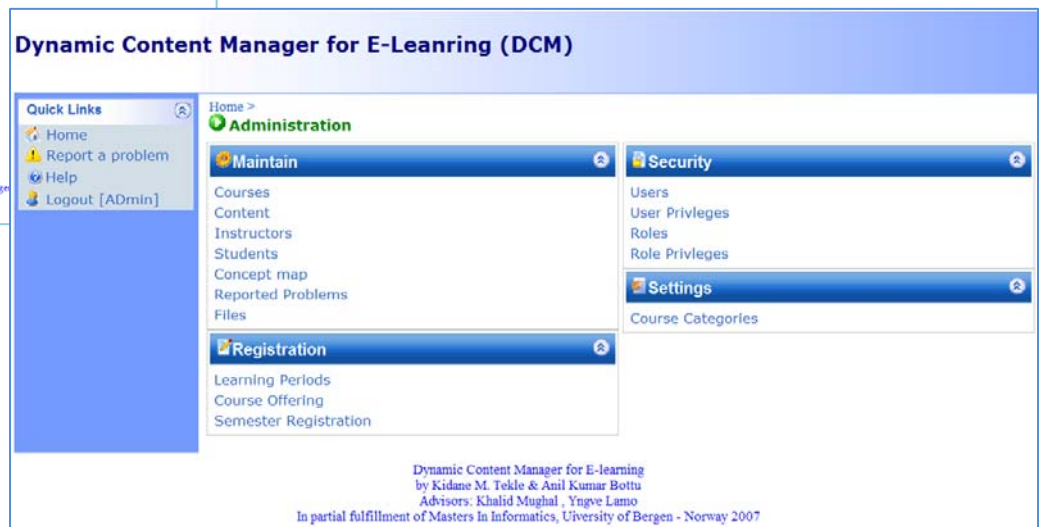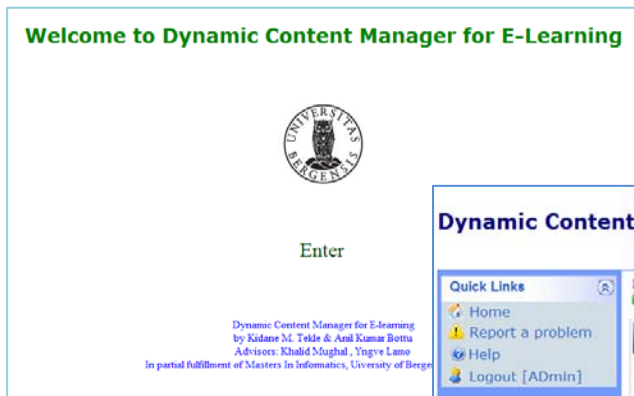# Dynamic Content Manager for E-Learning

By

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Preface

The DCM project is an e-learning system project done by Anil Kumar Bottu (Me) and Kidane M Tekle in partial fulfillment for Masters in Informatics at the University of Bergen, Norway. Firstly I would like to express my gratitude to the University of Bergen and Norwegian State Educational Loan Fund for bestowing on me this wonderful opportunity to study and work with the best strata of people in UiB.

Through the work with the present thesis, not only have I been acquainted to this highly interesting field, I have also learned new aspects of my own abilities. For this I owe my special thanks to my dearest friend Kidane M Tekle for his support and also being my mentor throughout the duration of my master studies. We are greatly indebted to our advisors Yngve Lamo (Phd.), Khalid Azim Mughal (Phd.) and Terje Kristensen (Phd.) for their skilled guidance and support throughout the duration of the project. We are also equivalently grateful to Adrian Rutle (Phd. Candidate) for helping us put the DCM system to use. A special regards goes to East Africa Systems for allowing us using their database and user interface components.

This document gives a historical description of e-learning systems and explores some of the popular ones being used today. It states some shortcomings of most e-learning systems and describes in detail the pedagogical and technological points taken into consideration in the problem definition, analysis, design, development and pilot deployment of the DCM system. More emphasis is given to description of parts of the DCM project that I am responsible for while describing the overall solution.

Finishing my thesis means finishing my days as a master's student, from which I bring along good memories. I believe the DCM project has given me great understanding of the exciting field of E-Learning and provoked me to come up with ideas and solutions for the realization of the DCM system. I would like to consider this as a stepping stone of my future endeavors in the area of developing expert e-learning systems of the future. The knowledge I have earned will hopefully make me able to meet new challenges. I feel privileged!

I dedicate this master's thesis to my beloved grandmother who passed away in october2007
and also to my family who believed in me.

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Definitions and Acronyms

CBT – Computer Based Training

LMS – Learning Management System

DPG – Dynamic Page Generator

DCM – Dynamic Content Manager for E-Learning

UP – Unified process

XP – Extreme Programming

CLR – Common Language Runtime

IDE – Integrated Development Environment

CMS – Content Management System

DNN – Dot Net Nuke

1. Introduction

In the past few years, information technology has become very influential in our day to day activities. Many people cannot imagine living without the facilities of using computers and the internet. All major decisions of today are powered by statistical results and information that is the outcome of some computational processing.

The teaching-learning environment is one of the areas where information technology has showed its strong influence. Traditional lecture-based learning is not so attractive for students of today. This type of teaching may be more ineffective and usually creates more passive students in the learning process. Traditional classroom learning is mostly based on *behaviorism* learning theories where the learner is the object of assessment. The teacher initiates the learning process and the learner responds. Another learning approach, *constructivism*, focuses on the learner's abilities to develop her own mental models and learning concepts. By introducing web-based teaching systems one is able to create more constructive learning paradigms. The students will be more active in the learning process and more able to construct their own mental models of the learning objects, rather than doing only pure knowledge acquisition.

Electronic Learning (popularly called E-Learning) is a learning paradigm by which computer based learning methods and tools are put to use. It avoids time and space barriers in that content published by the educator can be available to the learner in practically no time. E-learning also gives new possibilities for making learning material available to the learner. It offers educators flexibility in their work and allows co-operation through content sharing and working together. Thus, an E-Learning system is a software system that is used by educators and learners as a means of courses administration, content delivery, progress follow-up, realization of educator learner interactions etc... Currently, there are many free and commercial e-learning systems in use. Each e-learning system has its own strengths and also its weaknesses based on its history, underlying philosophy, development methodology, usability and target audience.

1.1 Problem Description

E-learning systems have undergone tremendous evolution and have incorporated lots of functionalities. The two forces that dictate the changes in e-learning systems are research on the pedagogical understanding and modeling of e-learning and technological advances. These two factors do not always go side by side and it is not an easy task to find the correct mix on the two. Some e-learning systems are too much technology driven and incorporate functionalities that sometimes become responsible for their own downfall. Such systems lose the pedagogical

grounds and may influence the teaching –learning process negatively. On the other hand, e-learning systems that focus too much on pedagogical structures are observed to be difficult to use since they lack the latest technological advances and ways of presentation that the user can find in most other places.

Most of today's e-learning systems are based on the constructionist pedagogical theory. As such, they focus on enhancing the interaction of the student and instructor via the availability of various resources and activities. The educator avails various resources to the learner during the running period of the courses she is giving. There is mostly little support for the educator while creating the learning materials and because most systems do not have an easy-to-use navigation mechanism of existing resources, much effort is duplicated. Another observed shortcoming is that learning content is closely tied to courses and that sharing and re-use of resources is restricted to file copying since there is no clearly defined model for it. The separation of learning content from specific courses and provision of visual navigation and arbitrary aggregation of the existing learning material helps the educator reuse existing resources and lets her focus on enhancing the quality of the learning material. Another shortcoming of most e-learning systems is that they are very much involved and do not provide flexibility enough for interfacing with other systems. This is an important feature where possibly more than one e-learning system is put to use and their parallel operation is desired.

1.2 **Justification and Motivations**

The Dynamic Content Manager (DCM) system is an e-learning system project that tries to define sound pedagogical modeling for removing the very tight coupling of learning material to specific courses. It defines a conceptual atomic unit of knowledge and builds up courses by organization of these knowledge units from the repository. This gives the ability to create knowledge elements at a finer granularity level which can be re-used across various courses. Resources like lecture notes, presentations, attachment files, questions etc… are attributed to the knowledge elements and hence can be imported while using existing knowledge elements.

