Dean, 2002]. Therefore, in an effort to diversify this form of sharing knowledge, it is common to use various available tools given by the available technology. We can safely say that Internet is at present the most interesting and dynamically expanding medium for providing educational contents in a truly distributed fashion for different actors.

E-learning becomes also very important for traditional universities. On one hand development of e-learning gives universities opportunity to reach potential wider audience. On the other there is a large need from students for supporting traditional way of teaching by a internet based one (so called blending learning).

During the last decade necessity of education, that facilitate gaining new abilities in IT and High Tech related professions, was exposed. The job market situation constantly changes; this state enforces constant skill improvement and also people retraining whose jobs are being replaced by automated processes. A lot of universities create new educational services based on different e-learning solutions. This situation resulted in growing interest of jobless community and youth toward alternative forms of learning. This form of teaching, when well organized, gives new undisputed opportunities for many social strata.

Despite of the fact that e-learning already proved its great usefulness, it suffers from many childlike deficiencies. We can count, among other things, to these drawbacks lack of the coherent vision for learning process accomplishment, practical guidelines how to organize consistent learning content. Due to these disadvantages e-learning is being perceived ambiguously and incorrectly implemented in e-systems, which leads to limitation its reliability. Usually, in reality, theory and practice are not on the par, same situation is clearly visible in e-learning theory and its implementations. In e-learning, whole pressure was put on the theory of learning, and there is no restrictions or even practical guidelines

present in field of its technology and implementations, which in many cases has negative influence on newly developed e-systems. Currently, most of the college teachers, government and many schools notice the need of standardization and rationalization this type of teaching. More and more is being told about so called e-education systems. Therefore, in this paper we would like to focus on technical aspects of e-learning i.e. e-learning systems.

From the point of view of computer engineering nowadays e-learning systems are examples of a web base application and us other information systems it's dependability aspects are very important. Dependability evaluation of e-learning in general, ought to be based rely on following pillars: (high) availability, usability, scalability, interoperability, stability and security [J. Hall, 2004 ].

## 2. Important

This work is devoted to dependability aspect of e-learning systems. Authors present technical aspects of the software part of e-learning systems (e-learning platforms, distant lectures, multimedia presentations and virtual laboratories). Next, a high availability approach to hardware part is discussed. It is followed by a short analysis of several dependability aspects (availability, usability, scalability, interoperability, stability and security) with a conclusion that business continuity is a crucial factor. Therefore, the analysis of the e-learning system monitoring techniques is given. It is followed by a proposition of a new technique of monitoring: the virtual user representative. At the end original and inexpensive method of lectures is presented.

## 3. E-learning systems

The core of each e-learning system is an e-learning platform. This is a tool that is a virtual equivalent of a university (understood as institution, facility) that has to meet four essential functions as: student's management, dissemination of knowledge, testing progress of its absorption and communication between e-learning process actors (students and teachers).

On one hand there exist a large number of e-learning platforms to mention only: Learning Environment Online (LEO), IBM Lotus Learning Management System, Blackboard Learning System, TopCalss e-Learning Suite, WebCT Campus Edition, R5, Oracle i-Learning, Manhattan Virtual Classroom, Moodle. On the other one can noticed a large integration of e-learning platform market. In case of commercial products and the university like education Blackboard Inc. after fusion with WebCT is a leading producer of e-learning platforms with really no competitors. In case of company training the leading products are by IBM and Oracle. Whereas the open-source leader is Moodle.

All modern e-learning platforms are a three tier Internet application. The uses HTML with CSS and JacaScript for a user interface. In the middle tier a large number of script languages are used, for example: Perl (WebCT), ASP (R5), PHP (Moodle) or JSP (Lotus LearningSpace). In the data tier a large number of different database systems are used. In case of Open Source products the most popular are MySQL or PostgreSQL (Moodle), among commercial ones Oracle (Oracle i-Learning), MS SQL (Blackboard, TopClass) or IBM DB2 (Lotus LearningSpace).

