

## QDITA: AN ECO-SYSTEM FOR ADAPTIVE E-LEARNING

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**Abstract:** In order to solve the issue of providing a total solution for the adaptive e-learning, an institution has to face more than one challenge. For an institution to develop a plan based on pedagogy and instructional methodology of the adequate course content creation, the institution must have an efficient assessment system, established rules for the sequencing and navigation, and a method of delivering content to its students. In addition, software tools and technical platforms have to be put in place. QDITA for e-learning offers a total solution eco-system capable of responding to the current requirements for adaptively in education. In this paper<sup>1</sup>, the main features of the QDITA eco-system will be detailed, starting from the high-level landscape, all the way through to the scalable architecture for content creation and the affordable technical platform to support this solution. Additionally, key concepts of reusability through the reusable Registry, customized Learning Object (LO), digital library, and the union between the DITA and SCORM standards, will be explained. Extension into the domain of mobile e learning will be drafted as well.

**Keywords:** Adaptive learning, content authoring, DITA, SCORM, content management, LMS, open-source, web application

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### 1. INTRODUCTION

It is worth noting that learning and e-learning content should be treated as a specialization of technical documents. So tools and solutions developed for the general content, and technical documentation preparation and management are applicable in the area of computer-based learning.

The QDITA (Qficient DITA) total solutions eco-system is designed to deal with a diverse multi-domain content preparation, content management, publishing and delivery.

The essence of the QDITA approach is the concept of structural writing of granular content, based on the DITA [5] framework philosophy. With DITA, every piece of content is a context-less topic written in order to be used as part of building block for a more complex content structure. Aggregating the topics can produce any kind of document. DITA was originally invented to solve technical documentation writing and management requirements, but since the framework became a powerful platform, it was applicable in any domain that cared about content structuring, reusability, search-ability, collaboration and content maintenance.

With DITA including learning specialization as a standard, it provided a vital foundation for the course preparation, learning object libraries and anything related to content preparation for learning and education.

QDITA has been created to solve the implementation issues, which have not been addressed by the frameworks theoretical definitions.

Some attractive concepts and features that are trumpeted as key benefits of the original DITA standard, are now left to future developers and implementators, as a significant challenge. Among them, reusability, content models, content management, and integration with publishing, were seen as the most important features and concepts to be realized for the purpose of practical usage.

This is where QDITA stepped in to provide a total solution eco-system for structural content preparation and delivery.

### 2. QDITA FOR E-LEARNING

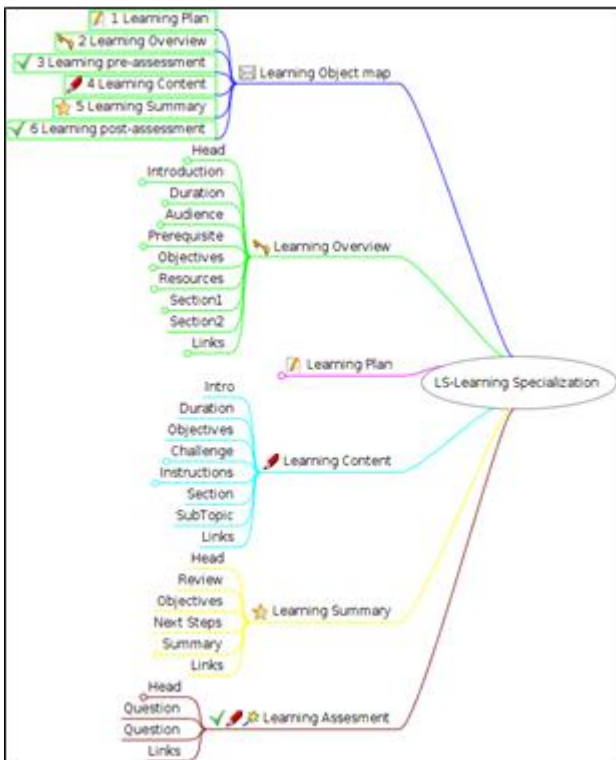
QDITA for e-learning is a variant of the total solution for preparing a wide range of documents types. In order for

that to be possible, certain essential functions have been integrated into the system.

