eNOSHA, a Free, Open and Flexible Learning Object Repository – An Iterative Development Process for Global User-friendliness

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Abstract

This paper describes the iterative development process of a Learning Object Repository (LOR), named eNOSHA. Discussions on a project for a LOR started at the e-Learning Centre (eLC) at The University of Colombo, School of Computing (UCSC) in 2007. The eLC has during the last decade been developing learning content for a nationwide e-learning bachelor of information technology degree (eBIT) and a preparatory programme for the eBIT program (The Foundation in Information Technology, FIT). After analysing the specific needs at UCSC a decision was taken to develop a new repository since none of the analysed existing LOR systems could fulfil the UCSC requirements. There was an urgent need for a system that makes it easier for the eLC staff to store and share course material. The system was designed with the main objectives to enhance the reusability of content and to support the content development process in a user-friendly way to assure user acceptance. We also identified the importance of a flexible LOR design to handle different type of content as well as various user contexts. The development process started with focus groups consisting of staff from UCSC and external project members from Sweden. A requirement analysis was carried out in December 2008, and based on the analysis a plan was drafted for the development and implementation of the system. As an overall system development method we used participatory design, where users have been involved in the design, evaluation and implementation of the system. Iterative testing and code revision for amendments and redesign and have been conducted at universities in Sri Lanka, Finland and Sweden according to the principles of Design science. Our aim with the chosen approach has been to develop a system that will meet the needs and requirements of the users at other universities countries than just only UCSC in Sri Lanka. Based on the testing of the system we had a positive response regarding the searchability and reuse of content but complaints on the uploading of content. Testing conducted in Finland and Sweden has revealed earlier unknown security issues as well lack of user-friendliness in the installation process. The integration of eNOSHA 1.6 with the Moodle virtual learning environment has been successful for the Moodle version 1.9 but with needs for redesign to work properly with the later Moodle 2.x versions.

Keywords: Learning object repository, content management, Software development, System integration, eNOSHA, Open source, Learning Objects, E-learning

Introduction

The history of e-learning in Sri Lanka is not much older than the establishment of the UCSC in September 2002. In a merger between *The Institute of Computer Technology* and *The Department of Computer Science* at the University of Colombo, UCSC was started to meet the challenges in the computer science of the 21th century. During the last five years the traditional Bachelor of Information Technology (BIT) has been transformed into the new and interactive e-learning distance programme eBIT (http://lms.bit.lk). Initially the aim was to serve 1000 internal students and 5000 external students. To strengthen the prerequisites and increase the pass rate a new bridging programme, *Foundation of Information Technology* (FIT), has been developed with courses in basic Mathematics, IT and English. This is an important initiative in a country where more than 100,000 students per year don't have access to tertiary education. (Warnapala, 2009)

This has been a fast development of around 50 new courses where most of the learning objects have been created and stored in the Moodle virtual learning environment. In a longer perspective it is not a working solution to just store the developed content without any structure, metadata or search mechanism. Discussions in the European – Sri Lankan eBIT project during 2006 and 2007 on how to store learning objects in an online system later resulted in a LOR group in the Swedish – Sri Lankan NeLC project funded by the Swedish international development agency, Sida (http://www.sida.se/English/).

The vast amount of free and reusable learning objects on the Internet is constantly increasing and so is the

need for quality LORs to sift the information (McGreal, 2008). A LOR can be briefly be defined as a storage and search system for digital learning material with support for reusing and sharing the content. LORs can be categorized into:

1. **Content repositories**: All learning objects are stored on accessible servers
2. **Linking repositories**: Portals with links to content provided by others
3. **Hybrid repositories**: A combination of 1 and 2.

Storing and updating your own learning objects with quality control is only possible in the type 3, Content repositories. (McGreal, 2008)

From the very beginning a fundamental design idea was to reuse or develop a LOR that should be free, open and flexible enough to serve all stakeholders at the UCSC eLearning Centre. Some of the most important groups to consider at the eLearning Centre are Subject Matter Experts (SMEs), Instructional Designers (IDs) and Content Developers (CDs). In the UCSC *Conveyor Belt Model* for digital content development (Mozelius and Hatakka, 2009) it is important to have a system flexible enough to serve the different needs for the different working roles and if the eNOSHA system should be a LOR flexible enough to use in other organisations the roles must be possible to redefine from within the system without any changes in the source code.

