

Strategies for Developing e-LMS for Tanzania Secondary Schools

Ellen A. Kalinga, R. B. Bagile Burchard, and Lena Trojer

Abstract—Tanzania secondary schools in rural areas are geographically and socially isolated, hence face a number of problems in getting learning materials resulting in poor performance in National examinations. E-learning as defined to be the use of information and communication technology (ICT) for supporting the educational processes has motivated Tanzania to apply ICT in its education system. There has been effort to improve secondary school education using ICT through several projects. ICT for e-learning to Tanzania rural secondary school is one of the research projects conceived by the University of Dar-es-Salaam through its College of Engineering and Technology. The main objective of the project is to develop a tool to enable ICT support rural secondary school.

The project is comprehensive with a number of components, one being development of e-learning management system (e-LMS) for Tanzania secondary schools. This paper presents strategies of developing e-LMS. It shows the importance of integrating action research methodology with the modeling methods as presented by model driven architecture (MDA) and the usefulness of Unified Modeling Language (UML) on the issue of modeling. The benefit of MDA will go along with the development based on software development life cycle (SDLC) process, from analysis and requirement phase through design and implementation stages as employed by object oriented system analysis and design approach. The paper also explains the employment of open source code reuse from open source learning platforms for the context sensitive development of the e-LMS for Tanzania secondary schools.

Keywords—Action Research Methodology, OOSA&D, MDA, UML, Open Source LMS.

I. INTRODUCTION

THERE is a lot of results in the field of software engineering concerning the question of how to represent systems and how to build a base for communication between the developer and the user of a software system [24]. In order to manage the return investment in ICT for education, here referred to e-learning management system (e-LMS), it is essential that the benefits, risks and cost effectiveness of using new technology and new media are well understood in the context of application. An effective approach is to involve users in establishing the expected use of ICT and the benefit of it in education.

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The e-LMS to be developed is for Tanzania secondary school members, who many of them are not aware of the ICT technology in education. Modeling methodology is the best way to create visualization of the system to be defined. With modeling, complex and real-world systems can be somehow understood, qualities of the system can be predicted and communication with stakeholders concerning the key characteristics will be promoted [2]. Models are developed as a way of creating a base for implementation of the physical system and testing.

Integrating the action research methodology with the whole issue of employing Model-Driven Architecture is of significance. Action research methodology and modeling support each other, when it comes to the software development for users.

The rest of this paper is organized as follows: section two elaborates on the strategy of using action research methodology in developing e-LMS. Section three focuses on the object oriented system analysis and design (OOSA&D). Section four gives the employment of Model-Driven Architecture and the use of the Unified Modeling Language (UML) as the documentation modeling language specified by OMG. The strategy of creating Platform Independent Model (PIM) for e-LMS and means of transformation of PIM into Platform Specific Model (PSM) is in section five. Another strategy is customization of the selected open source LMS platform based on e-LMS PIM is introduced in section six. Section seven gives the need for replication of the e-LMS database. Finally the paper will give the conclusion.

II. ACTION RESEARCH METHODOLOGY

The knowledge on how ICT and its application can improve social and economical life of people is not very much known to many of the Tanzania community in general. Although Tanzanian secondary schools may have and be in contact with computers, it doesn't mean that they really are aware of the impact of ICT when effectively used towards improving performance. Coming to the issue of developing a LMS for their use, the issue of lack of knowledge if not carefully considered, the utilization of LMS may be very minimal if at all not completely used. The emphasis of action research methodology is to be a methodology which accompanies the introduction of technology as well into organizations and learning. Action research represents a specific form of knowledge generation thus, with its methodology the

understanding of the use of e-LMS will be possible and hence increase assurance towards its utilization.

