DLNET: Creating a Digital Library for Learning Objects in Engineering

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Abstract

Funded by the National Science Foundation, the DLNET project is developing a specialized collection of engineering and technology-related "learning objects" targeted at the practicing engineer and technologist so as to facilitate lifelong learning, i.e., education beyond the classroom, using digital libraries. DLNET will provide an easy and efficient way to collect, review, package, and deliver information from the knowledge developer to the end user. The DLNET portal is a web-based application that will enable content discovery through search and retrieval of local storage as well as repositories in federated libraries. It will also provide mechanisms for submitting, reviewing, ranking, updating and validating of new and existing contents. The DLNET architecture and its services will meet the core standards and specifications adopted by the NSDL-CIS for digital libraries, and will become part of a larger network of learning environments and resources for science, technology, engineering and mathematics (STEM) education under the NSDL. DLNET is a collaborative effort of four institutions, namely, the American Society of Engineering Education (ASEE), the Institute of the Electrical and Electronics Engineers (IEEE), the Iowa State University and Virginia Polytechnic Institute and State University (Virginia Tech). It is currently managed by the Alexandria Research Institute at Virginia Tech and will eventually be served by IEEE's Professional Development Institute.

I.   Background

The National Science Foundation under its Science, Technology, Engineering and Mathematics (STEM) education initiative is establishing a digital library at the national level that will constitute an online network of learning environments and resources. The National STEM Digital Library (NSDL) is being structured as a gateway to a federation of digital libraries that will aggregate, manage and provide contents with coherent themes or specialties. As a partner in the federation of digital libraries, DLNET will field a collection of engineering and technology related contents targeted at the practicing engineer and technologist.

DLNET is a collaborative effort of four institutions, namely, the American Society of Engineering Education (ASEE), the Institute of the Electrical and Electronics Engineers (IEEE), the Iowa State University and Virginia Polytechnic Institute and State University (Virginia Tech). All come with extensive backgrounds and experiences in hosting and managing online resources for continuing engineering education and distance learning. Examples include ASEE's www.learnon.org, IEEE's www.ieee.org/pdi, as well as the joint Iowa State University and Virginia Tech PowerLearn project. The Alexandria Research Institute of Virginia Tech manages the overall project and is responsible for the development of DLNET's architecture consisting of content receiving, management and delivery subsystems.

Begun in 2001, DLNET is an 18-month project that is drawing to the end of its initial funding period by the National Science Foundation. The project team is meeting the goals of developing and testing tools for publishing learning objects. By the end of the project, DLNET will solicit content submissions through the organizations involved in this project.

II.   An Overview of DLNET

DLNET was conceived out of the need to complement engineering and technology education and in particular, to support lifelong learning activities such as training, self-paced study and literature search. A digital library such as DLNET would provide the necessary resources for advancing the knowledge, skills and competencies of engineering and technology students and professionals, and above all, enable them to stay abreast of developments and challenges of new and emerging systems and technologies in their respective fields.

As a digital library, therefore, DLNET will undertake the collection and discovery of content appropriate for educators and learners. More importantly, DLNET is envisaged as a repository of "Learning Objects," (LO), that will facilitate lifelong learning or "education-beyond-the-classroom" of practicing engineers and technologists by bridging the gap between knowledge-developers and end-users. Typical Learning Objects include applets, modules, video segments, narrated PowerPoints as well as other self-contained educational materials or resources that might incorporated into a larger educational scheme, such as a unit or course.

To accomplish this objective, DLNET will undertake the tasks of collecting, screening, packaging and archiving of learning objects for easy discovery. Its collection will be developed by acquiring contents through active harvesting and soliciting for submissions. Contents will be screened for their quality and pedagogical value using in-house as well as external (i.e., peer) reviewers. Packaging will convert content submissions into DLNET "Learning Objects" ready for discovery and use by the public. Archiving will involve the process of extracting important metadata about the content and placing it in the repository.

DLNET and its services are being designed so as to comply with the core standards and specifications adopted by NSDL's Core Integration System. The shared specifications and core commonalities will enable a high degree of interoperability and functionality with NSDL and federation libraries.

The objective of this paper, therefore, is to provide an introduction of DLNET by way of describing its conceptual architecture and the ongoing development process. The approach adopted in this document will be to describe the architecture using the flow of content and information throughout the system.