Problem

During the second half of 2008 a comparative study was carried out in the NeLC project to examine which of the existing free and open learning object repositories that could fulfil the UCSC requirements. Linking repositories or Hybrid repositories is not an option for UCSC or any other organization with a large production of digital content. All the analyzed LORs are in the category of Content repositories. None of the systems passed the tests and flexibility was the point where most systems failed. Proprietary software with high license fees would not be a good choice for universities in developing regions and systems where the source code is closed or not available would be an obstacle when it comes to extendability and flexibility. Some of the tested systems behaved unstable and unreliable and if a LOR should have a supportive role with good usability the technical aspects need to be considered as well.

Table 1:   Result of the comparative study of existing LORs

	Open Source	Free	User Friendly	Flexible	Well documented	Available	SCORM compatible
Mr Cute	X	X			X		X
FreeLoms		X				X	X
Plone	X	X			X	X	
SCAM	X	X	X	X		X	
CollectiveAccess	X	X	X		X	X	

Aim

The aim of the paper is to present the free and open LOR eNOSHA and describe the fundamental design ideas and how it can support usability, flexibility and adaptability for a learning object repository.

Development and methodology

Within the framework of action research (Davison et al. 2004; Kock 2007) the eNOSHA system has been developed in collaboration between the UCSC in Sri Lanka, The Stockholm University and the Örebro Business School in Sweden. In the initial need analysis the UCSC specific requirements for a LOR were analyzed. For the more general aspects existing literature was reviewed to find best practices for usability, flexibility and technical aspects. Focus groups with staff from UCSC and the involved Swedish universities have been meeting in traditional face to face meetings as well as in online distance meetings. After discussions during 2007 an initial draft plan for the development was created in December 2008. From the very beginning and through the process the eNOSHA development is based on a participatory design principle (Michael, 2003; Michael and Sarah, 1993) where the presumptive users have been iteratively consulted in matters of usability, user-friendliness, and graphical design.

The user feedback has been an important factor in the creation of the different project sprints and through the development we have conducted usability tests with scenarios using the new implemented functionalities. We believe that this is the only way to obtain user acceptance at the same time as you discover software bugs and optimize the design. Usability is essential in a system and the design has been done following the practical Shackel's Model of Usability based on the four pillars of effectiveness, learnability, flexibility and attitude. (Leventhal and Barnes, 2008)

In Design Science researchers try to extend the boundaries of human and organizational capabilities by designing and implementing new, innovative and useful artifacts. The results of Design Science research should, by definition, be a purposeful IT artifact created to address an important organizational problem. (Hevner et al., 2004) Design Science has roots that are derived from engineering (Simon, 1996) and is mainly a problem-solving discipline where the IT artefact is designed and developed iteratively and incrementally. New features in the eNOSHA system have been discussed, designed and implemented one by one with the idea that an incremental development will facilitate the testing. However there is always a need for more holistic testing than just unit testing. Database design and the major part of the implementation have been done in a core team working with the agile method Scrum (Schwaber and Beedle, 2001). A Scrum team work in time boxed iterations (sprints) with regular meetings and close collaboration without fixed working roles.

Designing for flexibility

During the different developing phases we have considered the following needs for flexibility:

- Different curriculum and course structure in different organisations
- Various type of content and various aggregation levels
- Template support for bulk upload to increase the usability
- Open and closed content should be stored in the same LOR
- Internal and external user should be able to share the same installation
- Different user roles with different needs and permissions
- All changes should be possible to make without modifying the code

eNOSHA is developed with the ambition that the system could be used in various kinds of organization and not only at university level. Courses will certainly not always be divided in the same way as they are at UCSC. The metadata set contains fields where languages, categories and aggregation levels can be modified and extended. In the daily work of a CD a lot of content is produced some are open for external users and some are not. Distinction between internal/closed and external/open content is dependent on one metadata field that can be modified to other settings in other contexts. But whatever the distinction this should always be done with the principle of different target groups with different permissions storing content in the same LOR.