At the heart of QDITA are the Content Management System (CMS) and the Registry/Digital library. Additionally, a publishing subsystem has been implemented, along with functions for structural content authoring. Included in QDITA is the function for SCORM [3] adaptivity (S/N) and delivery to an LMS. Furthermore, the introduction of Learning Object (LO) players for the Client side, allow users, either through a browser or mobile device, to view content available on an LMS.

DITAs Learning and Training Specializations (LTS) [39] standard is one of the key enablers of QDITA, which clearly separates instructional and informational content. They are also well suited for a traditional course/module/lesson/topic courseware structure. Furthermore, the use of micro topic substructures and aggregations, represent essential learning content patterns, very well.

Figure 1 below provides an image of the LTS - Learning and Training Specializations elements and aggregation. Learning Object as an aggregation is composed of learning topics: a Learning Overview, a Learning Plan, a Learning Content, a Learning Summary, and a Learning Assessment. Within each of those learning content topics are its sections (head, intro, section, etc.).



**Figure 1:** A map structure depicting the components of Learning and Training Specializations.

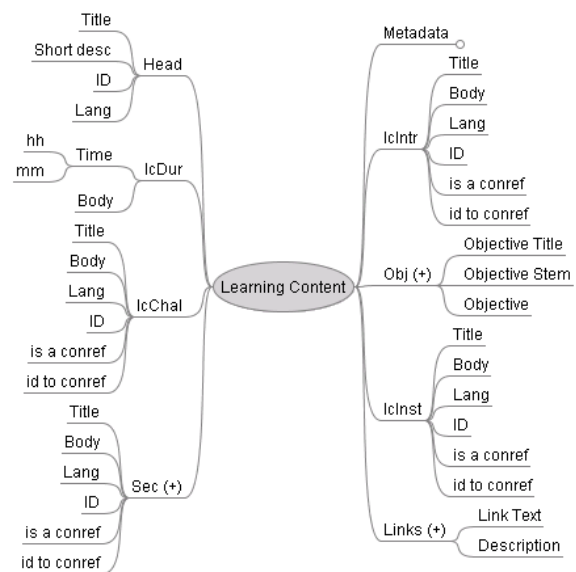
With QDITA there is also the option of publishing into another e-learning de facto standard format – SCORM. E-learning or learning content can be delivered not only as an online course, but in the form of traditional printed

text, or in other offline reader formats, such as EPUB, Mobipocket (MOBI), etc.

## 2.1 Learning and Training Specialization (LTS) Implementation Details

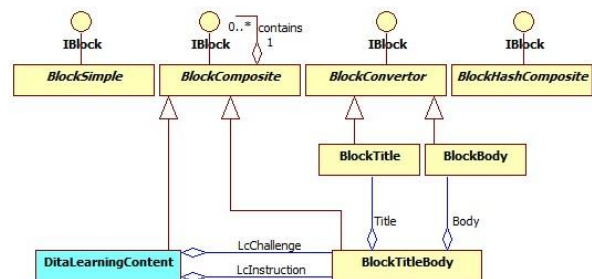
The key ingredient in the QDITA authoring architecture is the idea of authoring structured content in DITA. DITA is the carrier of information contained in a course, learning object or other abstraction. It is an excellent choice for e-learning environment since it provides a specialization for learning systems. It allows content to be separate from instructions, which may include descriptions, guides, course overviews, etc.

All specialized topic types, except Learning Content, are instructional, meaning that they don't contain any content intended for learning. Content holder is the Learning Content topic specialization whose structure is shown in the following figure.