III.   Architecture

DLNET's architecture is that of a typical digital library consisting of three core elements, namely, **content-receiving**, **content-management** and **user-interface** sub-systems. The building blocks are shown in Figure 1 together with a listing of key functions and operations. A description of each block is given below.
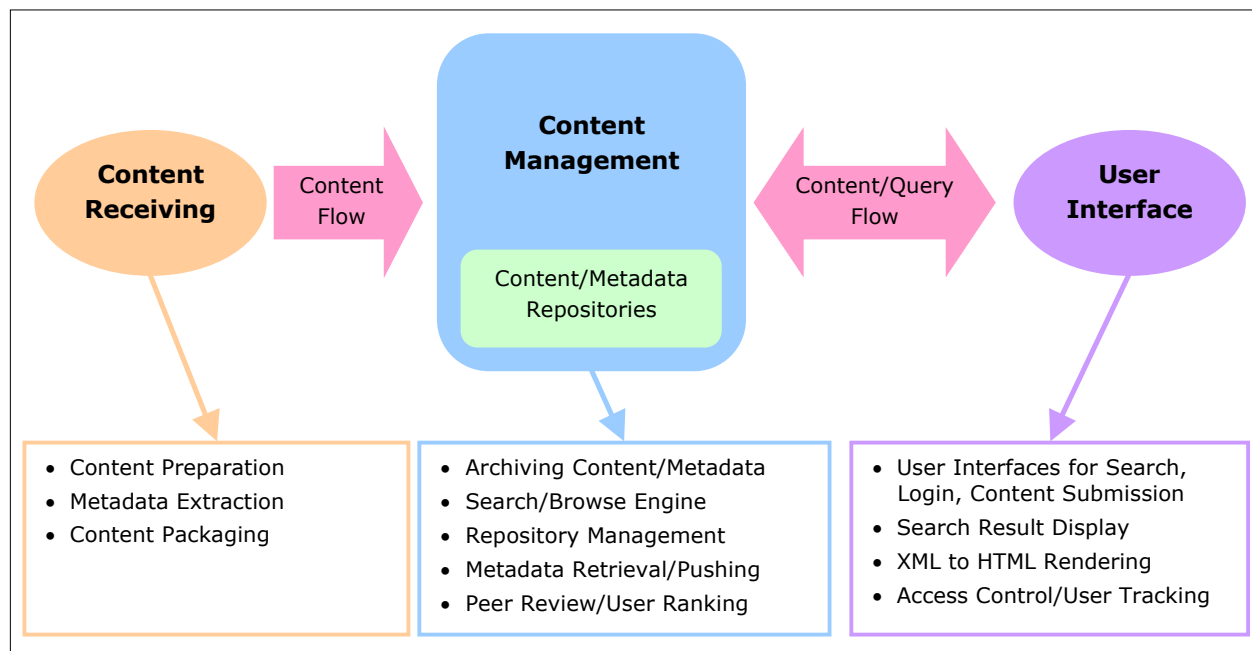
Figure 1 - Digital Library Network for Engineering and Technology (DLNET)

3.1 Content Receiving

DLNET will develop its collection through active harvesting and from submissions by contributors - the latter expected to be the main source of contents. Accordingly, a tool is being developed to assist contributors in preparing and packaging their materials for submission to DLNET. The underlying concept in DLNET's content-receiving process is that of "Learning Objects" (LOs) whereby the contributor's submission is transformed into a resource that can be readily utilized by both the learner and course builder. The most important attribute of a DLNET LO is its encapsulation of metadata thus facilitating its rapid discovery and distribution. DLNET's LO development tool will perform three major tasks upon the resource submitted by a contributor: (i). It will extract key metadata about the contributor and the resource, (ii). It will organize and validate the resource - a process to ensure that all the necessary components of the resource, i.e., files, folders and hyperlinks, are present and accounted for prior to packaging, and (iii). It will package the resources for upload.

DLNET has adopted the metadata and content packaging standards based on the Learning Resource Meta-data and Content Packaging Specifications of the IMS Global Learning Consortium, Inc., in developing the tool. Table 1 shows the list of metadata elements that will be harvested by the DLNET LO development tool, categorized into groups. Figure 2 shows the conceptual model of the LO as created by the LO development tool.