Different universities and organisations will have different needs for user roles and permissions and that can be set from the admin module. In a first attempt for quality assurance there is a built in review and ranking system for stored learning objects. To facilitate and make the uploading and tagging of the learning content more efficient, templates have been created to support bulk upload. Common metadata fields should be reused as much as possible. All modules should not be accessible for all users roles, and as an example, permission to the Administrator module for everyone is sometimes not a good idea. Which user roles there should be and their permissions should be adjustable for the actual context and they can be defined from within the Admin module without changing the source code or updating configuration files.

General design and modularization

eNOSHA is built on the idea about some core modules that can be extended with auxiliary units. Different universities and organisations have different needs and all modules must not be used by everyone. As an example, the module under construction for hypervideo handling might be an interesting add-on for some users, but maybe of no value at all in a country with low bandwidth. Core modules are the ones for uploading, searching, user management, administration, help, and error handling. Currently existing and tested modules are:
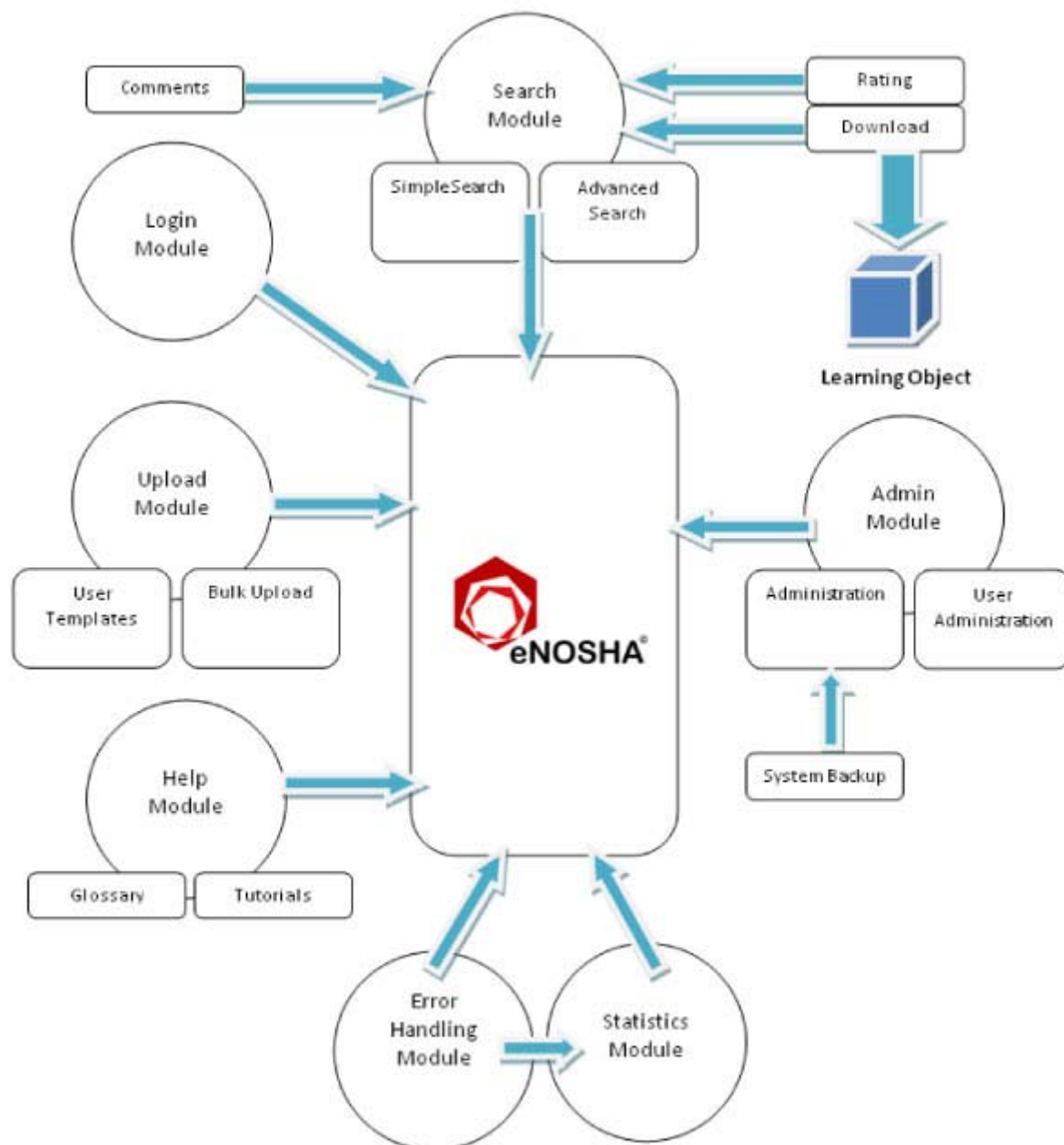
Figure 1. System Architecture

The *eNOSHA Moodle module* described below is not classified as a core module.