E-learning platforms can be deployed enterprise-wide to supplement the traditional classroom or for pure distance programs. Use of them allows the university to efficiently leverage campus resources to both extend their offerings and enhance the teaching and learning experience. One of the many benefits of using e-learning platforms includes the ability to offer an "always on" environment, providing more time for the student to interact with professors and classmates as well as with the course material in an efficient, engaging and effective manner. Moreover, their functionality allows to perform self test and quizzes allowing to check the level of the student knowledge.

Other elements of e-learning systems like multimedia presentations, recorded lectures and virtual laboratories are launched from inside the e-learning platforms. In case of multimedia presentations Adobe products like Authorware and Flash are the most popular. Delivering lectures through internet is based on media-streaming technologies (Microsoft Windows Media, RealNetworks, Quicktime, Flash Media Streaming) or Adobe FLV video format. Virtual laboratories [T. Walkowiak, 2005] could be developed in two different way by a designing a simulator in general purpose language or by a usage of a general purpose simulation software. The first solution is usually based on Java technology. The second uses general purpose software that allows to simulate complex systems like LabView, Matlab, Mathematica , MathCAD or Maple.

To summaries e-learning systems uses a large number of different software technologies. Moreover, an e-learning system provides the platform for the enterprise's online learning environment by enabling the management, delivery and tracking of blended learning (i.e., online and traditional classroom) for employees, and customers. Therefore, a robust e-learning system should integrate with other systems, so administrative and supervisory tasks can be streamlined and automated and the overall cost and impact of education can be tracked and quantified [J. Hall, 2004 ].

#### **4. Model of high-availability e-learning system**

To meet these nowadays requirements, an e-learning solution must be based on a scalable hardware and software architecture that can be easily optimized to deliver high performance while improving the utilization of IT resources and reducing power, cooling and floor space requirements.

The numerous core e-learning services require multiple computing platforms to meet various needs of multiple commercial and open source systems, while the internal operations typically need OS environment including an email server and a file server, resulting in a wide range of computer hardware and software. Therefore, these diverse computing needs cause a complex computing environment, where a wide range of hardware, operating systems (OS), and applications co-exist [Y. Han, 2004 ]. Such environment requires choosing the right hardware to support and maintain business continuity of the system.

Most of the e-learning system implementation is being based on one of the following models:

Cost Performance Model - which was designed for cost-conscious learning institutions looking for the best performing system at an affordable pricing structure. It is not a minimum requirement, but rather a recommendation that will support cost concerns institutions while efficiently supporting their usage and load.

High-Performance – aimed at institutions, primarily concerned with performance over cost. Most configurations consist of highly-available recommendations. The purpose for multiple servers at the various tiers within the technology stack is to support distributed, parallel processing.

High-Availability Model – aimed at institutions primarily concerned with uptime and availability. Highly-available models can be cost conscientious and/or high-performing.

In this chapter will focus on last model. Right choice for a suitable hardware for e-learning system for an organization could be really a challenging task. Now, we may present some advice that might be worth to consider. There are a number of vital questions to ask, but given below are ones that must be asked:

Users influx and increase of courses within the institution;

Archive strategy, meaning the removal of data from the system that no longer applies/valid;

Lease or purchase terms on equipment (hardware is typically turned over every x academics years);

Concurrency of user community (number of online concurrent user);

System performance expectations;

Expected availability / redundancy expectations.

Generally speaking, high availability system should be resilient to common failures (system as a whole should be resilient not its components), easily maintainable should provide alerting / monitoring mechanisms that allow to warn when system enters in danger state to prevent its collapse. It has to support recovery automation after an outage and have built-in procedures that prevent unrecoverable data lost.

E-learning system that could be called dependable should meet number requirements as [Optimizing eLearning, 2007]:

High service levels—Systems must operate 24X7 with little downtime, planned or unplanned and must be able handle spikes in user demand without degrading response time;

Low TCO—Systems must be cost-effective to own and manage when considering; everything from hardware and software license costs to the system's impact on datacenter power and cooling costs;

Scalability – With a growing population of students and an ever-growing demand; for online delivery, the eLearning infrastructure must be easy to scale in support of higher levels of throughput, more users and more online courses;

Easy to manage – With limited IT staff to assign to the project, it must be easy to deploy and manage the solution so that service levels can be met without an extensive IT staff.

