Abstract: This paper describes the development process of a Learning Object Repository (LOR), named eNOSHA, at the University of Colombo School of Computing (UCSC), Sri Lanka. The e-Learning Centre (eLC) at UCSC has during the last years 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 that UCSC had with the repository, and investigating existing and available LORs, a decision was taken to develop a new repository as none of the analysed systems could fulfil all of the UCSC requirements. There was an urgent need to have a system that makes it easier for the eLC staff to share information and material between them. Their previous model was no longer sustainable as the amount of objects constantly increased and there were no appropriate mechanisms to store and search for them. It is, hence, important that the system helps with the internal content development process as well as work as a repository for external dissemination of open content. The system has to enhance the reusability of content to speed up the content development process. It also has to be user-friendly to make the users accept the system and be flexible in regards to different type of content as well as different 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. The initial plan has iteratively been revised based on the feedback from the users. Our aims with this method were to develop a system that meets the needs and requirements of the users and increase the user acceptance.
Based on the testing of the system we had a positive response regarding the searchability and reuse of content. Tests have however shown that there are additional features that need to be implemented to help with the usability of the system, e.g. bulk uploading and to further expand the use of templates. Even though the system has been developed based on the needs of UCSC, one of the objectives has always been to make it as independent of context as possible. In our internal tests of the system we can conclude that the system is flexible enough to work in different contexts but the design may need some minor changes once tested in other organizations or cultures. eNOSHA is a Free and Open Source Software (FOSS) and we strongly believe that it is a system that will work in any country or organization. Local adaptation can be done from within the system.

**Keywords:** eNOSHA, learning object repository, content management, system development, e-learning, open source, FOSS

1. **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 21st 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](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 organizations the roles must be possible to redefine from within the system without any changes in the source code.

**1.1 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

<table>
<thead>
<tr>
<th>Open Source</th>
<th>Free</th>
<th>User Friendly</th>
<th>Flexible</th>
<th>Well documented</th>
<th>Available</th>
<th>SCORM compatible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr Cute</td>
<td>X</td>
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<tr>
<td>FreeLoms</td>
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<tr>
<td>SCAM</td>
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<tr>
<td>CollectiveAccess</td>
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<td>X</td>
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</table>

1.2 Aim
The aim of the paper is to present the free and open LOR eNOSHA and describe the fundamental design ideas for usability, flexibility and adaptability.

2. 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) Programming and database design have been done by 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.

3. Designing for flexibility

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

- Different curriculum and course structure in different organizations
- 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.

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.
3.1 General design and modularization

eNOSHA is built on the idea about some core modules that can be extended with auxiliary units. Different universities and organizations 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
3.2 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.

3.3 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

LOM is a huge standard that covers a lot of metadata aspects. Research shows that 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 with the UCSC subsets

<table>
<thead>
<tr>
<th></th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
<th>I4</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
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<td>M</td>
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<td>1.7. AggregationLevel</td>
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<td>1.8. Modifiable</td>
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<td>4. Technical</td>
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<td>4.3. Location</td>
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<td>4.4. Requirement</td>
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</table>
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 searchability 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).

### 3.4 User roles

Most multi-user systems need different user roles with different permissions. In the eNOSHA system we believe that all organizations 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.

3.5 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.

Existing tested modules and installation scripts are available for download at [http://www.e-learning.lk/enosha](http://www.e-learning.lk/enosha). 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://kammala.cmb.ac.lk](http://kammala.cmb.ac.lk).

4. Discussion and Conclusion

So far no user tests have contradicted our fundamental design idea of context independency and adaptability. If categories, learning object granularity and user roles can be changed and redefined from the administrator module without making any changes to the source code we believe that also organizations without internal software engineering support can run and use the system when it is installed. Installation scripts and instructional videos will be available at the eNOSHA homepage. As every software system the eNOSHA LOR needs an introduction to the basic features. The help module can be customized to the actual target group and language situation. 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.
For Instructional Designers and Content Developers 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. The most important extension in the 2010 sprints will be the eNOSHA – Moodle integration. To be able to search content in the eNOSHA system directly in the Moodle environment is a request from the UCSC eLearning Centre staff that we think will be appreciated also by other organizations using the Moodle virtual learning environment. However, Moodle is just one of many virtual learning environments used in e-learning and to provide interoperability and true context independency the eNOSHA system will need a general interface for integration with all major learning platforms. Since eNOSHA and Moodle both are open source systems and written in the PHP programming language, the integration is easier to obtain than what would be the case with a proprietary system like Blackboard written in another programming language. But a possible solution here could be a *Web Services* based interface with a common protocol for intercommunication. eNOSHA is for the moment a system for the FOSS community with FOSS design ideas but another aspect of flexibility is to extend the system with a gateway module working with different protocols.

5. **Future Works**

During 2010 and 2011 the eNOSHA system will be tested at universities in Sweden and Finland and there are presumptive partners in Austria, Italy and Nepal as well. New more detailed interviews will be made with the users to try and separate context dependent problems from the general LOR problems. The eNOSHA – Moodle integration needs to be evaluated and the new module for hypervideo is still under construction. Based on the eNOSHA – Moodle integration a common interface could be constructed that serves for interaction and integration with any existing virtual learning environment.

6. **Acknowledgements**

We like to thank all the programmers in the eNOSHA development team. You have been just great, and without your committed work there wouldn’t have been any LOR to present.
7. References


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