The importance of considering users in developing computer systems has been recognized since the 1970s (Abel et al, 1998) [1]. O'Brien (2001) [13] stated that action research or sometimes known as participatory research is "learning by doing"—a group of people identify a problem, do something to resolve it, see how successful their efforts were and if not satisfied, try it again. Walker and Hermann [24] also argued that participatory design and continuous business improvement can be brought together in a framework which presents a set of different phases in a cyclic order. In the Nordic countries the "Scandinavian model" was introduced in the middle of the 80s [20], introducing a participatory approach involving users for context sensitive and robust IT system solutions. Coming closer to a sub Sahara African context the action research conducted in the presented project is more likely linked to participatory rural appraisal (PRA) introduced by Chambers (1997) [4] and Rydghagen (2002) [21].

Users mainly students, teachers and school administrators are considered to be the primary source of data in such that they will be involved in the whole process of implementation of e-LMS, starting from requirement phase through implementation. During e-readiness, requirement and analysis survey as it has been evaluated by Kalinga et al [9]; questioners, physical observation and focus group discussion with students, teachers and school administrators were employed. The visualization was on the reasons for poor performance, problems facing the current status of education system and the needs towards the performance improvement. The survey was the starting point on introducing and creating awareness of the whole issue of development of e-LMS for Tanzanian secondary schools.

III. OBJECT ORIENTED SYSTEM ANALYSIS AND DESIGN

There are several approaches employed in system analysis and design. The most two commonly used approaches are: structured system analysis and design (SSA&D) and object oriented system analysis and design (OOSA&D).

Davis (1983) [6] and [10] discuss that structured analysis prescribes analyzing and designing software system through functional decomposition. It examines an Information System in terms of the functions it performs and the data it uses and maintains. SSA&D identifies the major functions or processes of a system, then breaks or decomposes each function down into its smaller composite steps [6] [10]. On the other-side OOSA&D decomposes the system down into objects and examines how these objects act and interrelate. The analyst first identifies the object that comprise the system, then create an object model which groups the objects into classes, and describes each class in terms of its attributes (or data), methods (or functions) and relationships to other classes [22].

OOSA&D approach will be employed in development of e-LMS. The main reason of this selection is that it employs

UML as its documentation language. UML is also the one to be used in MDA. In software development successful information system are subject to frequent evaluation and revision within a framework known as System Development Life-Cycle (SDLC). The e-LMS is a system to be developed hence will abide to System Development Life Cycle (SDLC). SDLC for e-LMS will have:

- requirement and analysis phase where use-case and conceptual diagrams will be used
- design phase where sequence, collaboration, design class and component diagrams will be used
- implementation and testing phase where coding will be implemented

IV. MODEL DRIVEN ARCHITECTURE

The development of eLMS for Tanzania secondary schools will finally be implemented by customization of the selected open source LMS platform as per requirement and specifications of Tanzania environment. Selection of which open source platform to customize will be preceded with the creation of eLMS platform specific model. The reasons for choosing open source is discussed below, see section VI.

Object Management Group (OMG) is promoting model driven Architecture (MDA) as a way to develop systems that more accurately satisfy customer's needs and that offer more flexibility in system evolution (Brown, 2004) [2]. MDA improves requirement capture and system specification. Unified Modeling Language (UML) is one among the technologies specified by OMG as a language to enable model driven approach. OMG in its UML specification version 1.5 [16] defines UML as a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual modeling.

With the use of UML at its metamodel level, i.e. logical model level, several modeling graphics with different viewpoints will be created as a visual representation of the model. We found UML Modeling promote action research methodology by providing a basis for understanding the expected platform and promote a ready-to-use motion.

V. CIM, PIM, PSM AND TRANSFORMATION

MDA is a conceptual framework created by the OMG that separates business-oriented decisions from platform decisions to allow greater flexibility when architecting and evolving software development and deployment [2]. To support these principles, the OMG has defined a specific set of layers and transformation that provide a conceptual framework and vocabulary of MDA. These are Computation Independent Model (CIM), Platform Independent Model (PIM) and Platform Specific Model (PSM) [15] [2] [23] as shown in fig. 1. Along with conceptual framework, OMG through MDA also provides a set of standards to express models, model relationships and model-to-model transformations [2].