High reliability unfortunately is tightly connected with initial cost, which is usually very steep. By with passing of time, the cost incurred, will bring massive savings, due to low maintenance and exploitation costs and for unparalleled reliability (hardware redundancy, which reduce the downtime by allowing for component replacement without entire system turn off).



## 5. Dependability aspects of e-learning systems

E-learning system must be robust enough to serve the diverse needs of thousands of learners, administrators, content builders and instructors simultaneously (availability).

The infrastructure should be flexible enough to support future system growth, both in terms of the materials size number of students (scalability).

In order to support a number of highly personalized services, such as self-paced and role-specific learning, the access, delivery and presentation of material must be prepared in easy to use and highly intuitive way (usability).

To cope with a common problem how to join a content from different sources and multiple vendors hardware/software solutions, e-learning system ought be based on widely known, accepted and what is most important open, industry standards, like Web based one (XML, SOAP, JAVA, EJB) and support the major learning standards (AICC, SCORM, IMS and IEEE) (interoperability).

Since e-learning system main tasks are to reliably and effectively manage a huge datasets and provide hassle free access for numerous users from a different time zones it should be able to run outages free twenty four hours per week (stability).

One of the key aspects of e-learning, and very often neglected or forgotten is confidentiality / security. Each e-learning system must provide essential security mechanism that prevent from identity theft, frauds, system misuse or personality spoofing (Security).

## 6. Monitoring for dependability analysis

One of major concerns in e-learning is to have the working system, and prevent outages or slowdowns since it has a great impact on learners. Since business continuity of e-learning system is crucial factor, all the underlying services may not be disturbed in any manner. Therefore many precautions should be undertaken. And versatile safety measures should be involved to keep the system in a working state. Any unexpected system behaviors are reflected in stress for users, and in the end impact their learning experience. Therefore, there continuous monitoring of the e-learning system is a very important aspects.

With improvement of administration in mind, many software companies offer commercial tools for network monitoring. One of the most advanced monitoring tools is IBM Tivoli Monitoring. This is very complex platform that provides professional tools for gathering data and presents it to administrator in very convenient graphical diagrams. This feature helps to have a quick view of what is happening on the network. This software is also supplied with special feature that may inform administrator about any threats like i.e. bottlenecks. Additionally Tivoli makes possible to use gathered data in data mining researches because all data are stored in data bases. Tivoli architecture is divided in three layer with top level manager, through middle layer to low level agent layer. It provides support for Windows and UNIX like platforms and has very professional help desk support from IBM.

Other solutions are not as advanced as IBM Tivoli software, however there is some interesting software like OpManager (<http://manageengine.adventnet.com/products/opmanager>) that provides interface for monitoring network traffic, CPU usage, memory and disk usage. It can also generate daily (weekly) statistics. Producer assures that it can cooperate with SNMPTRAP mechanism that makes possible to supervise system, by receiving information from SNMP server. According to data from product web site, there is

free version of this software. However, it does not contain any interesting features like mentioned SNMPTRAP handling, report generation or CPU usage monitoring.

AdRem NetCrunch (<http://www.adrem.com.pl/netcrunch>) is another monitoring platform. This system is dedicated for network data analyzing basing on SNMP protocol. It makes possible to gather system statistics characteristic for monitored workstation (i.e. memory usage). It available many interesting features like physical and logical topology recognition. This is achieved through ICMP scanning and SNMPGET queries. It is also supplied with alert mechanism, a dedicated event manager that handles with events like network interface state monitoring or filtering syslog - logs exchange standard in IP networks. Moreover it has very well developed network monitoring interface, among other things capacity monitoring. Still this product has its disadvantages. System statistics are gathered by enquiring other devices, except SNMPTRAPS that are triggered from SNMP servers.