Learning Objects Granularity

A learning object can more specifically be defined as "*any reusable digital resource that is encapsulated in a lesson or assemblage of lessons grouped in units, modules, courses, and even programmes.*" (McGreal, 2004) In another broader perspective it can defined as just any digital resource (Wiley, 2000). Whatever the definition there is a big difference between a text file and a full course. To facilitate reuse and to decrease context dependency a LOR needs to divide courses and course modules into more fine grained units (Sicilia and García, 2003). In the UCSC adapted version of the eNOSHA system learning objects are divided into 4 granularity levels:

- **Atom**: The lowest level for content like text, graphics, and sound files
- **Collection of atoms**: The combination of atoms, like XHTML documents with embedded Java applets or Flash applications
- **Course module**: A section/module/part of a course containing atoms and collections of atoms that could be reused and integrated in other courses
- **Full course**: A full course with all the course modules for the specific course included.

At another university or educational organization the granularity levels can be specified in another way according to the actual curriculum/course outline.

The Metadata Set

Metadata which often is defined as *data about data* is an important tool to categorize objects in LORs and make them searchable. All existing courses in the BIT, eBIT and FIT programmes at UCSC exclusively use digital content following the SCORM standard (http://www.scorm.com/). Since the SCORM standard has many metadata fields in common with the Learning Object Metadata model (LOM) it was a natural choice for the UCSC and NeLC focus groups to look for a metadata set construction based on the LOM standard. (http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf)

LOM is a huge standard that covers a lot of metadata aspects. Research shows that to complex metadata models will reduce the usability and user-friendliness in software systems (Cardinaels et al., 2005). The eNOSHA system is using a reduced subset of the LOM metadata set where some LOM elements are removed and 4 new eNOSHA specific elements are added. The new metadata fields that are included to support the eNOSHA design ideas of flexibility, reusability and context independency are:

- ***Audience*** (to specify the target group, internal/external)
- ***CopyrightChecked*** (is the learning object open and free to use)
- ***Localization*** (is the context global or local)
- ***Modifiable*** (is it possible to extend or modify the learning object)

The metadata set is divided into 4 subsets to match the 4 levels of learning object granularity. There are also 2 different versions of subsets for internal (I1 -I4) and external (E1-E4) content to provide parallel access for internal and external users. To minimize the number of metadata fields that are mandatory to fill in the elements have been given different modalities: Mandatory (M), Optional (O), Automatically generated (A) and Not Applicable (N/A). (Hatakka and Mozelius, 2009)

Table 2   The Metadata Set

	I1	I2	I3	I4	E1	E2	E3	E4
1. General								
1.1. Title	M	M	M	M	M	M	M	M
1.2. CatalogEntry								
1.2.1. Catalog	O	O	M	M	O	M	M	M
1.2.2. Entry	O	O	M	M	O	M	M	M
1.3. Description	O	O	M	M	O	M	M	M
1.4. Keyword	M	M	M	M	M	M	M	M
1.5. Language	O	O	M	M	O	M	M	M
1.7. AggregationLevel	M	M	M	M	M	M	M	M
1.8. Modifiable	M	M	M	M	M	M	M	M
1.9. Audience	M	M	M	M	M	M	M	M
2. Lifecycle								
2.1. Version	A	A	A	A	A	A	A	A
2.2. Status	M	M	M	M	M	M	M	M
2.3. Date	A	A	A	A	A	A	A	A
2.4. Author	A	A	A	A	A	A	A	A
2.5 CommentOnChangesMade	O	O	O	O	O	O	O	O