**Figure 2:** Learning Content topic type structure

QDITAs implementation of topic types, including specializations, is based on four building blocks from which every DITA component can be built. The following diagram shows a cut-out of the DITA implementation architecture from QDITA Authoring Application. Here the implementation of sub-elements lchal and lcnst which are parts of the Learning Content topic type can be observed.



**Figure 3:** Cut-out of the DITA implementation architecture

## 2.2 Adaptivity Enabled by a DITA and SCORM Union

Adaptive learning [13] or adaptivity, introduces the idea of delivering content in the manner which is not "one size fits all". Adaptivity is a very promising concept, but in actuality it should be heavily grounded by laying pedagogy and instructional methodology, adopted by the educational institution.

By profiling students and tracking their progress along the learning process, it is possible to optimize the learning effort. Through navigation, students can be guided to consume appropriate knowledge pieces based on the check point results, and the rules defined by the institution. Ultimately, their preparation for the final exam should be short and accurate.

To implement adaptivity in learning, some essential prerequisites should be considered:

- Provide and organize knowledge to the optimal granularity.
- Develop comprehensive assessments to be used as the criteria for adaptive sequencing of content.
- Develop consistent institutional policies and processes for content creation.
- Have and adopt software tools that can efficiently support all aspects of the process, including content authoring, course publishing, content delivery and course maintenance.
- Have a tool to enable key adaptivity element sequencing and navigation during the content delivery.

In the field of e-learning there are two frameworks that are complementary and not in competition: DITA and SCORM. They are ideal candidates for a union which can best serve the e-learning community.

DITAs role is to enable structural writing content granularity, separation of the raw content and formatting, and the reusability platform.

SCORM 2004 on the other hand will bring the presentation layer, with the strong sequencing and navigation engine which is a key enabler of the adaptivity.

## 2.3 The Solution Landscape

High-level business architecture is based on subsystems which provide complementary services for the eco-system:

- CMS
- Registry-Digital library
- Publishing subsystem
- Structural Content Authoring
- SCORM adaptivity (S/N)
- LMS delivery
- LO players - Client side
- Printed material production
- Offline and classroom tools

- Digital asset editing
- User management and administration
- Quiz management

QDITAs eco-system is best presented by Figure 4, which depicts at high-level sub-system aggregation in a full landscape.



Figure 4: QDITAs sub-system architecture

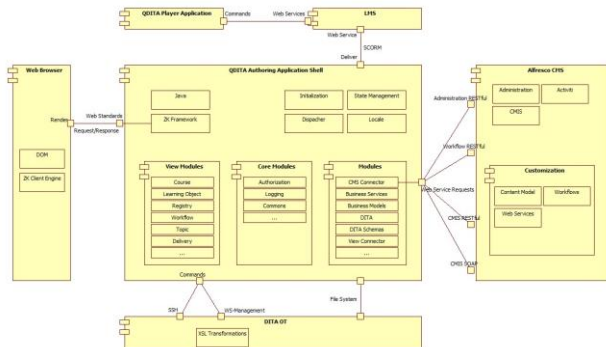
## 2.4 QDITA Authoring Walkthrough

In the QDITA domain, by authoring, we mean authoring a product. A product is a deliverable entity, which can, in traditional systems, be a book, but in an e-learning environment it is most commonly a SCORM content package. SCORM content package is a single source deliverable package which is placed into LMS to be read by clients. But firstly, this SCORM content package must be authored. QDITA authoring architecture provides all the necessary support needed to produce a fully functional and good-looking product.

An overview of technical implementation of QDITA solution includes all components which take part in the process of authoring, publishing, storage, delivery of published products and "playing" them. Modular approach was used to implement the solution so it would be easily extensible and reusable. Each of these components is isolated and can be extended or customized to support communication with the centerpiece application or to support business logic defined in the centerpiece application. Components can reside on different platforms, computers or even locations, which enables optimization of the solution and its extension when needed.