From free software there are usually local applications like top - a command line tool that presents system statistics of the local workstation for Linux/Unix or Task Manager for Windows. There is also network version of the top application called RPCTOP, however like original top it can only read CPU and memory usage.

The main player on open-source market of network management software (which has network monitoring capability) is OpenNMS (<http://www.openms.org/>). OpenNMS is a truly distributed, scalable platform for all aspects of the FCAPS network management model (FCAPS is a network management functional model defined by ITU-T and ISO in specification M.3400 - <http://www.itu.int>). Currently, OpenNMS focuses on three main areas:

Service Polling - determining service availability and reporting on same.

Data Collection - collecting, storing and reporting on network information as well as generating thresholds.

Event and Notification Management - receiving events, both internal and external, and using those events to feed a robust notification system, including escalation.

All mentioned commercial and free products can, and are applied for monitoring e-learning system. However, all of them have one important drawback - they monitor the system from the inside. In case of many information systems and especially in case of e-learning systems the most important are users. It could happen that the system is operating well from the inside but could be not accessed from Internet, for example in case of some error in external DNS system. Therefore there is large need to monitor the e-learning system from the outside. Authors proposed the use a User Virtual Representatives (UVR) [M. Woda, T. Walkowiak, 2007]. It functions as a substitutes of a user, acts like human users, perform regular human actions in pursue to detect service unavailability. When service, which agent is ascribed to, is no longer responding, and UVR agent give can't itself recognize the culprit, it could give commands to lower tier monitoring agents in order to recognize the situation, which of component services.

## 7. The low-cost and universal approach to reliable lectures delivery

One of the most important ways of teaching is a lecture. In the case of distant learning, usually, TV transmission or video tape is used. Nowadays, DVD discs or internet transmissions using streaming servers are rather more common.

Currently, the most popular form of lecture is slide presentation, where whiteboards or multimedia animations are very rarely present. So, to make from such lecture from multimedia e-learning material, only the lecturer has to be recorded. Presented slides can be taken directly from power-point presentation or pdf (or other) files. In this chapter, the authors present an approach to produce internet lectures in a simple and inexpensive way.