Another motivation for the DCM project is the need to create an e-learning system that utilizes the technological advances made in the area of software development. Usage of proven design and development methodologies enables easy creation of a system that is highly customizable and expandable. Such a system could be very useful in addressing major interfacing issues that are displayed when more than one e-learning system is put to use in a learning environment. Creating such a highly customizable, extensible and light weight system can be a foundation on which more advanced and highly intelligent e-learning systems can be built.

1.3 **Construction of Thesis**

This document is organized into seven chapters. Chapters two begins by giving a historical background to E-Learning systems and describes some of the most widely used ones. Chapter three states observed shortcoming of existing systems and raises various points that have been given consideration in the development of the DCM system. The fourth chapter of this document describes available technology, software development methodology and design issues used in the development of the system. Chapter five gives a detailed description of the DCM solution focusing on the security, questions and quiz generation, student registration, instructor course assignment and error reporting facility. Chapter six is about the testing and different types of testing used while developing the system. The last chapter summarizes the project, describes the current status of the system and points out directions for further enhancement and extended development.

2. E-Learning Systems

2.1   Historical Background

The first modern learning technology emerged during World War II when the United States used film to train millions of service people around the world [1]. These military training films covered such topics as personal hygiene and weapons maintenance. The success of these films, and their later use through television, led the military to partner with universities to conduct research into modern learning techniques.

In the 1960s, the first types of teaching machines were developed, while instructional film became more creative and broadened its reach to children in schools.

Then television came as a new learning delivery method. But, because the expense was too great and the delivery of the information too dry, there were only a few successes. What evolved from this were videotapes, which were produced for use in corporate and school classrooms. Since then, e-learning systems have evolved dramatically to incorporate rich learning material delivery to learners with multimedia content and providing a virtualized class room environment.

Currently, there are many E-Learnings systems that have gained popularity. Some of these are: FirstClass, WebCT, Desire2learn, BlackBoard and Moodle. Out of these BlackBoard and Moodle are by far the most used systems. Blackboard is an LMS system that is available commercially and a yearly license fee is paid to use it. On the other hand, Moodle is an open source product distributed under the terms of the GNU General Public License.

Beginning from the early nineties, some research and development has been undertaken in the field of e-developing E-Learning systems in the Bergen region or Norway. About ten years ago web-based learning systems were constructed and used that had great impact on the development of e-learning systems of today. The "Gudmundstad" project [2, 3] was started in 1994 and was a quite successful e-learning project for its time. It showed a learning system that started from fairly local initiatives and expanded to regional, national and even to an international project.

In 1997 the "Gudmundstad" project was followed up with another e-learning system, "Reidar", developed on the Windows platform. The "Reidar"system was very much used in both the curriculum and in distance education at Bergen University College. "It's learning" is another e-learning system that has been developed in Bergen, Norway [4]. The origin of this project system was a student project at the Bergen University College in 1999.

The Dynamic Presentation Generator (DPG) system project, was a project that was initiated in 2001, and aims at decoupling the storage and manipulation of learning material (content) from its presentation (learning structure)

Following, the Moodle learning management system, the "It's Learning" system and the DPG system project are described.

2.2 Moodle [5]

The word **Moodle** was originally an acronym for **M**odular **O**bject-**O**riented **D**ynamic **L**earning **E**nvironment. Moodle is by far the most widely used E-Learning system of today. Currently there are 22,387 registered Moodle sites from 172 countries of the world.

2.2.1 Philosophy

The design and development of Moodle is guided by a particular philosophy of learning, a way of thinking that is referrer to as "*social constructionist pedagogy*". The four main concepts behind this philosophy are:

1. Constructivism - This point of view maintains that people actively **construct** new knowledge as they interact with their environment.
2. Constructionism - asserts that learning is particularly effective when constructing something for others to experience. This can be anything from a spoken sentence or an internet posting, to more complex artifacts like a painting, a house or a software package.
3. Social Constructivism - This extends the above ideas into a social group constructing things for one another, collaboratively creating a small culture of shared artifacts with shared meanings.
4. Connected and Separate - This idea looks deeper into the motivations of individuals within a discussion. Separate behavior is when someone tries to remain 'objective' and 'factual', and tends to defend their own ideas using logic to find holes in their opponent's ideas. Connected behavior is a more empathic approach that accepts subjectivity, trying to listen and ask questions in an effort to understand the other point of view. Constructed behavior is when a person is sensitive to both of these approaches

2.2.2 Overall design

The overall design of the Moodle is very simple, lightweight, efficient, compatible, low-tech browser interface. Its easiness makes the users to install on almost any platform that supports PHP. The database abstraction supports all major brands of database. One model site can

support thousands of courses – courses can be categorized and searched and course listing shows description for every course on the server, including accessibility to guests. It has a very strong security throughout the system.
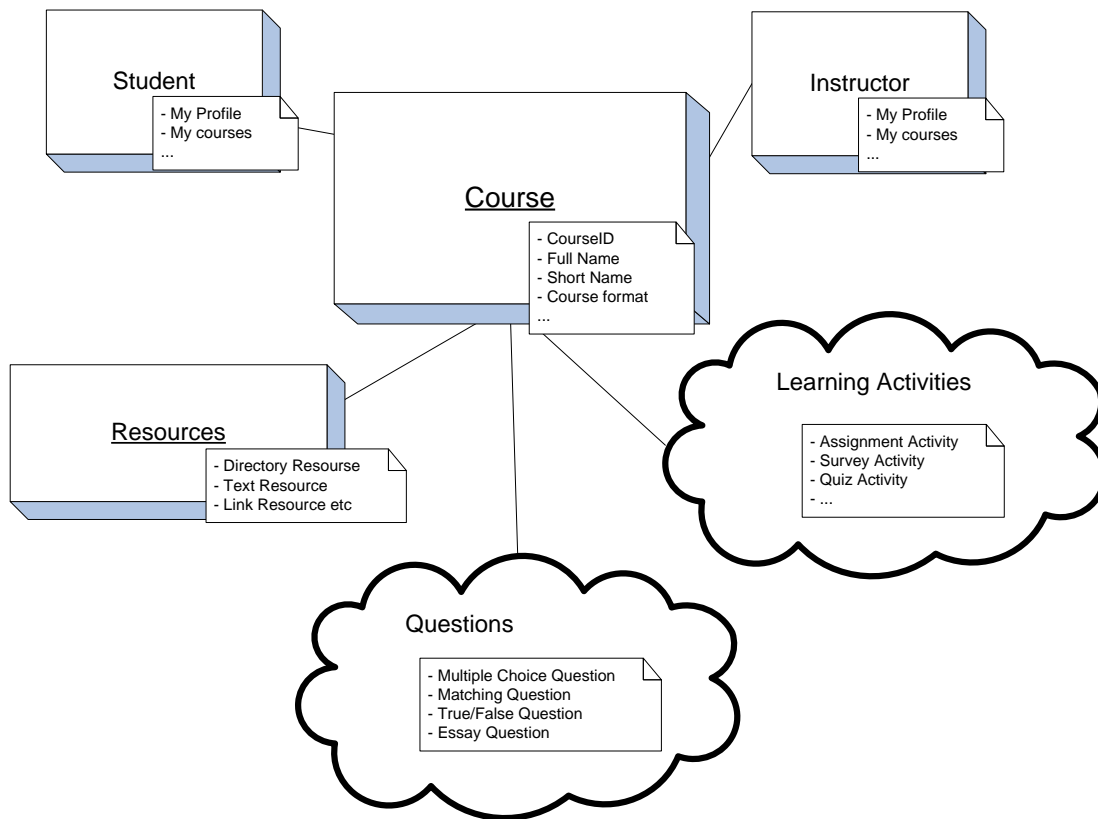
Figure 1 – Shows a simplified model of the Moodle E-Learning system.

2.2.3 Site management

A Moodle site is managed by an admin user, defined during setup. Plug-in "themes" allow the admin to customize the site colors, fonts, layout etc to suit local needs. Plug-in activity modules can be added to existing Moodle installations. Plug-in language packs allow full localization to any language. These can be edited using a built-in web-based editor.

2.2.4 User Management

One of the design goals of Moodle is to reduce admin involvement to a minimum, while retaining high security. It supports a range of authentication mechanisms through plug-in authentication modules, allowing easy integration with existing systems.