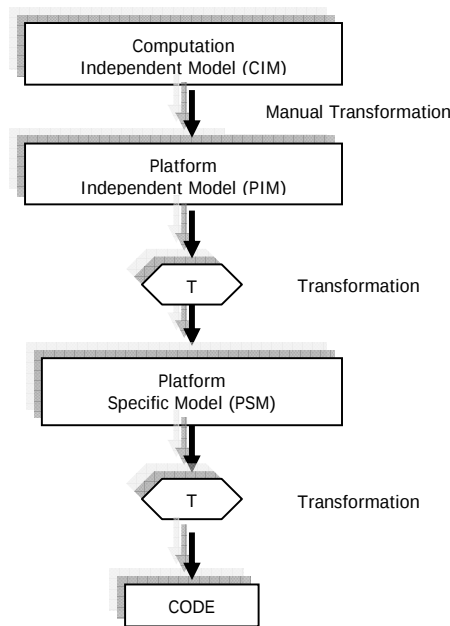


Fig. 1 MDA Framework

A. Computation Independent Model

CIM for e-LMS will be based on the requirements and specification of the early survey for e-readiness status [9] conducted for Tanzania secondary schools. UML will be used to model the user requirements and their boundaries. The e-LMS has considered several users including students/learners, teachers/instructors, authors, school administrators, system administrators and officials from the concerned Ministry, here Ministry of Education and Vocational Training (MoEVT). CIM also shows the e-LMS system architecture and standard specification to be employed.

B. Platform Independent Model

UML will model e-LMS at different viewpoint levels of abstractions from the platform independent viewpoint. This model will give what is being expected to be provided by e-LMS to Tanzania secondary schools. At this stage the structure of the e-LMS database through design class diagram can be used to select the open source LMS platform. The model of that platform will enable implementation of a system with desired qualities and will promote the nature of mapping towards PSM, which is in this case a web services platform.

C. Platform Specific Model

The e-LMS is a web based platform in order to cater for wide access to a big number of rural secondary schools in different regions of Tanzania. The functionality specified in the PIM is realized in a PSM through the application of some transformation. Web services applications is our target in this case which will run in an application server. Web services application is the nature of transformation from PIM to PSM. The transformation from PIM into PSM will be to express the UML into XML Metadata Interchange (XMI) using standard definitions expressed as XML Schema Definitions (XSD) as

shown in Fig. 2.

XMI is an application of Extensible Markup Language (XML), which lends itself to transporting information that is highly internally referential. XMI is applied to transport UML models by generating a special XSD through applying the rules of XMI to the concrete UML metamodel. The general mechanism applied within OMG to transport meta-information is XMI [17].

Finally, PSM will be mapped to application using interfaces, code and Structured Query Language (SQL queries) adapted from open source LMS platforms.

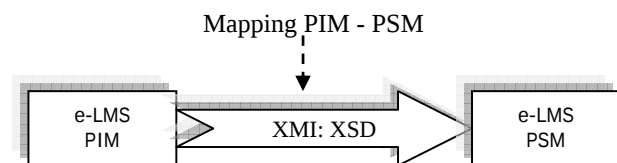


Fig. 2 PIM Transformation into PSM

Model transformation is the process of converting one model to another model within the same system. The PIM and other information are combined to produce a PSM. To perform this UML extension mechanisms are used to both PIM and PSM. UML are extended with UML profiles by adding semantics information to the models transformation [17].

We can relate the phases in OOSA&D with the conceptual framework created by OMG in MDA as shown in figure 3.

VI. CUSTOMIZATION OF OPEN SOURCE LMS PLATFORM

Learning Management Systems (LMS) are specialized Learning Technology Systems (LTS) [7] [8], based on the state-of-the-art Internet and WWW technologies in order to provide education and training following the open and distance learning paradigm. Moore et al, [12] and Carlson, [3] argue that the design and implementation of such systems is not an easy task, since they are complex systems that incorporate a variety of organizational, administrative, instructional and technological components.