3. Metametadata								
3.1. MetadataScheme	A	A	A	A	A	A	A	A
4. Technical								
4.1. Format	A	A	A	A	A	A	A	A
4.2. Size	A	A	A	A	A	A	A	A
4.3. Location	A	A	A	A	A	A	A	A
4.4. Requirement								
4.4.1. Type	A	A	A	A	A	A	A	A
4.4.2. Name	A	A	A	A	A	A	A	A
4.4.3. MinimumVersion	N/A	N/A	N/A	N/A	O	O	O	O
4.4.4. MaximumVersion	N/A	N/A	N/A	N/A	O	O	O	O
4.5. OtherPlatformRequirements	O	O	O	O	O	O	O	O
5. Education								
5.1. InteractivityType	O	O	O	O	O	M	M	M
5.2. Context	A	A	A	A	A	A	A	A
5.3. Difficulty	O	O	O	O	O	M	M	M
5.4. EducationDescription	O	O	O	O	O	M	M	M
5.5. Localization	O	O	O	O	O	M	M	M
6. Rights								
6.1. Cost	N/A	N/A	N/A	N/A	M	M	M	M
6.2. CopyrightsAndOtherRestrictions	M	M	M	M	M	M	M	M
6.3. RightsDescription	O	O	O	O	O	O	O	O
6.4. CopyrightChecked	M	M	M	M	M	M	M	M

In all situations where it is possible eNOSHA reuses metadata and fills in fields automatically. To further reduce the metadata set is not an option since it also would reduce the systems searchability and version handling. Without good searchabilty and version handling the system would not be an alternative in modern digital content development. The contradiction between how many fields you need to provide appropriate searchability and how to optimize user-friendliness by minimizing the metadata set is still an unsolved issue (Hatakka and Mozelius, 2009).

User roles

Most multi-user systems need different user roles with different permissions. In the eNOSHA system we believe that all organisations like to have one or several administrators with permissions to change the database structure and take regularly backups. In cooperation with external partners it can be practical or secure to restrict uploading possibilities for guest accounts. In the first UCSC version the following 5 user roles are defined with a descending degree of permissions:

1. Administrator

2. Instructional Designer
3. Content Developer
4. Internal user
5. External user

Internal tasks like uploading and version handling are possible for roles 1 – 4 but closed for external users that only can search and download material marked as "open". In another organization the number of roles must not be 5 and the permissions can be set in a way that is appropriate for the actual context. These changes are done in the *admin module* which not necessarily must be with exclusive access for administrators.

The eNOSHA – Moodle Integration

The version 1.6 of the eNOSHA LOR is integrated with the Moodle 1.9 virtual learning environment. The eNOSHA module for importing learning objects directly into Moodle from existing eNOSHA repositories is build from a Moodle module template. Learning objects stored in eNOSHA systems can be found from a search feature in the Moodle system. In the need analysis at the UCSC the three identified basic needs for the integration were:

- Login/Authentication
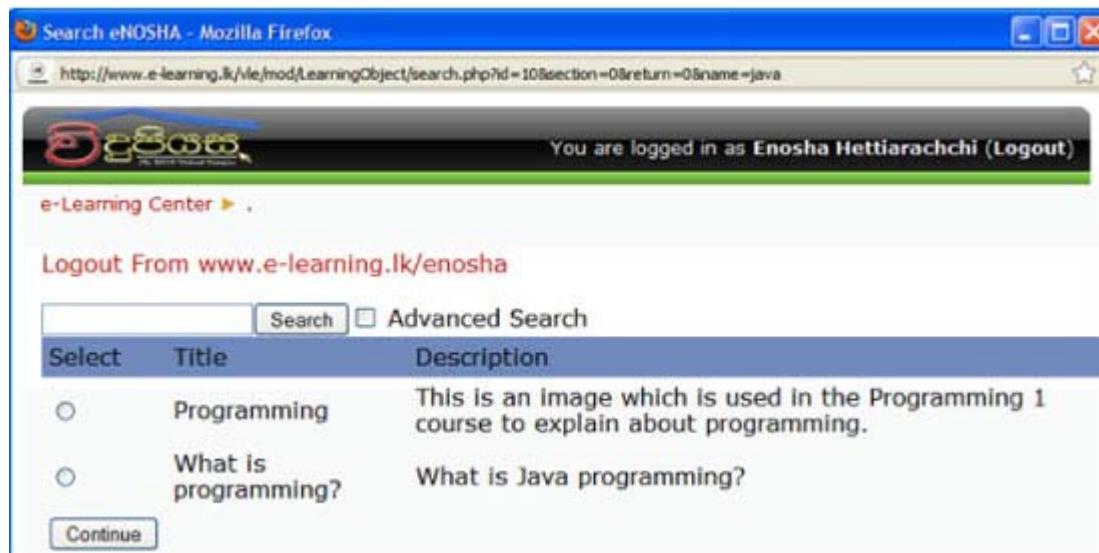- Integrated searching
- Import of learning objects