An admin account controls the creation of courses and creates teachers by assigning users to courses. A course creator account is only allowed to create courses and teach in them. Teachers may have editing privileges removed so that they can't modify the course. Teachers can add an "enrolment key" to their courses to keep out non-students. They can give out this key face-to-face or via personal email etc and can enroll and un enroll students manually if desired.

2.2.5 Course Management

Moodle incorporates easy to use facilities to manage the various courses to be offered. A course can be defined by selecting from the various available formats formats such as by week, by topic or a discussion-focused social format. Courses can be packaged as a single zip file using the Backup function. These can be restored on any Moodle server

2.2.6 Learning Activities in Moodle

In Moodle learning activities are used to realize various interactions between students and instructors. Moodle has an extensible interface for adding more activity modules. Some of the commonly used activity modules of Moodle are:

- Assignment module – implements the interaction of giving assignments and giving feedback

- Quiz module - Teachers can define a database of questions for re-use in different quizzes. Questions are stored in categories for easy access, and these categories can be "published" to make them accessible from any course on the site. The quizzes can be:

  - Multiple-choice questions supporting single or multiple answers Short
  - Answer questions (words or phrases)
  - True-False questions
  - Matching questions
  - Random questions
  - Numerical questions (with allowable ranges)
  - Embedded-answer questions (cloze style) with answers within passages of text
  - Embedded descriptive text and graphics

2.3   It's Learning

"It's learning" is an e-learning system that has been developed in Bergen, Norway [4]. It has had a great success in the Scandinavia market, with more than 450.000 users. The "It's learning" platform is designed for schools and universities. The origin of the "it's learning" system was a student project at the Bergen University College in 1999. "It's learning" is a tool for supporting and enhancing different learning activities, new teaching methods and also providing easy access to knowledge. The system uses a fixed learning platform.

"It's learning" has a variety of built-in tools for communication and cooperation such as internal messaging system, e-mail, chat, SMS notifications, discussion forums, etc.. This offers a lot of possibilities for the instructor of a course. However, on the other hand much of the tools are not necessary to use in a course and by ordinary users. The tools may appear as noise that distracts the user in a given learning situation. One problem is that the system gives the user too many possibilities. An ordinary user does not need all these options. One other problem is that the graphical layout and navigation are not consistent. This makes it difficult for the users to have a global overview and control of the learning objects.

"It's learning" is also a tool for course administrators and course leaders. The system provides a range of automatically generated reports that provide an overview of a group and individuals progress within the learning cycle. One problem is that the reports do not have a consistent design.
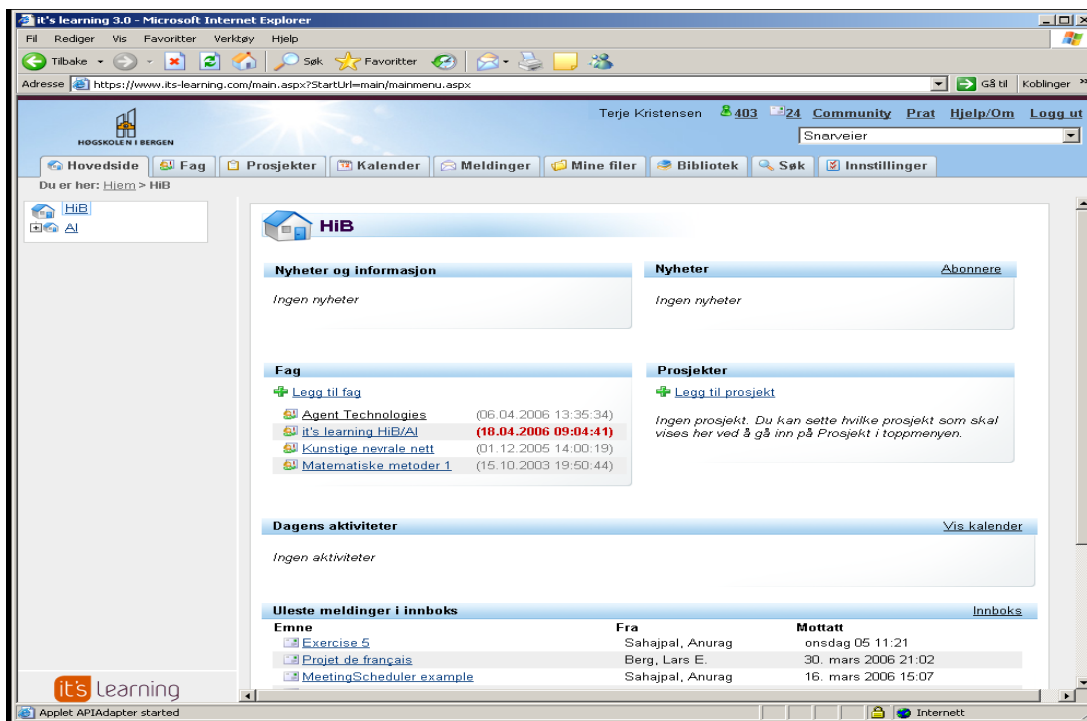

Figure 2 – It's learning system user interface

2.4 Dynamic Presentation Generator (DPG)

The Dynamic Content Manger (DPG) system is a project with an approach to generate online courses from presentation patterns. In order to simplify setting up new on-line courses one wants solutions that do not require particular programming skills. The main objective of the teacher is to develop and presents good learning material.

The structure of the learning content of the Dynamic Presentation Generator (DPG) system is specified in XML, and its visualization is dictated by a course pattern. The teacher needs only supply the contents of the learning material in order to create an online course. The system takes care of the rest; dynamically generating the web pages for the course and making them accessible to the users

2.4.1 The work flow model

The workflow model of the DPG system is shown in Figure 3. It comprises two phases:
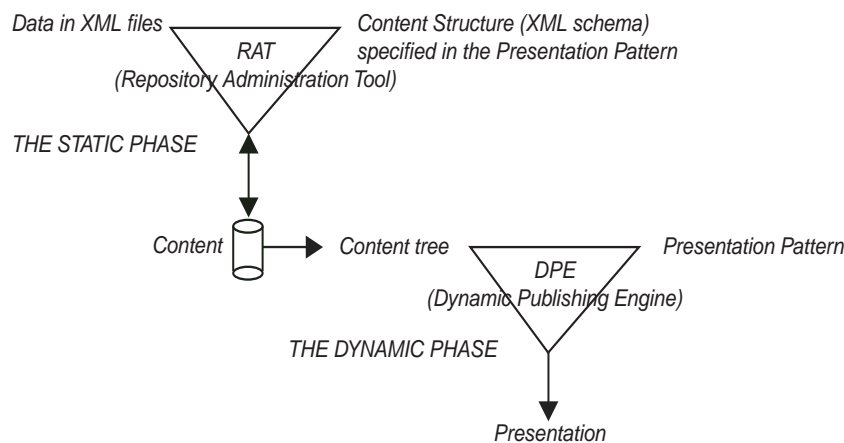

Figure 3 – Workflow model of the DPG

• The static phase, and

• The dynamic phase

In the static phase, the Repository Administration Tool (RAT) validates the data in XML files against the content structure specified in the presentation pattern.

Only validated data is stored in a XML database. RAT is also used to retrieve the data from the database for updating purposes.

The core of the dynamic phase is the Dynamic Publishing Engine (DPE). Given the content tree and the corresponding presentation pattern, the DPE renders the web pages that comprise the presentation. The DPE dynamically generates a web page in response to a browser request. The content tree is created from the content in the XML database at the start of the web application. Data for a browser request is retrieved from the content tree. Formatting of a web page is done according to the presentation pattern specification. The most obvious advantage of this workflow model is that different content and presentation patterns can be mixed and matched to create different presentations, as long as the content conforms to the presentation pattern.

2.4.2 The DPG system in use

The DPG system has been used since 2003 to create online Java programming courses at the Department of Informatics, University of Bergen and since 2004 at Bergen University College in a regular course in programming technology. The DPG system and the presentation specifications have now gone through a number of iterations and have provided the proof-of-concept for presentation patterns, as well as hands-on experience from running and maintaining the online courses.

The experience has shown that there are several advantages of using presentation patterns to create online courses. For instance, an initial investment in defining a suitable navigation structure and visually appealing layout can be capitalized on in later courses, as these aspects of a presentation are captured in the presentation pattern. From a course administration point of view, no programming experience is needed to prepare and update the content, and web-based tools are available for content generation and maintenance. In terms of cost and effort, the threshold to deploy this system is low compared to other such systems.