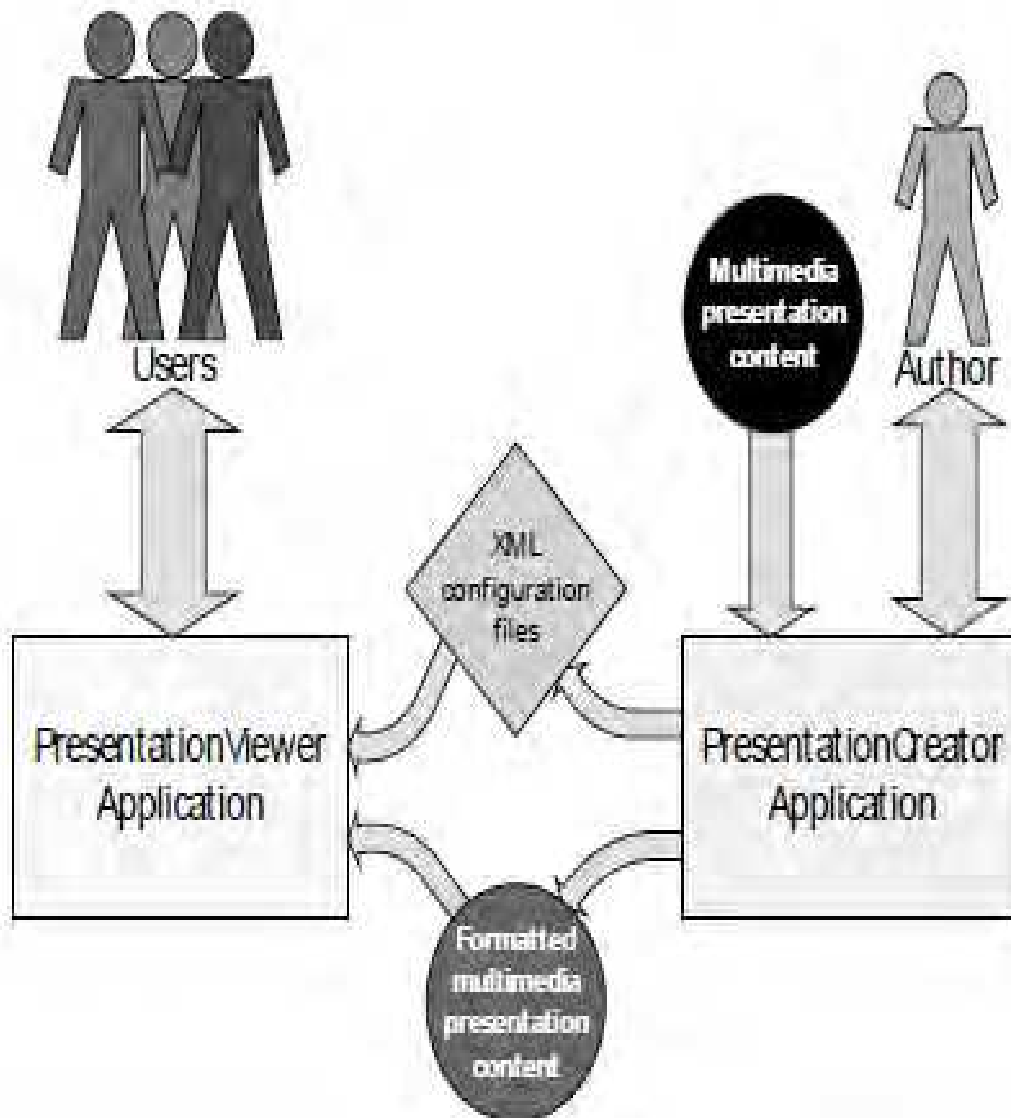


Fig. 1. Solution architecture

Two applications have been developed: PresentationViewer and PresentationCreator. The first of them allows users to explore and watch multimedia lectures. The second application helps lecture authors to save their lecture recordings and slides as the PresentationViewer



application content and makes possible to easily configure the look and feel of the PresentationViewer.

In some aspects, it is similar to the approach taken in ([Dean, Ch. 2002],[ English, J., 2006]), but it does have more functionalities and does not need any, especially commercial, streaming server. It uses new technology: Adobe Flash 8 environment. The authors assumed that the internet lecture should be available for everyone who has internet connection, without any additional software. Due to Adobe Flash environment, the PresentationViewer application was created. It meets requirements and is easy to use. Even adding new content to the PresentationViewer application or configuring it to users' preferences is very simple and fast due to XML based configuration files and thanks to the authors who created this user-friendly PresentationCreator application. Thanks to Adobe FLV video format, the authors avoided using streaming servers and any commercial applications that would have been possible needed to convert standard AVI video files to streaming formats. FLV video files can be placed even on the simplest HTTP server and play in Flash application on user side while downloading. The PresentationViewer application uses this feature. Furthermore, no commercial application is needed to convert video files to FLV format.