The centerpiece web application – QDITA authoring application – was developed with modularity in mind as well; many of its modules can exist outside of the application shell if there is need for that kind of integration. QDITA authoring application is implemented as a shell which encapsulates all necessary functionality inside it, but leaves entry points for integration with other components in the architecture. It enables high performance of business logic and high responsiveness to user requests by embedding time critical modules and leaving remote access to what needs to (or just can) stay accessible outside of the application shell.

Extensibility is an important paradigm in the QDITA solution architecture. It is a framework in its core, which can be utilized to implement desired functionality as a total out-of-the-box experience. Several components are included in comprising this extensible architecture.



**Figure 5:** QDITA Authoring Architecture

QDITA Authoring Application as a central component which makes connections to other components. It is mapped to the Structural Content Authoring subsystem in QDITA solution. It also maps to the Registry-Digital Library subsystem by providing a registry as virtual view of content in CMS, as well as to the SCORM adaptation (S/N) subsystem.

Alfresco ECMS is a component which stores content and provides a workflow engine. It maps to the CMS subsystem in QDITA solution.

DITA OT component is responsible for creating product from source content and assets. It maps to Publishing subsystem in QDITA solution.

A Web Browser is a tool which enables interaction with the solution. QDITA Authoring Application is implemented as a web application which is accessible from any location, avoiding the necessity to be installed in the client environment. It can therefore be mapped to Structural Content Authoring subsystem.

An LMS is a component assigned to the processing of a product delivered in form of a SCORM package. It is mapped to LMS delivery subsystem.

The QDITA Player Application component renders content provided by LMS. It can be a web browser, or a mobile application which is a part of the QDITA mobile architecture. This component is the students' entry point into course material.

One of the challenges when designing this architecture was in keeping customizations of the CMS component to a minimum. APIs are not extended until it is an only option. This keeps CMS component separate from the business logic which is encapsulated in QDITA Authoring Application. Extensions made to Alfresco CMS can be seen on the following images.



**Figure 6:** Customizations to the CMS

Customizations of the DITA OT are limited to the XSL transformations used for translating structured DITA into different outputs – SCORM, EPUB, PDF... By modifying them, new functionality can be added, such as supporting custom tags in DITA, or existing functionality can be adjusted to satisfy business requirements.

## 2.5 Architecture details behind the QDITA solution

The focus will be set on QDITA authoring architecture, but firstly its place in the QDITA architecture must be defined. To achieve this goal different perspectives will be presented, which may help in understanding the architecture behind complex QDITA solution and how authoring architecture found itself in the spotlight.

With that in mind, several perspectives can be defined:

- User's abstraction of the solution;
- Layered view of the QDITA authoring application architecture;
- Technical overview of the system's extensible architecture where modular architecture of the centerpiece application can be observed as well as extensions made to other components;
- Model view which provides mappings between models in user interface and physical models.

Users interact only with the centerpiece application which "hides" the system architecture from them. This application dispatches user's requests to other components in the system, or handles them by itself. It is called QDITA Authoring Application and handles product creation, from inception to delivery.

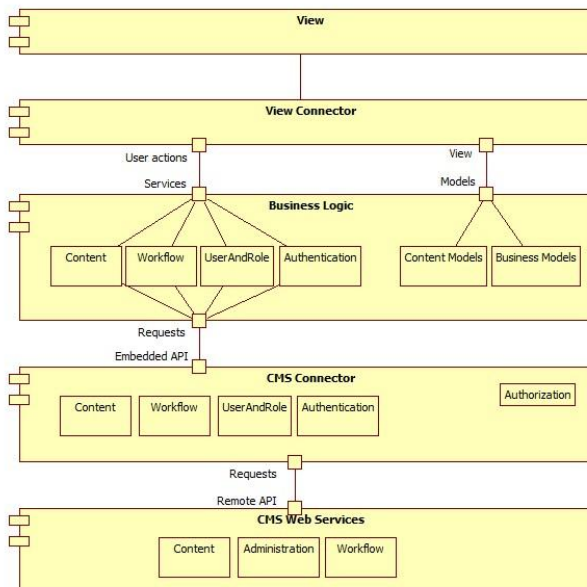
When working with the application, user can outline a number of components in the system:

- Content authoring enables authors to author structured content.
- Course outlining enables course lead to design outlines for courses, modules, lessons and other non-content related entities.
- Course publishing provides publishers with an interface which enables them to create products and style them. It also enables adaptation of sequencing and navigation in SCORM content packages.
- Course delivering provides an interface of delivering products (SCORM content packages) to an LMS.
- Registry provides a virtual view of content which can be reused.



- Collaboration is an advanced interface which guides users of the system through predefined pathways (workflows).
- Administration adds support for managing users, groups, templates for various entities...

QDITA authoring application is an implementation of QDITA authoring architecture. Layered view is a good choice when in need to understand the pathway between user interface and content management system which holds actual data. It is also an overview of a flexible architecture which can easily and quickly adapt to different content management system, can be customized to any user interface with changes made only in one layer of the architecture. This can be crucial when delivering QDITA solution to various organizations as it shortens the delivery time and increases reliability by avoiding changes in all layers. Also, business logic can be tuned, optimized and customized in various ways without visible changes in GUI and need of administering complex enterprise content management systems.



**Figure 7:** Layered overview of QDITA authoring architecture

The pathway can be easily described. User interacts with the View component. This component can be either a web application implementation or a desktop application implementation. It can be developed in many different frameworks and can take desired looks.

Next layer, the View Connector, is an adapter between the View and the Business logic. It is a generalized, small as possible, implementation which translates user actions into business actions and maps business and content models to the View.

The Business logic component holds all business logic and models which are abstractions of the real world entities. It holds generalized concepts which can be extended to support a variety of content management implementa-

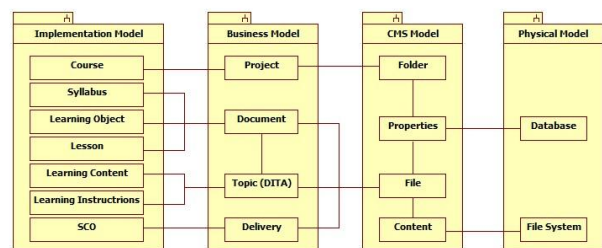
tions, e-learning being one of them. It must communicate with the storage of content, but since many different storage implementations can be used, Business logic communicates with CMS Connector's embedded API.

CMS Connector provides an actual connection to a storage service – an enterprise content management system, a database or even a file system! It provides an implementation of services which the Business logic component uses to store content and go through workflows.

Content Management System layer is responsible for storing content and providing a workflow management mechanism. Many enterprise content management systems provide said functionality through remote APIs, they use standards, such as CMIS standard [1] which provides unique interface for content management, so they pose themselves as an excellent choice for the purpose.

In conclusion, this layered architecture provides an authoring environment which is highly flexible, quickly customizable and can provide experience for users which they find most comfortable.

Previously defined QDITA Authoring Application and Alfresco ECMS components are key components in the architecture responsible for preparing source content, which will then be transformed by DITA OT component into a SCORM package, which we place in LMS, for it to be available to students who use QDITA Player Application. QDITA Authoring Application's modular architecture allows working with abstractions of entities we get in touch with when authoring a product, a SCORM content package for example, by providing a base set of entities to which all our abstractions get mapped to. With the help of Alfresco CMS these abstractions are stored in a safe place and can be parts of workflows that we define. Abstractions include course, syllabus, course outline and learning object among others. They get mapped to project, document, topic and other models in business layer which are then mapped to folders and documents with properties and binary content in Alfresco ECMS.



**Figure 7:** Mappings between models in different layers

### 3. OPEN SOURCE AS UNDERLAYING TECHNOLOGY

Many different technologies have been utilized which are presented in the table (1) below. Common characteristic is that all come from the open source domain. This builds the case for the affordability and adaptability to the future requirements or customized solution.