The current system is implemented by using Java and Tomcat and is available for installation on nearly all platforms. The RAT facility has a web-based GUI that allows uploading of initial content from XML files and its storage as a set of resources in the XML database. The tool also incorporates a general-purpose editor for content inspection and modification. For convenience, the database files and any associated resources (for example, images) are stored as part of the DPE web application.

If the administration tool modifies the content, the publishing engine automatically updates the presentation. One high-priority task is to create new presentation patterns. Typical examples of new patterns would be for slide shows, for interactive presentation of a lecture or for "webifying" articles and books. The main challenge will be achieving this goal through reuse of web-based presentation components.

3. Problem Analysis

3.1 Shortcomings of Existing Systems

Most of today's e-learning systems are based on the constructionist pedagogical theory. As such, they focus on enhancing the interaction of the student and instructor via the availability of various resources and activities. The educator avails various resources to the learner during the running period of the courses she is giving. There is mostly little support for the educator while creating the learning materials and because most systems do not have an easy-to-use navigation mechanism of existing resources, much effort is duplicated.

Most of the commercial e-learning systems of today have a lot of facilities, but the problem is that they are missing a solid underlying pedagogical structure. This means that the major challenge for e-learning systems is to develop a pedagogical structure of the system – not to develop further its technical functionality. Most existing E-Learning systems contain too much functionality, but not the possibilities to make presentations suited to specific end-users. All these functionalities may disturb the actual learning situation, both from a user and a course administration perspective. Systems like "It's learning", have evolved very much technologically, but the short comings are still there because the underlying pedagogical structure of these systems is not well structured. Another shortcoming that is common to most e-learning systems is that of non-uniformity in the quality and ease of use of the different modules.

Much of the effort duplication observed in today's systems could be avoided or kept to a minimum by defining of atomic small knowledge elements and building courses by assembling these elements in a structured manner. This results in a decoupling of content from course so that the same content material can be used by more than one course, in possibly more than one version. These knowledge elements could be organized according to the domain knowledge and desire of instructors to make various aggregations of inter-connected navigational entities giving a mesh that can be better described by use of a concept map. Furthermore, various course resources, questions and quizzes could be organized better by attributing them to the atomic knowledge elements.

Student modeling is a concept that is an active field of research. The level of modeling of the student in an E-Learning system shows its maturity and suitability for logical reasoning assertions. With a good conceptual student model, mathematical model can be defined for the learning and knowledge acquisition of the student in a manner than can be proven using theorem proving algorithms.

Following, a description of the DCM system and the requirements it tries to address will be described.

3.2   Decoupling of Content and Course

The major shortcoming of most existing E-Learning systems is that learning material is very tightly coupled to courses. This is present inherently since educators create courses that are availed to the students via the E-Learning system. Thus, the scope of the learning material developed will be limited to the defined course or to passing around of some shared files at the maximum.

The DCM defines an atomic knowledge element as a basic building block of all learning material. A course is defined as a hierarchical organization these knowledge elements. Such a model introduces an inherent decoupling between courses and learning content.

The instructor still defines learning material in more or less the same manner as most E-Learning systems but the DCM stores them as knowledge elements that can later be queried for re-use. The decoupling of course and content gives the possibility to develop a good domain knowledge with scoping of more than a single course.

3.3   Content reuse

Content reuse refers to any situation where a single piece of source content is written once, and then used in multiple locations or contexts [6]. There is not, however, a consistent understanding of what content reuse means in practice, and the term is used to mean many things, each of which may be met by different technology solutions

3.3.1 Types of content reuse

In theory, there are various scenarios where content reuse is applied. Some are:

Content is linked to from multiple locations – this is the simplest scenario where a single page is linked from more than one location

Content appears in multiple locations – in this scenario, a page appears in multiple locations within a site

Usage of standard elements – by this mechanism of content reuse, standard elements like headers, footers or disclaimers are shared among different content pages

Assembly from 'components' – this is the most complex scenario for content reuse. Content pages are assembled from a pool of content components from some repository. This model of

content reuse is implemented in the case of the DCM with knowledge elements defining the atomic reusable content components

3.3.2 Benefits of content reuse

There are various benefits to content reuse. Some are:

Improved accuracy and consistency – content is written mostly once or a minimal number of times. This avoids the case of multiple copies being edited in a non consistent manner

Increased efficiency – using content material only once and reusing it in multiple locations reduces authoring effort required. With a good content reuse in place, lots of hours of authoring can be saved

Greater control – with the proper content reuse in place, the content material will be created, updated and generally managed in a predefined way such that there is more control over the content material.

3.3.3 Challenges of content reuse

In practice, content reuse is quite difficult to implement. Some of the challenges of content reuse are:

Increased complexity for authors – introduction of a content reuse management system introduces more constraints on authors/educators on their ways of creation of content. There is a learning curve before the system can be used with relative ease and in most cases, some people may even revert to other solutions unless they are able to understand and appreciate the advantages of content reuse.

Content versioning – this is also a challenge introduced in cases where content material is allowed to be edited by multiple authors to be used on different contexts. The content reuse management system should employ appropriate measures of content versioning and also authors need to be aware of the way the versioning scenario works

4 Available Technology and Methodologies

Often developing software is compared to building houses and bridges. Careful planning and understanding of what is actually needed is the starting point to the building of a house. The person needs to be clear on what she needs, like number of rooms, capacity, color and the like to some extent as a starting point. Then an architect or a designer is hired to put those requirements into a drawing that can be viewed and analyzed. After going through some enhancements and incorporating new ideas, the plan for the construction is laid out and then constructed. Development of software follows more or less the same steps as those needed in the construction of the house.

Any software development project is aimed at achieving some goal objective. The beginning point is always some domain problem the software is expected to model, assist or facilitate. The requirements of the domain should be analyzed at first and continuously revised during the development process for changes or enhancement. Different software development processes define different stages to be followed and address the requirements understanding, system modeling and system construction stages. Hence, the implementation of a software system is dictated by the development methodology and to some extent by the technology employed.

In this chapter, we will first consider popular software development practices will be stated with their relative advantages and shortcomings. Then, some of the popular development technologies will be described with justification as to the specific one that was used in the DCM project.

4.2 Object Oriented Software development

Object oriented software development is a software methodology that has gained great success and has been put to great use. [11], [12], [13], [14] This model follows the object oriented approach of modeling in that it focuses on identifying objects and their interaction to model the domain and the software system.

There are three stages to be followed when using the object oriented software development methodology. These are:

Requirements Elicitation

Requirements elicitation is mostly the first phase of the development process. The major task that is tried to be achieved is that of requirements understanding and modeling in an object oriented manner. During the requirements elicitation stage meetings are held, presentations

conducted and various consultations followed so as to have a clear understanding of the requirements of the problem domain.

The requirement elicitation phase uses three types of objects to model the requirements of the system. The first type of objects is called "Entity Objects" which represent the data that is persistent. As an example, considering a requirement of registration of a student for a course, the details of students like name, age, and sex go under the category of entity objects. The second category of objects identified during the requirement elicitation stage is "Boundary Objects". These objects represent the interface between the user and the software system developed. Considering our previous student registration example the web page that the student must open, the buttons that she must use to submit her desired operation requests fall under the boundary objects category. Clear definition and understanding of the boundary objects is crucial for the usability of the system and for achieving better user experience. The third type of objects that the requirement elicitation stage identifies is "Control Objects". These objects define the constraints and business rules that have to be fulfilled by the system. Considering the student registration example, boundary objects should be defined to realize the constraints that the same student is not registered multiple times and other registration related requirements are met.

Requirement analysis (Elaboration)

After identifying the entity, boundary and control objects in the requirement elicitation stage, the requirements of the system should be further analyzed and elaborated. The requirements analysis phases focuses on further investigating the requirements of the system and developing detailed description and documentation. Standard documentation methodologies are employed in the form of activity diagrams and sequence diagrams. The outcome of this phase of the development process is clearer understanding and documentation of the requirements.

System design

In the Object oriented software development paradigm, the system design process stage defines object interactions, collaborations and prepares the grounds for the development. The system design describes the details of the software to be developed by use of use case diagrams, class diagrams, collaboration diagrams and deployment diagrams.

System development

The system development stage is the stage where the design is programmed to produce working software that meets its requirements. System development comprises of coding and testing at various levels of detail.