Table 1 – Metadata Elements harvested by DLNET LO Development Tool

Category	Metadata Element
Information about the Contributor	• Author Name • Email Address • Department • Organization
Basic Metadata	• Title • Language • Description • Keywords • Date of Creation
Educational/Pedagogic Information	• Interactivity Type • Learning Resource Type • Interactivity Level • Intended User • Context of Use • Learning Duration
Other Additional Information	• Format • Rights • Classification
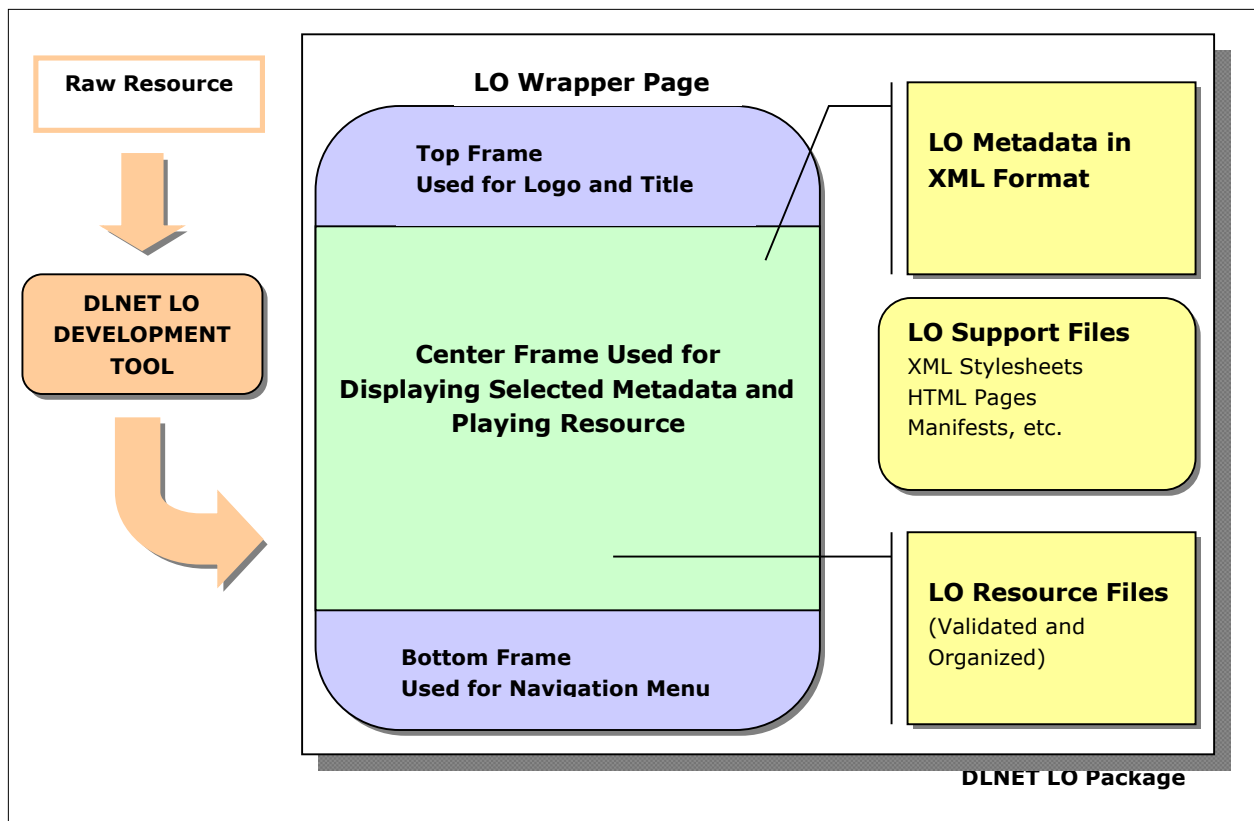
Figure 2 – DLNET's Learning Object Model

As seen in Figure 2, DLNET's LO package will be a composite structure consisting of the physical learning resource submitted by the contributor, its metadata in XML format and supporting files such as XML stylesheets and transition html pages. The main page will contain static frames at the top and bottom that will be used for navigation. The center frame will be the main area used for displaying metadata or playing the resource itself. The LO will be packaged as a zipped folder that can be uploaded to the DLNET website by the contributor.

3.2 Content Management

Content-management will serve as the core engine of DLNET that controls and directs the flow of data and information in the system. Its main components include the repositories, the search engine, the content review/ranking mechanisms and the metadata pusher.