**Table 1:** Open-source technology used

Technology	Reasons
DITA	OASIS standard XML data model for structured authoring and publishing. Content reuse. Conditional publishing. DITA Open Toolkit is available for publishing of DITA content.
ZK CE	Ajax Web application framework. Rich modular GUI. No JavaScript from developers. Desktop application experience. CKEditor support integrated. Java programming language for development.
Alfresco CE	Enterprise content management system. Highly modular and extensible. Activiti workflow engine integrated. Supports CMIS standard. Content indexing.
Activiti	Supports BPMN for business process modelling.
JAVA	Wide acceptance. Proven.
CKEditor	WYSIWYG text editor in web pages. Lightweight. No server side implementation. Executes at client without installation.
DITA OT	Processes DITA maps and topics. Good publishing results.
CMIS	OASIS standard. Language independent. Many ECMSs use it. Decouples web services and content. Java wrapper library available.
LMS	ILIAS open source LMS. Robust commercial grade. PHP technology extremely customizable.
Android	Mobile device OS and application framework.

#### 4. APPROACHING THE CONCEPT OF REUSABILITY THROUGH THE LEARNING OBJECT (LO) REGISTRY

Reuse or Repurpose are two terms which exist in a very close proximity and are very often a source of confusion.

Reusability, as a concept, can be very attractive and promising in the case of guiding learning content creation and the design of an e-learning eco-system. Unfortunately, many obstacles will arise in an attempt to implement any efficient and reliable reusability approach. It is therefore crucial at first to make a clear distinction between two close terms: reuse and repurpose.

The term Reuse means using the same piece of content (item or object) in multiple situations, without applying any change to the content, such as formatting or the status of the process that led to its creation. Repurpose, on the

other hand, is disassembling a piece of content into fragments, and then using those fragments to build new content. Disregarding the distinction between the two concepts will cause an impact in the collaborative environment, future maintenance of the content, and in some cases bring upon legal consequences. In the case of Learning Object reusability, the subject of reuse can be the visual presentation and formatting, or it can be the instructional part of the object. But most likely the main point of interest will be the raw content itself.

SCORMs definition of a reusable object (Shareable Content Objects) is not a suitable candidate for content reusability, because by definition, Shareable Content Objects (SCO) aggregates all aspects (instructions, format). This is where structural topic based content writing, based on DITA learning specializations can help. DITA clearly separates instructional and informational topics, and separates raw content from formatting.

For the purpose of BMU, it is recommended that content reusability be considered at the level of a DITA Learning Content topic, as it will become a basic reusability element inside the QDITA e-learning eco-system. The Reusable Learning Content Registry will host all pedagogical concepts and knowledge pieces in the form of DITA XML Learning Content files. These pieces should be enriched by the appropriate set of metadata, which should be reviewed and approved for further reuse.

By applying this reusability policy, BMU can expect to significantly improve content creation, course assembly, collaboration among authors, reusing content for online, and printing through single source publishing.

What are challenges of reusability implementation? DITA offers high reusability of content which is a paradigm heavily exploited in the architecture. Everything is subordinated to the idea that - what is missing must be added, and what is defined can be improved. As a consequence, if a course reused content (topic, learning object or even whole lessons) it can be automatically updated to have a new version of reused content. This shortens the time needed to author a product, but leads us to a challenge – do we need new versions of reused content, automatically made available, or should the previous version be used instead. This may depend on the business scenario, and not on the framework. But the flexibility of the architecture allows us to implement exactly what is needed!

This challenge spreads to LMS as well, where things get more complicated. After publishing a course in the form of a SCORM content package and delivering it to LMS, should the package be updated if, for example, some typographical error were corrected? Technology behind e-learning may provide a solution, but in traditional publishing, a book published as course material will not be printed again in the middle of semester.