4.3   Popular software development processes

4.3.1 Unified Process (UP)

The Unified Process is an extensible framework which describes the various activities that must be followed in the development of software. It defines key points that are characteristic and that should be kept in mind throughout the software development process. The UP defines a concept called a "project lifecycle" that defines the stages that have to be followed. The UP is a highly generalized framework and hence, each software development institution or group should define its own adapted model as per the points of emphasis and domain model.

Project Life cycle

The UP defines the life cycle of a project (or iteration) as having four stages. These are the inception phase, elaboration phase, construction phase and transition phases. Following, a brief description of each stage and its output will be described.
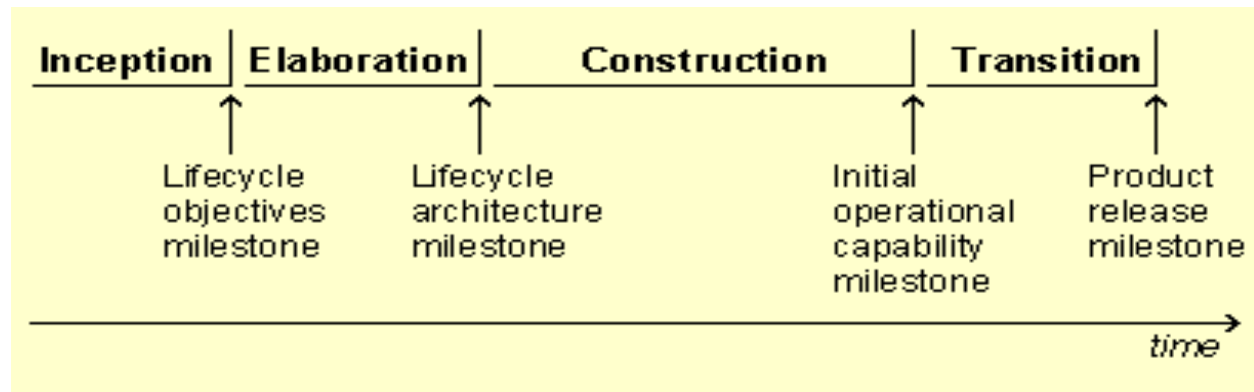
Figure 4 – Software life cycle

Inception phase – this phase analyzes the risks and scope of the project. The necessary assumptions are made on the project (iteration). The inception phase is aimed at achieving concurrence among all stakeholders of the project on the lifecycle objectives. The output of this phase is a document called "Inception Report".

Elaboration phase – the elaboration phase starts by reviewing the output of the Inception phase and performs detailed analysis of requirements. Business requirements, conditions and constraints are investigated to depth and documented. The output of this phase is a document called "Requirement Analysis Document"

Construction phase – this phase is where the analyzed system is put into implementation. At the early stage of the construction phase, the requirement analysis document is reviewed and the overall design and architecture of the system is made. This result in a document called "Design Document". Then the software system is developed and subsidiary documents like system documentation and training manuals are produced during the construction phase.

Transition phase – the transition phase is responsible for porting of the developed software system from development platform to actual operational platform. Tests are done on the system by end users and the software is modified to reflect the outcome of the tests. During this phase, end users are given training and produced software is put to use

The Unified Process defines some qualitative characteristics that should be followed during all the phases of the development lifecycle. Some of the key characteristics of a UP process driven software development are:

Iterative and Incremental

This characteristics of UP defines that development should be performed in small volumes and that the various stages of the development cycle should be iterated. This is very helpful in that at each release, some working testing functional portion of the system is released it is as an increment to the previous developments.

Use case driven

A use case can be defined as a formal description and generalization of a specific requirement. Hence, each use case of a system captures some functional requirement of the system. By use case driven development the UP dictates that each iteration and each stage of the development process should be focused on identifying, elaborating, constructing and testing of use cases.

Architecture centric

The Unified Process insists that architecture sit at the heart of the project team's efforts to shape the system. Since no single model is sufficient to cover all aspects of a system, the Unified Process supports multiple architectural models and views. One of the most important deliverables of the process is the executable architecture baseline which is created during the Elaboration phase. This partial implementation of the system serves to validate the architecture and act as a foundation for remaining development.

The Unified process is a heavy weight process and as such it is most suited for big projects that involve many requirements and developers. Recently, other light weight software development

processes have come into the picture and have gained quite an audience. Following, we consider a software development process called Xtreme Programming.

4.3.2 Agile software process (Xtreme Programming -XP)

In software development, the cost of change has an exponentially rising behavior. One reason that accounts for this behavior is the usage of heavy weight software development processes. The rigid and time consuming procedures of doing activities and the need to keep the body of related secondary documents accounts for most of the cost of making changes.

As a response to the increasing weight of processes, a group of software experts met in 2001 to discuss key principles of agile development. They came up with the following manifesto that says "*We are uncovering better ways of developing software by doing it and helping others does it*" [15].

Xtreme programming (XP) is one of the most popular agile software development processes. It is a very light weight process that gives more emphasis to customer satisfaction than to producing documents and rigid methods. Some of the points that are given great values in the XP process are:

Communication – there should be very open and high level of communication between the project teams. This includes a representative of the customer that must actively participate in the overall process.

Simplicity – keep things simple. The main objective of software development is to produce working software and not documents. Also, the implementation should be kept to the bare minimum so that if some functionality is not needed at the moment, then it is not implemented. This helps keep the coding simple and avoids unnecessary complications.

Feedback – customer involvement is a key practice of the XP software development model. The customer's representative(s) are considered as part of the development team and should provide extensive and timely feedback.

Although extreme programming and agile methods have gained popularity over the past few years, they are not a replacement for the Unified Process. XP is better suited for projects of small size and where is not much difference in the knowledge and capability level of project teams. Although the Unified Process is a more rigid and some most of the times over bureaucratic, it gives a more deterministic process model and is better suited for software development projects of critical nature.

4.4   Development Technologies

The development technology chosen on a project greatly influences the flexibility, ease of development and in some cases ease of use by the end user as well. Thus, choice of development technology is one of the major factors that play an important role in the overall software development process. Some of the points to consider when choosing development technologies are:

Inbuilt functionality – most development frameworks and programming languages have inbuilt support for most of the routine operations in programming. But the ease of usage and extent of specialization of functionalities greatly varies from one framework to another. Primarily, the problem domain and need for supported functionality plays a big role in choosing a development environment.

Graphic support – ease of use in creating graphical user interfaces is one major quality to look for while choosing development technologies. The developers should spend most of their time on realizing the business logic of the system and making the system come to life. As such, a development environment that provides graphical support for creating user interfaces greatly reduces development effort and is preferred over other ones.

Support for component orientation – component oriented software development is a means of developing software as composition of different parts which could be developed by the same team or another. Effortless integration of third party of project developed components greatly reduces development time and also allows multiple users to work on parts of the project with seamless integration.

License issues – development and deployment software license is also one major factor to be considered when comparing choice of development technology. Decision on whether to use open source license products or proprietary technology has implications both on price and usability of the software system to be developed.

Development support tools – software development environments that give good support on runtime compilation, debugging and tracing greatly increase the productivity of the development team. Hence, the supporting tool an environment provides plays an important factor during selection of development technology.

Development team experience – another major factor to be taken into consideration when choosing a development framework is the level of experience and expertise of the development team. Most companies have a predefined development environment and work

towards making their developers achieve higher efficiency by way of attending conferences and trainings.

Taking the above mentioned points into consideration, the following development technology was chosen for the implementation of the DCM project.

Development environment – Microsoft Visual Studio 2005

Programming language - asp.net used as user front end, C# as core component development language and code behind logic for asp.net pages.

Database management system – Microsoft SQLExpress

Following, a description of some of the functionalities and tools of the visual studio 2005 development environment and the dot net framework will be described.

4.4.1 Dot Net framework and Visual Studio 2005

Dot Net Framework

The Dot Net framework is a platform for developing applications on the windows platform. It was first released in 2002 with the visual studio 2002. It provides a large body of pre-coded solutions to common program requirements, and manages the execution of programs written specifically for the framework. The dot net framework provides unified solution for developing windows applications, web applications and also XML web services. The Dot Net framework has two parts: the common langue runtime (CLR) and the dot net class library:

Common Language Runtime (CLR) – the CLR is part of the dot net framework that is functionally equivalent to the JVM (Java virtual machine) in a java environment. It performs the operations of: management of running code, verification of type safety, providing garbage collection and error handling, security and a unified type system. The CLR provides access to system resources through native API, COM interlope and other facilities.