Figure 2. Searching for eNOSHA assets from Moodle 1.9

Remote procedure calls are executed by the HTTP protocol for the transport using XML in the encoding. The XML-RPC technique is designed to be as straightforward as possible, but with the possibility to transmit and process complex data structures. (XML-RPC, 2010) Parameters for the user actions/selections are passed on and executed in the remote repository and later transported back to be displayed for downloading in Moodle. Function calls and their responses are handled by a PHP script in the eNOSHA system. (Mozelius et al., 2011a)
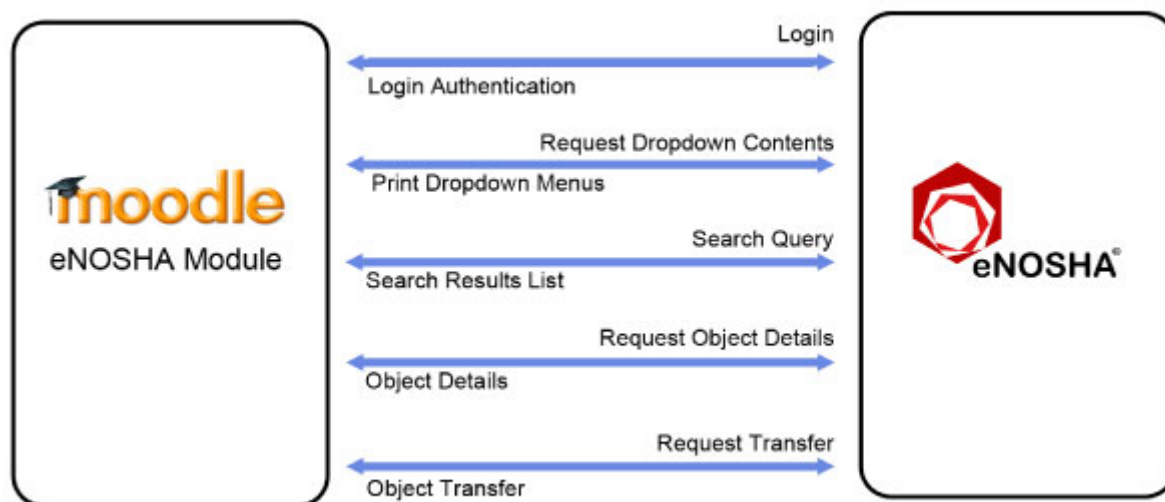
Figure 3. Inter-system communication by remote procedure calls

The described eNOSHA-Moodle integration has been tested since July 2010 at the UCSC in Sri Lanka and so far without any discovered problems or major bugs. In the testing conducted at the Department of Computer and Systems Sciencies in Kista, Sweden the solution works well with versions < 2 of the Moodle learning platform.

Implementation and availability

The eNOSHA LOR system is a XAMP product tested on the Windows and Linux platforms. In addition to the main PHP programming language, JavaScript and Ajax were used on the client side. All data and metadata are stored in a MySQL relational database and eNOSHA has a localization scheme based on language files.