A Learning Management System is aimed at managing an e-learning environment, establishing the organization and delivery of content, administrating resources and tracking learning activities and results [5] [14]. LMS that are in use today are either commercial products (e.g. WebCT, Blackboard), or free open source products (e.g. moodle, caroline), or customized software systems that serve the instructional purposes of particular organizations. LMS that belong to the third category are exponentially increasing, as most education and training institutions are building or planning to build their own LMS. This is due to the fact that a customized LMS will fit better their specific learning purposes, and proves to give a good return of investment over the years [5].

It is obvious that Tanzania secondary schools can not afford

the cost of commercial learning management systems like, as well as get hold of a system optionally fitted in the specific context. The alternative means is to customize and use open source LMS. To ease e-LMS development process and to help generate a timely solution, existing open source LMS codes will be re-used. Most open source LMS could support the basic functions we need in developing e-LMS, but there was an obvious need for detailed customization.

The drive of thinking on customization of open source platform is that open source software (OSS) is a software that is free in terms of its source code being available, as well as

free in terms of purchase charges, and software licensing [18]. OSS source code is freely available to individuals to customize according to their own needs and distribute provided they abide by the accompanying license. This differs from commercial software which may only be obtained by some of payment; either by purchasing or by leasing. Open source software is based on open distribution of the source code that forms the software's foundations. This means that any technically competent programmer can examine the inner working of the source code, make changes to the operation of the software and contribute the source to others.