Dot net class library – this is a collection of unified classes that provide easy to use ways of access for the developer.
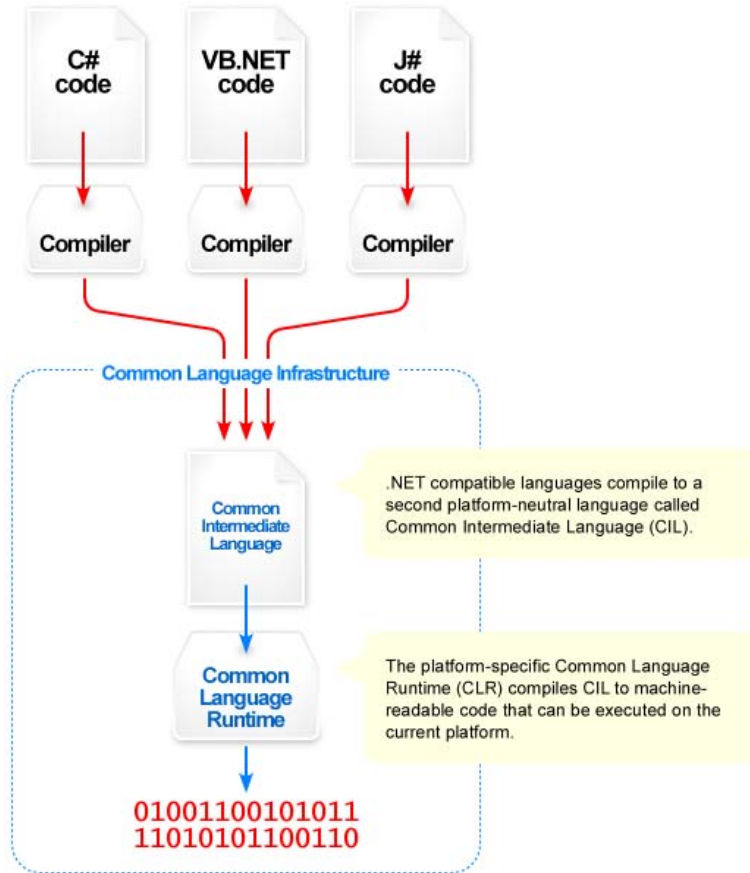
Figure 5 – The Dot Net framework

The Dot Net Programming Model

The dot net programming model is a multi language, same IDE (Integrated Development Environment) programming model with cross language inheritance and exception handling. It has tools that work in multiple programming languages and platforms. It introduces a zero impact installation model and also side by side execution of different versions of the same assembly. The dot net programming model provides seamless integration with the earlier technology of COM and gives easy access to system functions. It follows a unified type system where everything is an object and objects created in different languages can be cross inherited.
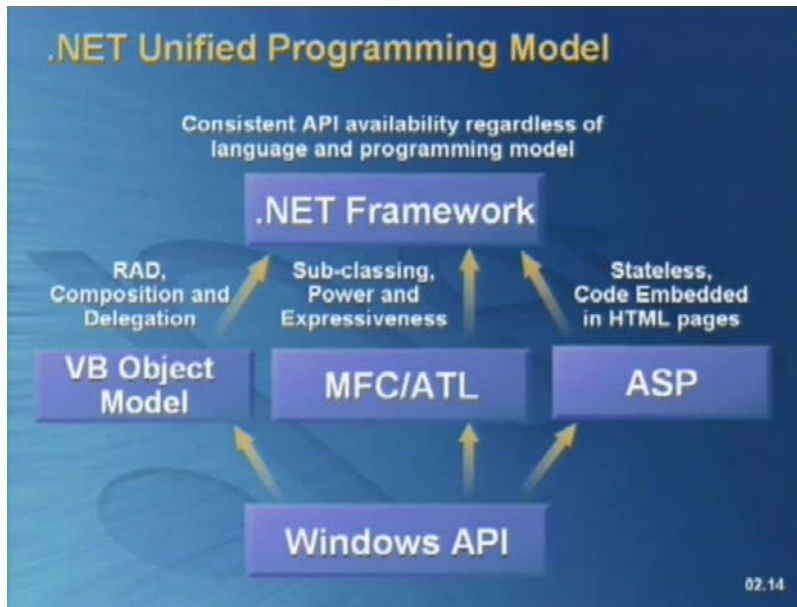
Figure 6 – Dot net unified programming model

Visual studio 2005

Visual Studio 2005 was released online in October 2005 and. It is the current latest release of development environment in the .net line which runs the dot net framework 2.0. Visual studio 2002 was the first one in this product line containing version 1.0 of the dot net framework. Visual studio 2003, containing the dot net framework 1.1 introduced many changes as the framework matured.

The highest level of organization in visual studio 2005 is given the name "solution". A single solution can contain one or more projects of similar or different types. A project is a set of classes and files organized and outputs assemblies of different types depending on the project type. Some of the project types supported by visual studio 2005 are: class libraries, windows console applications, windows forms application, web applications, windows service application, deployment projects etc…

The component orientation inbuilt in the dot net framework provides the facility to distribute the system functionalities into different projects and also to use external assemblies. Following, a screen shot of the DCM solution is shown with its different projects:
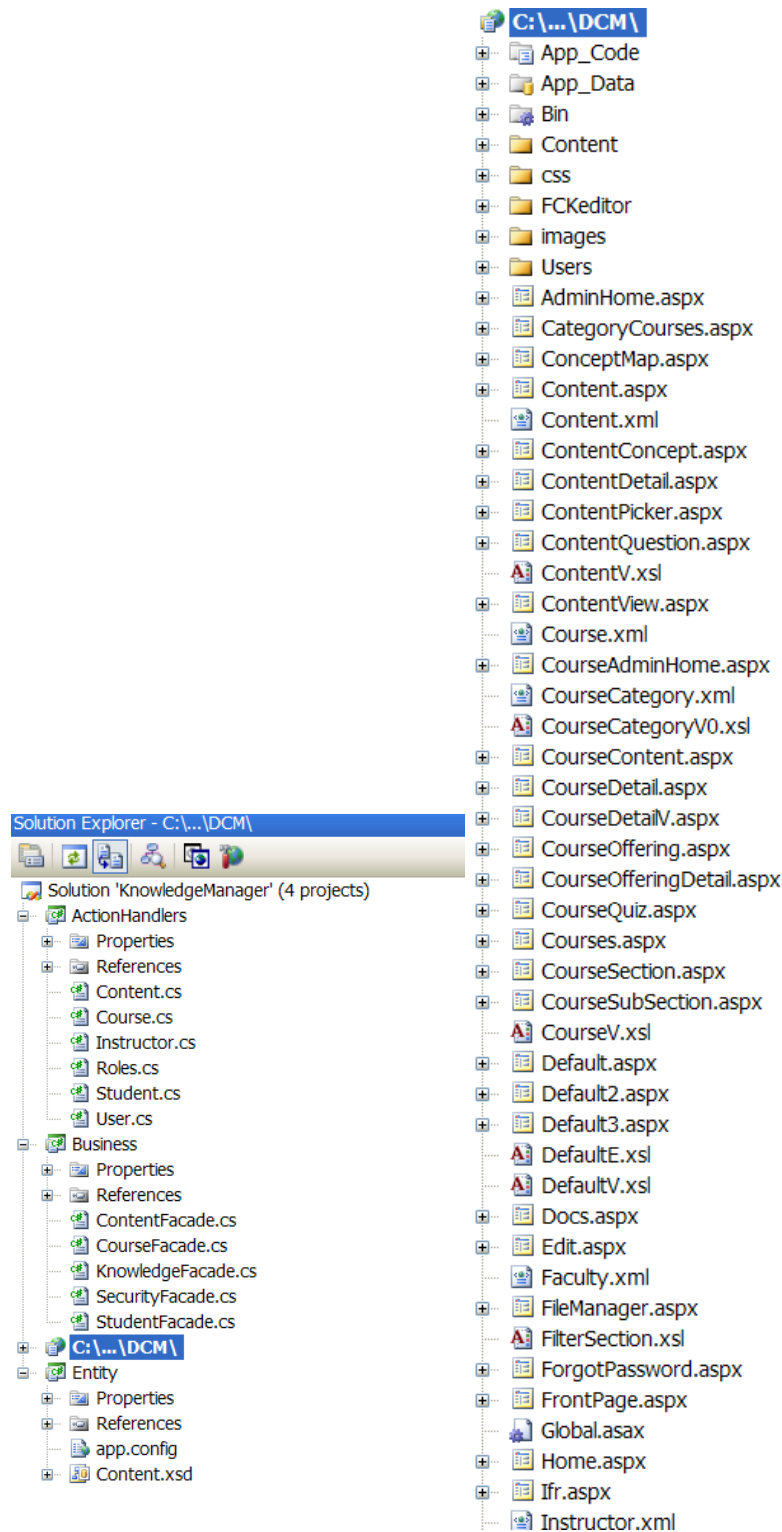
Figure 7 – The DCM project in Visual studio 2005