The sequence of activities is as follows: Once an LO package is uploaded to DLNET, it is unbundled into its components, i.e., the resource folder and the metadata, which are then stored in their respective repositories. Prior to publishing the LO, however, the Content-Management engine will initiate a peer-review process in which the resource is assessed for its quality, pedagogical effectiveness, and ease of use by designated reviewers. Once published, user feedback will be solicited to rate the LO's quality and usefulness.

One of the main tasks of the Content-Management sub-system will be handling the search and browse queries from the user interface. The current search engine in DLNET will operate mainly upon the metadata repository to locate LOs in the collection. A more powerful search engine being developed for the NSDL federation of digital libraries will be implemented in the future. NSDL's search engine known as ADEPT will have the capability of searching both the metadata and content repositories. The results of search queries will be rendered in HTML format using the appropriate XML Stylesheets.

The Content-Management sub-system will also handle queries from other libraries in the federation and, in particular, from NSDL's core metadata repository. The latter will require DLNET to periodically upload or "push" its updated metadata records to NSDL in conformance with the Open Archives Initiative (OAI) Protocol for metadata harvesting.

3.3 User-Interface

The user-interface sub-system serves as the primary interface or portal to the public. Its front-end is represented by the DLNET website. A main feature of the user-interface will be its access control that will confine the use of selected services to registered users of the digital library only. Table 2 lists DLNET's services that will be placed under access control as well as those that will not require registration.

My DLNET Page

Users will be encouraged to register and open an account on DLNET. A basic registration form is provided for the user downloading LOs only while an extended form is available to users who will want to participate by contributing and/or reviewing LOs at DLNET. All registrants will be given access to a personal page on DLNET called the "My DLNET Page" where they will be

able to view and update their profiles as well as view statistics on their recent activities at
DLNET including downloads, reviews and contributions.

Table 2 – User-Interface Access Control List

Services Requiring Access Control	Openly Accessible Services
- Downloading LO and Metadata - Downloading DLNET Resources - Submitting/uploading Content - Reviewing DLNET LO - Accessing "My DLNET Page" - Updating Personal Profile - Viewing Personal Statistics - DLNET Forum	- Simple Search - Advanced Search - Browsing DLNET - Viewing DLNET Resources - Viewing DLNET Statistics

Search Interface

The main task of the front-end is to serve as an openly accessible search platform. The user-interface will forward all queries to the search engine in the content-management sub-system that will parse through the metadata repository for LOs meeting the criteria. Query results will first be processed using the appropriate stylesheets (to render XML records into HTML) and then displayed at the user interface. Three search options are available to the user for discovering resources at DLNET:

- **Simple Search**: searches the collection based on a **Keyword** entered by the user
- **Advanced Search**: searches the collection based on an AND/OR combination of common metadata elements. These include the **Title**, **Author Name**, **Keyword**, and **Format**.
- **Browse**: searches the collection based on a three-level taxonomy of engineering and technology fields specifically developed for DLNET. The user selects the type of engineering followed by the topics and sub-topics of interest.

The three-level taxonomy used in the Browse Engine has also been incorporated in the LO Development Tool discussed earlier. A section of the taxonomy is shown in Table 3 to illustrate its structure. In the example below, the bolded taxons indicate the path that would classify or locate an LO as a resource in electrical power transformers.

Table 3 – Example of an LO Path in the Three-Level Taxonomy Used in DLNET

Level 1: Eng. Fields	Level 2: Engineering Topics	Level 3: Engineering Sub-Topics
Aerospace	Circuits and Systems	Direct Energy Conversion/Energy Storage
Chemical	Communications	Power System Analysis and Computing
Civil	Control Systems	Power System Design, Operation & Control
Computer	**Power Systems**	Power System Planning, Load Forecasting
Electrical	Electronics	Reliability, Risk and Probability
Environmental	Electromagnetic Fields	**Substations, Switchgear, Transformers**
Industrial Systems	Instrumentation/Measurement	Transmission & Distribution Systems
etc….	etc…	etc…

IV.   Conclusions

At this stage, DLNET is finalizing the development of the platform (http://www.dlnet.vt.edu) and the learning object development tool and will soon embark on the most important phase of collections-building. This will be done through the concerted effort of project partners to introduce and promote DLNET and the NSDL initiative among learning institutions, organizations and the general public. The initial focus of the content will be on electrical engineering related topics, and it is expected that first set of contents will be submitted by academia-based members who have produced such materials for use in their home institutions and would like national and international exposure. We also expect to see some initial contributions from international sources as well.

V.   References

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