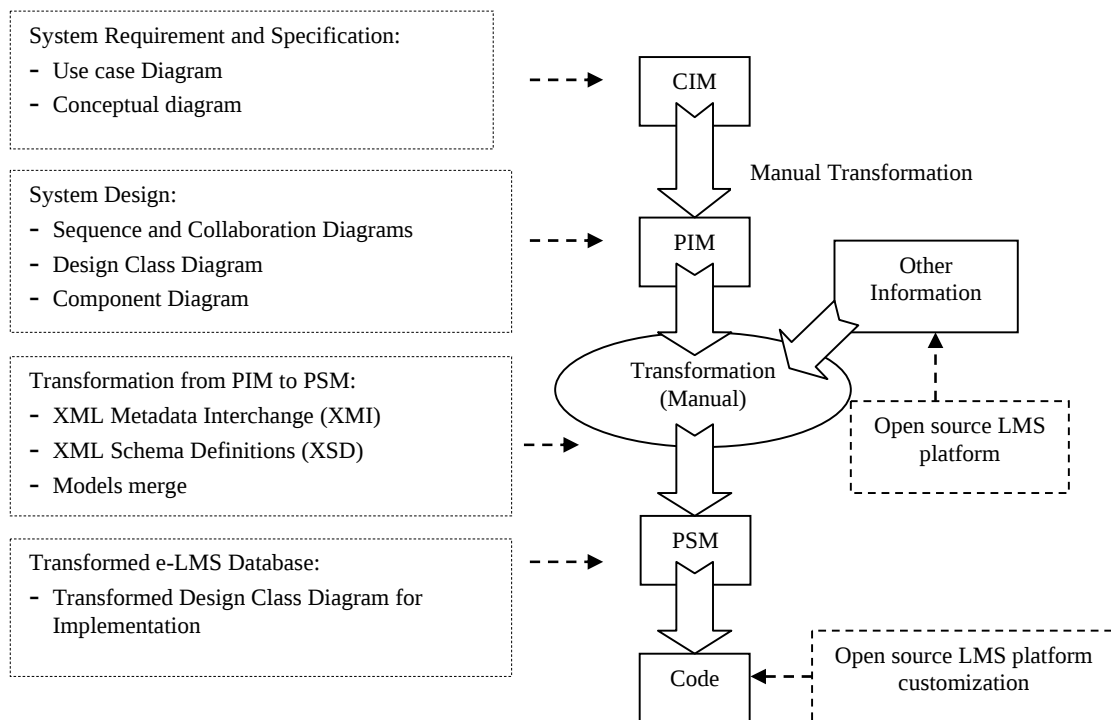


Fig. 3 OOSA&D Related to MDA Model-to-Model Transformation

VII. THE E-LMS DATABASE REPLICATION

The e-LMS database for Tanzanian secondary schools is intended to be centrally placed at the University of Dar-es-Salaam, College of Engineering and Technology. The idea of keeping the database centrally is mainly due to easiness of administration and maintenance of it by expertise. In reality majority of users of the e-LMS database are geographically dispersed and they rely on the Internet connectivity to access the database. The application response time and the availability of the database will be subjected to the condition of the Internet. Yair et al, [25] argue that the centralized approach suffers from two major drawbacks:

- Performance problems due to high server load or high communication latency for remote clients.
- Availability problems caused by server downtime or lack of connectivity. Clients in portions of the network that are temporarily disconnected from the server cannot be serviced.

Lack of connectivity due to several reasons like electrical power failure is the major problem in Tanzania. The server load and server downtime problems can be addressed by replicating the database servers to form a cluster of peer servers. There are many reasons why database replication is needed. Replication is generally for query load balancing, for disaster recovery (Restoration), for reducing latency, for bringing the data closer to the user, and for consolidating data from multiple sources. Because replication is based on the database logs it is very efficient in terms of performance compared with other methods of moving data [11]. Replication is an asynchronous, log-based process that permits copying of data from one location to another, keeping the data in the second location identical to the first [11].

Replication is a challenging issue since it involves much more than setup and there are not many sources of information for replication implementation and troubleshooting [19]. The challenge is on how to ensure database availability and meet end users needs. Fig. 4 shows the general replication outline.

VIII. CONCLUSION

Software design approach is applied simply to produce a software solution to a problem. To produce quality software we need to thorough understand the requirements that satisfy the user's needs. Visualization in the course of continuous improvement is a necessary basis for the participation of the personnel, and allows end-users to grasp the concept of operations of the system without having to understand software terminologies.

A model is used for understanding a system properly before its actual implementation. Integration of the power of models as emphasized by OMG with software development lifecycle stages promotes description of a system from different viewpoints, each focusing on particular concerns. A viewpoint, applied to a system, gives a view of that system. Customization of open source LMS platforms can be used to

develop a system which is optionally fitted in the specific context.