5   DCM solution

5.2   Overview

The DCM (Dynamic Content Manager for E-Learning) is an e-learning solution that tries to remove the very tight coupling of learning material to specific courses. It defines a conceptual atomic unit of knowledge (given the name *Content*) and builds up courses by organization of these knowledge units from the repository. This gives the ability to create knowledge elements at a finer granularity level which can be re-used across various courses. Resources like lecture notes, presentations, attachment files, questions etc… are attributed to the knowledge elements and hence can be imported while using existing knowledge elements.

The DCM is designed with the functionality of knowledge elements, courses and resources versioning and history tracking so that changes made to the underlying knowledge elements is carefully tracked. This ensures that a specific course or some aggregation of the knowledge elements the educator has created, can appears unchanged as far as she is concerned while giving her a chance to follow the various revisions made on it.

The concept of dynamic presentation patterns tested in the DPG system is put to use in the DCM project. This gives the system the feature of being highly customizable in that the presentation of courses, resources and navigation can all be enhanced according to the configuration set by the site administrators. The instructor could, in future versions, be given the freedom to define the appearance of the courses she is giving and can use already used presentation patterns as well as define her own.

At the beginning of the DCM project, survey of various E-Learning systems was done. The survey was crucial in capturing the general operational functionality of E-Learning systems and in defining the direction of pursuit for the DCM project. After defining a domain model, an overall design of the system, subsystem decomposition and a decision on the development technology to be used were made.

Considering the complexity of the requirements of the DCM system and the short duration of the project development period, it was decided that the project be developed using a development environment giving good support on user interface and on project organization and componentization. The DCM project is implemented using the Dot Net Framework 2.0, Visual Studio 2005 using Asp.Net technologies and the C# programming language. It is optimized to work with Microsoft SQL Server 2000/2005 but its database abstraction layer also enables it to run on most of the major popular database providers. Extensibility is given great

emphasis in the design of the system and hence provisions are made for the seamless addition of more external functionalities by possibly different developers

Following, a description of the system design, subsystem decomposition, and database abstraction is given. Afterwards, the dynamic processing and presentation schema designed to minimize coding efforts is described followed by description of the functionalities of the DCM system.

5.3　Concept map

When dealing with a huge collection of items stored in a repository, a storage and retrieval mechanism is desired that is based on sound technical as well as pedagogical grounds. The degree of usability of the information stored depends highly depends on the naturalness of storage, navigation and presentation of the content.

There are many researches being conducted worldwide on how to best model an arbitrary aggregation of small knowledge elements. The DCM system uses the ideas of Concept maps [7] to model the arbitrary relationship that can be created by the educators by their selection of the knowledge elements from the repository. Concept map is the concept of representing knowledge in graphs where nodes represent concepts and the links represent the relation between concepts. Fig 8 shows a sample concept map
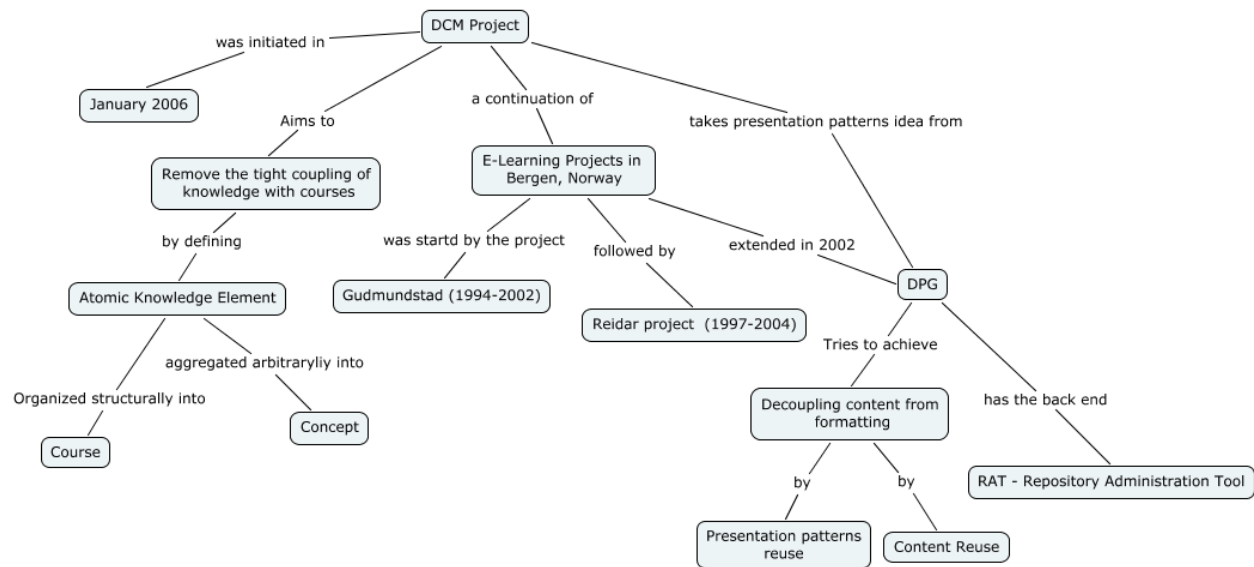
Figure 8 - A sample concept map created using IHMC CmapTools [10]

The DCM provides the educator with a graphical navigation of the knowledge repository in the manner depicted in fig 8 (although the display is not yet perfected). Such a visual presentation gives the educator a feel of the resources of the repository and enables her to create her own universe of knowledge elements collection. The educator can also specify different dependencies in the learning content that can influence the students' assimilation of the learning material. The interconnection between the various knowledge elements defined by many educators can be used for data mining purposes and to create a better structuring of the knowledge repository as a whole.

5.4   Student modeling and progress follow-up

5.4.1 Student modeling

Simply put, student modeling is the construction of a qualitative representation, called a student model, that, broadly speaking, accounts for student behavior in terms of a system's background knowledge [8]

Student modeling, as the model of a learner, represents the computer system's belief about the learner's knowledge [9]. Building a student model involves defining; the "who", or the degree of specialization in defining who is modeled, and what the learner history is; the "what", or the goals, plans, attitudes, capabilities, knowledge, and beliefs of the learner; the "how" the model is to be acquired and maintained; and the "why" , including to whether to elicit information from the learner, to give assistance to the learner, to provide feedback to the learner, or to interpret learner behavior.

In maintaining the student model, the factors that need to be considered include the fact that students do not perform consistently, forget information randomly, and then display large leaps in understanding. For an intelligent instructional system to be tailored to the student, the student model is the essential component in individualized learning. It is the student model that builds and maintains the system's understanding of the student.

The knowledge base of the student model takes both domain and pedagogical knowledge into account. The method to elicit a student model is closely tied to the approach. In the overlay approach, first the expert domain is modeled as a set of correct production rules. The learner is modeled as a subset of these correct rules, plus a set of incorrect production rules. Each new learner requires an individualized student model. In developing the student model, the type of knowledge (i.e., declarative, procedural) to be defined must be determined. It has to be decided whether or not to include student goals, and how to include these. The methods used

include the users outlining their own goals, providing self-documentation, and submitting answers to a pre-test

5.4.2 Student modeling in the DCM

The DCM system defines a very simple model of the learner. The knowledge level of the learner is modeled on each content category. The system puts a learner initially into a default category with respect to the specific content she is studying. The updating category of the learner is provided by the DCM and based on assessments of the exercises delivered by the students.