## 5. CCMS – COMPONENT CONTENT MANAGEMENT SYSTEM ASPECT

Content Management Systems (CMS) nowadays are used to manage complex publications, far more often than a few years ago. The basic principles of CMSs are the separation of structure, content, presentation, and an exactly defined workflow management, as well as the management of content in the form of small units, called assets. This leads to improved quality, better reusability and reduced costs.

A component content management system (CCMS) is a content management system that manages content at a granular level (component) rather than at the document level. Each component represents a single generic topic, concept or asset (for example an image, table, product description, or a procedure). Learning type topics (learning plan, overview content, summary, assessment) are in the same category.

The CCMS must be able to track different versions of topics and assets, but additionally, it needs to track relationships among topics, maps, publications, and deliverables.

The size of a component is always an issue that needs to be discussed, but in practice a component can be as large as a chapter, or as small as a definition, or even a word. Components in multiple content assemblies (content types) can be viewed as components or as traditional documents.

There is strong case that XML notation is the best choice for structured and modular documentation. The DITA framework standard, being open source, provides a complete solution off the shelf for the modular components information architecture. This is especially the case for the e-learning-ready content and documentation, because DITA has a dedicated Learning and Training specialization.

Implementation and usage of CCM systems comes with the price, of course. Challenge for technical writers is the shift from topic-based authoring, in the form of books and linear documentation, to writing modular, structured and reusable content components.

Each component is stored only once in the content management system, providing a single, trusted source of content. These components are then reused (rather than copied) within a document or across multiple documents. This ensures that content is consistent across the entire set of documents. Each component has its own lifecycle (owner, version, approval, use) and can be tracked individually or as part of an assembly.

Component Content Management (CCM) was originally developed for the purpose of multi-channel, customer-facing content (marketing, production, support), but became a perfect fit for a learning system.

Some specifics of the e-learning system can be observed as:

- A large portion of the functionality commonly found in e-learning platforms, can be abstracted from its domain-specific usage and can be shown to be common content management functionality.
- The architecture of systems for e-learning has to be modular.
- The functionality of a typical e-learning platform can consist of basic content management and assessment functions.

Content Management Systems (CMS) offer more general and more robust functions for managing content, which means that e-learning platforms can be built on top of already available robust and proven content management systems. If the architecture is modular, the only requirement is that all lacking functions need to be added as a specific modules.

As a proof of concept, we have designed and implemented the QDITA total solution for e-learning, as web content enabled application with a general-purpose content management system extension, which facilitates course management and delivery.

Details of the modules development, described in earlier sections, demonstrate that having a well-established kernel, based on Alfresco ECMS and DITA content model, can be extended to provide great scalability and to meet all e-learning platform demands.

The key to successfully re-using content, is by managing it at a granular level. These grains of content – components – can be shared, reviewed, updated, or combined and compiled into different document aggregations and collections. Each component can be separately edited and re-used, with an enforced workflow processes. Content components can have their own lifecycles and properties (versions, owners, and approvals) that support fine-grained reuse, with the ability to track such usage.

## 6. CONCLUSION

To summarize the key achievements of the QDITA project one can observe the following:

- Solving the reusability challenge by introducing new concept – Registry. A Registry is a repository for reusable content management, designed to deal with different type of granular content.
- SCORM SCO reusability can be tracked to the raw DITA Learning topic.
- Addressing adaptive e-learning by implementing existing DITA and SCORM frameworks into the sequencing and navigation area.
- QDITA eco-system was developed as a type of Component CMS solution. It is a proof of concept to demonstrate that most e-learning platform functionalities can be found in standard content and document management systems. Alfresco as an extremely ro-

bust Enterprise CMS. It is arguably a strong foundation on top of which it was possible to build a content enabled web application, which implements the DITA components framework theory. Even though DITA itself is a pure XML environment, it was proven that efficiently handling XML documents can be realized by not utilizing a specialized XML CMS solution, but by using a more affordable and ordinary ECMS, instead.

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