Those who are interested to contribute or review the eNOSHA LOR system can download the full product together with the source code from the g-forge server located at: http://enosha.sourceforge.net/

Testing, test findings and updating

Software development is an iterative process where updating, amendments and extensions should be based on testing. Software artifacts like the eNOSHA system need various kind of testing. New features and algorithms needs unit testing and to improve usability and user-friendliness there must be a repetition of user testing. eNOSHA is also a modularized system where each and every module should be tested and debugged separately before tested all together as a system.
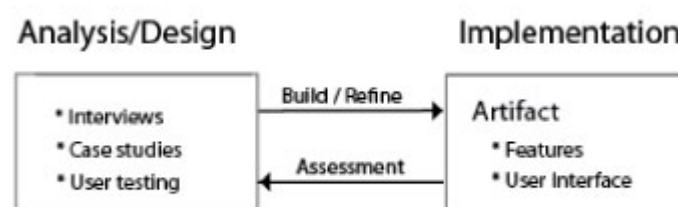

Figure 4. The iterative and continuous process of assessment and refinement

Testing at the University of Colombo School of Computing

Most of the basic testing and debugging was done at the UCSC in Sri Lanka during 2009 and 2010. Then we had the privilege to develop and test the system as a part of the Sida funded NeLC project. Technical functionality and database connections were then tested unit by unit by the members in the Scrum development team. Most Scrum sprints also included some scheduled code reviews. The development has not been test-driven in the way it is prescribed for agile XP-development (Janzen and Saiedian, 2005).

Testing has rather been scheduled in the various Scrum sprints and conducted after the development of units and features.

Usability testing scenarios were created by Enosha Hettiarachchi where Content Developers and Instructional Designers had to follow instructions for a set of activities related to their use of the system in their daily work. Semi-structured interviews with the staff at the UCSC eLearning Centre have been conducted by Peter Mozelius and Enosha Hettiarachchi. Database design has been optimized and installation scripts have been evaluated by Isuru Balasooriya. Results of the testing at UCSC have been discussed and analyzed together with the head of the eLearning Centre, Dr. K.P. Hewagamage.

Testing at the University of Eastern Finland

In May 2011 the eNOSHA system was installed and evaluated at the University of Eastern Finland (UEF) in Joensuu, Finland. Since none of the authors had access to the servers at UEF the installation and evaluation of the installation process was done by Antii Rantaeskola. The eNOSHA system was installed to serve as a LOR for an UEF programme named ViSCoS with the purose to store courses and learning objects used in the programme. Installations were done on two separate servers with different UNIX systems, one server running on Solaris UNIX and the other using a Linux operating system. (Mozelius et al., 2011b)

Virtual Studies of Computer Science (*ViSCoS*) is an e-learing programme for first year University level Computer Science studies, called Basic studies in Computer Science. The programme is run by the School of Computing Department at UEF and originally targeted to high school students in the sparsely populated areas of Eastern Finland. Later ViSCoS has been opened to anyone interested in studying Computer Science at university level via the Continuning Education Center at UEF (Mozelius et al., 2011b).

Antii Rantaeskola has also been the main evaluator of the basic eNOSHA functionality in Finland. Amit Roy has during 2011 constructed, executed and evaluated test cases on context dependency of the eNOSHA software system. He has done uploading and searching tests as well with content in the Chinese language in collaboration with his Chinese colleague at UEF, Qinpei Zhao. Semi-structured interviews have been conducted by Peter Mozelius and Amit Roy.

Testing at the Stockholm University

When the findings at the UEF showed that the installation process on servers with a different setup than the servers at the UCSC in Colombo was not user-friendly we decided to evaluate the system more in detail at another university. The only department that were willing to give us some minor funding for further testing was the Flex Unit at the Department of Computer and Systems Sciences at the University of Stockholm. Installation, testing and updating have been done during the autumn semester 2011 by Isuru Balasooriya and Peter Mozelius in collaboration with some interested test users at the department.

A new and general code review has also been initiated where the code for the next version of the system now will be better and more consistently commented. When the version 2.2 of the Moodle VLE will be released we will try to integrate the eNOSHA system as we succeeded with for Moodle versions < 2. Some tests have been done with Moodle 2.0 in the end of 2011.

Findings and Updating

A lot of bugs and system inconsistency were found during the testing at the UCSC. Updating of the found bugs was done as activities in the development sprints. Due to the large metadata set several instructional designers and content developers found the system to lack in user-friendliness. Most usability testers were satisfied with search module and its features for good searchability. But the tedious process of filling in the metadata fields that are the base for the searching irritated the Content Developers as something that was time consuming and slowed down their work routines. A template system for bulk uploading was later implemented and in the new tests there were less complaints, but not all testers where satisfied when they answered questions on efficiency and user-friendliness.