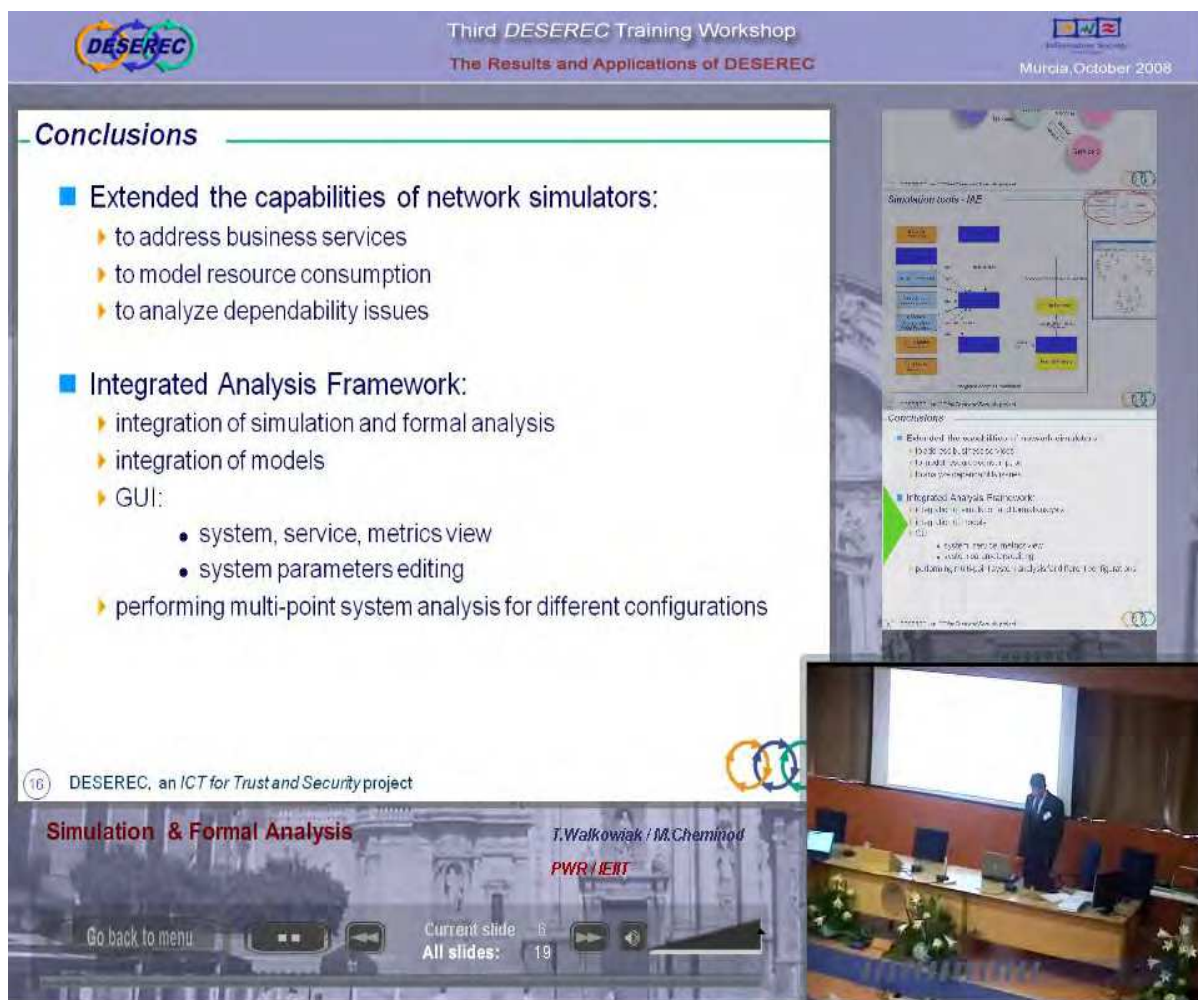


Fig. 2. Example lecture made within Presentation Creator application

## 8. Conclusion

The paper presented dependability aspects (availability, usability, scalability, interoperability, stability and security) of software and hardware components of e-learning systems. The authors proposed the business continuity of e-learning system as a crucial dependability factor. Therefore, the hardware high availability approach was presented and methods of monitoring the underlying services is given.

Authors presented an inexpensive platform for reliable online lectures creation, which assures lectures delivery in timely and desired by a student way, that makes learning more convenient and the same time more efficient.

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This book is consisting of 24 chapters which are focusing on the basic and applied research regarding e-learning systems. Authors made efforts to provide theoretical as well as practical approaches to solve open problems through their elite research work. This book increases knowledge in the following topics such as e-learning, e-Government, Data mining in e-learning based systems, LMS systems, security in e-learning based systems, surveys regarding teachers to use e-learning systems, analysis of intelligent agents using e-learning, assessment methods for e-learning and barriers to use of effective e-learning systems in education. Basically this book is an open platform for creative discussion for future e-learning based systems which are essential to understand for the students, researchers, academic personals and industry related people to enhance their capabilities to capture new ideas and provides valuable solution to an international community.

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