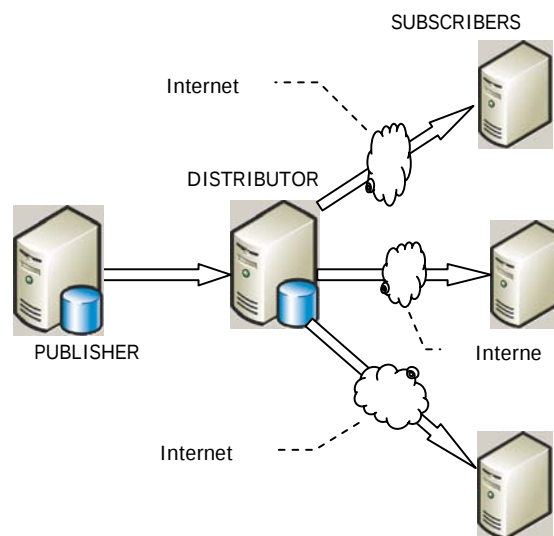


Fig. 4 Database Replication Outline

REFERENCES

- [1] Abels E. G., White M. D., and Hahn K., (1998), "A User-Based Design Process for Web Sites", *Electronic Networking Applications and Policy*, Volume 8 · Number 1 · 1998 · pp. 39–48, MCB University Press · ISSN 1066-2243
- [2] Brown A., (2004), "An Introduction to Model Driven Architecture", Part I: MDA and Today's Systems, Addison Wesley.
- [3] Carlson, P. (1998), "Advanced Educational Technologies – Promise and Puzzlement", *Journal of Universal Computer Science*, 4 (3), 210-215.
- [4] Chambers, Robert, (1997), "Whose Reality Counts? Putting the First Last, London: IT Publications".
- [5] Collier, G., (2002), "Elearning application Infrastructure", Sun Microsystems white paper, <http://www.sun.com/products-n-solutions/edu/whitepapers/index.html>, January 2002.
- [6] Davis W. S., (1983), "Systems Analysis and Design: A Structured Approach", Addison-Wesley, ISBN 0201102714
- [7] IEEE Learning Technology Standards Committee (LTSC) (2001a), "Draft Standard for Learning Technology Systems Architecture (LTSA)", Draft 9, <http://ltsc.ieee.org/>.
- [8] IEEE Learning Technology Standards Committee (LTSC) (2001b), "Draft Standard for Learning Object Metadata (LOM)", Draft 6.4, <http://ltsc.ieee.org/>.
- [9] Kalinga E. A., Bagile B. B. R., and Lena Trojer L., (2007), "An Interactive e-Learning Management System (e-LMS): A Solution to Tanzanian Secondary Schools' Education", XXI. International Conference on Computer, Electrical, and Systems Science, and Engineering (CESSE), 2007 WASET.ORG, ISBN 978-975-01752-0-6, V-21, 19
- [10] Kendall P. A., (1996), "Introduction to Systems Analysis & Design: A Structured Approach", ISBN: 0697124142, Irwin.
- [11] Mika Nikolopoulou, 2004, "Replication setup for DB2 Universal Database, A step-by-step approach to user-copy replication", 27 May
- [12] Moore, M. G., & Kearsley, G. (1996), "Distance Education: A Systems View", Belmont, CA: Wadsworth Publishing Company.
- [13] O'Brien, R. (2001), "An Overview of the Methodological Approach of Action Research", Roberto Richardson (Ed.).
- [14] Oleg, S., Liber, B., (1999), "A framework of pedagogical evaluation of Virtual Learning Environments", Available online at [<http://www.jtap.ac.uk/reports/htm/jtap-041.html>], 1999.
- [15] OMG, (2003), "MDA Guide", Version 1.0.1, Document Number: omg/2003-06-01

- [16] OMG, (2003), "Unified Modeling Language Specification", Version 1.5, March, Formal/03-03-01
- [17] OMG, (2006), "Diagram Interchange", Version 1.0, Formal/06-04-04
- [18] O.S.S. AFRICA, (2005), "Frequently Asked Questions. [online]", <http://www.ossafrica.com/index.php?pg=faq> [05 August 2005]
- [19] Pavliashvili B., 2004, "Introduction to Database Replication", Article from <http://www.informit.com/articles>, Mar. 26
- [20] Pelle Ehn, Dan Sjögren and Yngve Sundblad , (2000), "Co-operative Design — perspectives on 20 years with 'the Scandinavian IT Design Model'", Report number: CID-104, ISSN number: ISSN 1403-073X, Publication date: October
- [21] Rydhagen, Birgitta, (2002), "Feminist Sanitary Engineering as a Participatory Alternative in South Africa and Sweden", BTH, Dissertation Series Nr 2002:06, ISBN 91-7295-017-X.
- [22] Schach S. R., (2004), "An Introduction to Object-Oriented Systems Analysis and Design with UML and the Unified Process", McGraw-Hill/Irwin, ISBN 0071215107
- [23] Schibrowski E., "MDA Model Driven Architecture", <http://www.inf.uni-konstanz.de/dbis/teaching/ws0607/busintelligence/talks/schibrowski.pdf>
- [24] Walker T. and Herrmann T., (1998), "The Relevance of Showcases for the Participative Improvement of Business Processes and Workflow-Management", ISBN 0-9667818-0-5
- [25] Yair Amir, Claudiu Danilov, Michal Miskin-Amir, Jonathan Stanton, Ciprian Tutu, (2002), "Practical Wide-Area Database Replication", Technical Report CNDS-2002-1 Johns Hopkins University, <http://www.cn.ds.jhu.edu/publications>