The installation of the system at UEF in Finland was a good test where the system failed. Two minor errors in the installation scripts made the installation unnecessary time consuming and gave eNOSHA unexpected Badwill. We suspect that this have been the main obstacle that earlier has scared away several potential eNOSHA users. Staff at universities that do not have basic knowledge about PHP, SQL and the UNIX operating system might just close down and quit the use of the system early without even completing the installation process. (Mozelius et al., 2011b). The two relatively small discovered errors are:

1. A missing comma in a SQL query line 166 in the file enosha.php
2. Backslashes (\\) instead of slashes (/) in the file config.php

The login procedure must also be made more secure and to have the login done using a https connection instead of the current http connection is another updating for the next version. A more serious security

issue that was discovered in Joensuu was that all files and directories are given reading and executing permissions by the installation scripts. University servers are multi-user systems and at the UEF users given an account on the server will be able to read the eNOSHA system configuration. This creates a security problem since the password to the eNOSHA database can be retrieved if the current default settings are not changed. User settings could of course be modified later according to security regulations at the actual university or organization, but it could be a good idea to restrict the default privileges to what was suggested by the staff in Finland. (Mozelius et al., 2011b)

During the installation of the system in Kista in Sweden the installation scripts were modified and that the installer now is prompted for entering the actual platform early in the process. We also found that the code for the uploading module needed updating to eliminate some found errors that occurred in the storing of learning objects. Uploading tests were conducted with learning objects from a C# course given by the Flex Unit in Kista and strange new bugs were found when files names contained a hash mark/number sign (#). There is also a need for a redesign of the graphical user interface if the eNOSHA system should be able to follow the Stockholm University design guidelines and recommended colour schemes. System integration tests have been done in Kista with Moodle 1.9 and Moodle 2.0. The integration with Moodle 1.9 works fine as it is described in the section above but when it comes to version 2.0 the eNOSHA Moodle module can establish a contact using XML-RPC but it is not possible to make a successful upload of learning objects since the structure of the file system has been redesigned in the new Moodle version. The current tutorial video got no complaints from testers and users in Sri Lanka but in Finland and Sweden testers have asked for several shorter instruction videos instead of the existing one containing all the system information.

Discussion and conclusion

So far no user tests have contradicted our fundamental design ideas of flexibility and adaptability but the finding at UEF shows that there is a need for a general updating of the eNOSHA version that currently is available online. Two errors in the config.php and enosha.php files must be seen as irritating and unnecessary obstacles and maybe the reason why not more of the, earlier interested organisations, actually use the eNOSHA system. The security issues that were discovered in Finland definitely need updating and that this should be combined with a general code revision to make the system more robust.

Considering context independency the system performs quite well but maybe that the contextual differences between a Computer Science programme in Sri Lanka and one in Finland are not that large. At universities the English language is not a problem but if the system should be used in other educational organisations, where English is not the main language, there would be a need for support of local languages. Installation scripts must be rewritten to be platform independent with conditional and branched installation possibilities.

Course categories and user roles are different in different context but in they can be changed and redefined from the administrator module. Without any rewriting of the source code we believe that also organisations without internal software engineering support can run and use the system. What can be seen as lack of flexibility is that the granularity levels are not possible to change from within the system. As every software system the eNOSHA LOR needs an introduction to the basic features and the help module might need to be customized to the actual target group and the local language situation. The existing, and long help video needs to be split into several shorter videos and maybe combined with the idea that the English accent in the narration should be of local flavour.

For Instructional Designers, Content Developers and Subject Matter Experts with a lot of course material to upload the usability can be improved in the *Shackel's Model* aspects of effectiveness and attitude. Better template design and a higher degree of metadata auto-filling would definitely increase the user-friendliness. If this is not addressed the system will never get good user acceptance at the UCSC in Sri Lanka. The idea of internal and external users sharing content in the same LOR installation has only been tested in a small scale, but so far without complaints.

Future works

Based on the testing and updating done in Finland and Sweden during 2011 a new and updated version 1.7 of the system will be released as a FOSS product during 2012. After that the main challenge will be to integrate the eNOSHA system with Moodle 2.2. We would also like to test the system in a non-academical organization and during 2012 a need analysis will be conducted in a telecentre network in a rural region of Sri Lanka.

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Acknowledgements