The DCM supports questions and associates them to the knowledge element. These questions are the building blocks for the practice module where the learner goes through questions that have been associated to the knowledge elements of the course she is taking. The learner's category is taken into consideration and as a default optional filtering mechanism while providing the learner with the practice questions

5.5   Overall system design

Designing in software development is process of getting from a description of the properties a system should have (a specification) to a description of a system that has these properties (a design). Software Design focuses both on the significant structural elements of the system, such as subsystems; Use Cases, classes, components, Packages and nodes, as well as the collaborations that occur among these elements via interfaces.

The overall system modeling of the DCM system is shown in Fig 9. The system maintains the repository of knowledge elements which are organized structurally into courses and arbitrarily into concepts. Resources and questions are attributed to the knowledge elements.
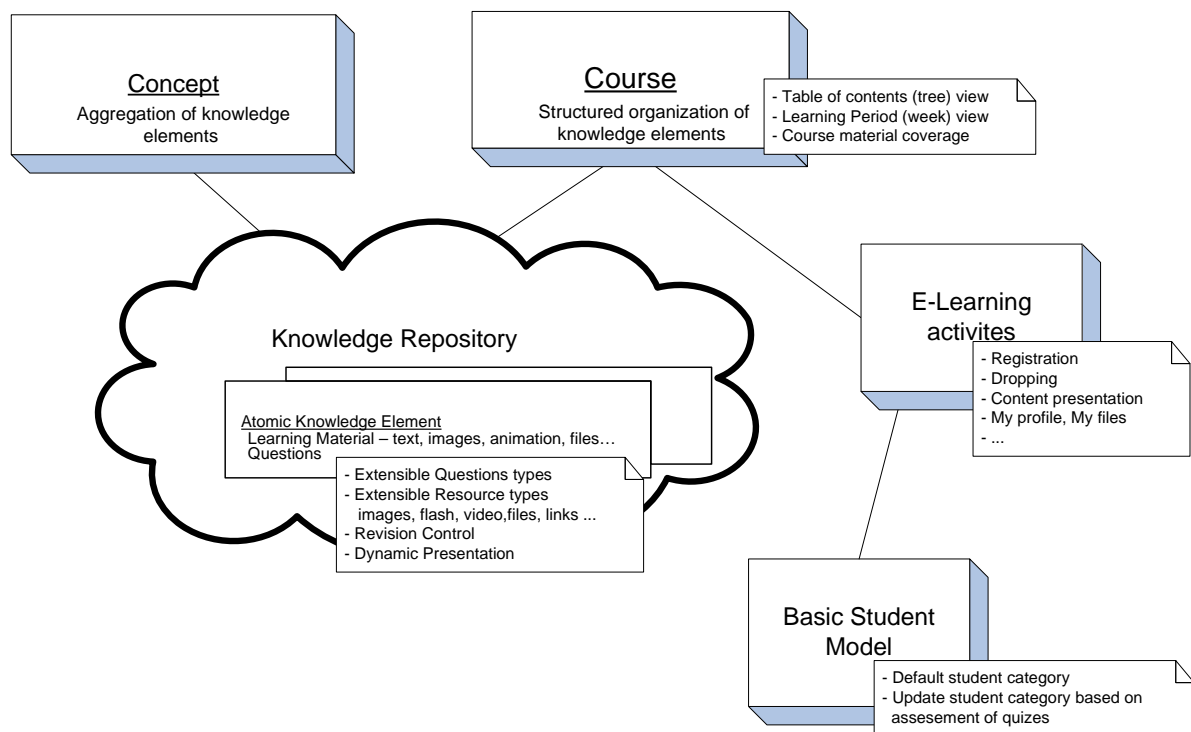
Figure 9 – Overall system design

5.6 Subsystem decomposition

In the development of systems that address many requirements, it is a software engineering principle that the system should be decomposed into smaller, more manageable and more closed subsystems. Subsystem decomposition helps ease the difficulty of addressing lots of requirements since each subsystem is created according to the natural, logical organization of the requirements. Interactions and dependencies between the subsystems are captured using interfaces of each subsystem with the others. By using subsystem decomposition, most of the operations and requirements become localized into one subsystem so that its detail implementation does not affect the other subsystems. This allows independent development of system components by possibly independent teams.

The DCM system was divided into five major subsystems: the *security subsystem*, *instructor subsystem*, *student subsystem*, *course, content and concept map subsystem* and the *question and quiz subsystem*. Following, the diagrammatical display of these subsystems with their interdependence is shows followed by description of each subsystem.
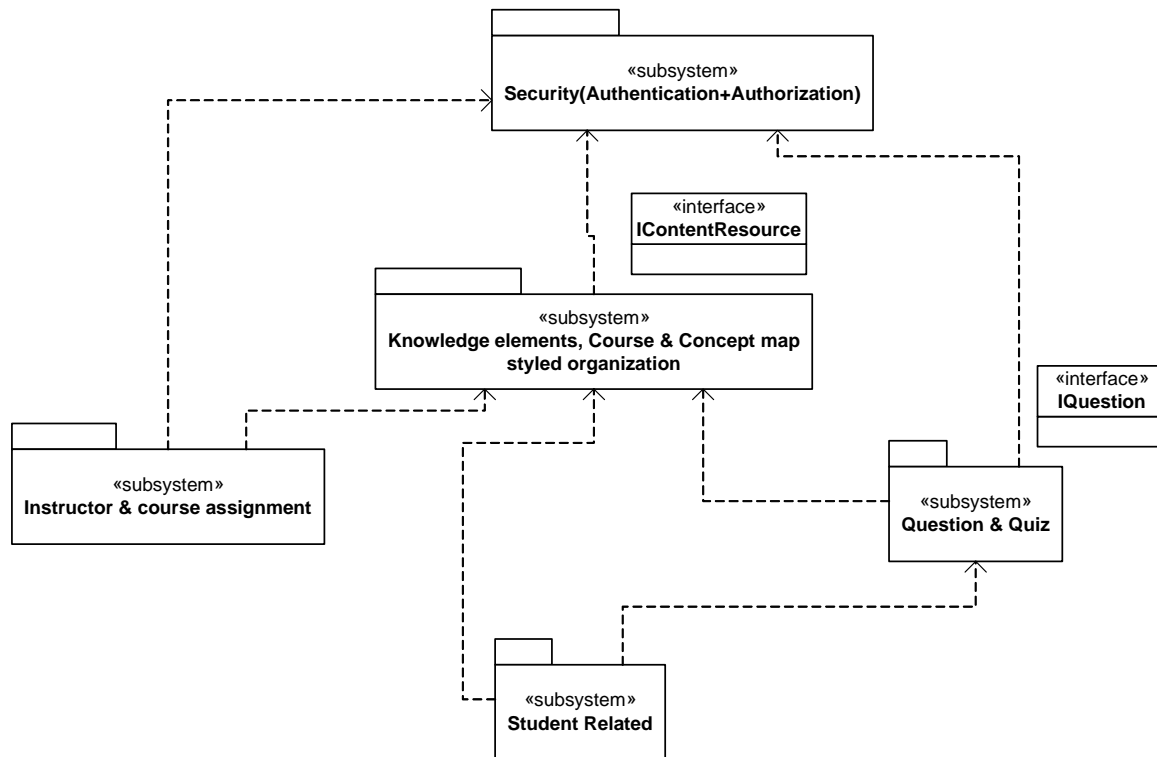
Figure 10 – Subsystem decomposition of the DCM system

Security sub system

In a multi user environment, security is a very crucial requirement. Especially systems used in learning environment need to be extra secure since they are faced with a very dynamic, enthusiastically ambitions and creative student. The security subsystem of the DCM project handles the authentication and authorization of users, roles membership and operations assignment. User passwords are stored using a strong, irreversible one way encryption.

Role based security is a security schema where roles are defined into the system and users are given membership into the roles. Users inherit privilege levels from their roles and are subject to the rules defined on their roles. Role based security gives great ease in administration of systems so that the privileges of only a few well defined roles is required instead of the great number of users that are present.

The DCM system employs an additional security schema that can be called operation based security. This schema defines the functionality of the system as a list of operations and gives finer grained security on the operations by assigning/revoking different access levels to roles or users. To consider an example of usage of the operation based security, consider a situation where different instructors are given access update content of specific courses based on their offering assignment. As being a member of the Instructor role, they get privileges to the general *maintain course* operation whereas which specific course they can update is defined by the detail of the privilege which is set while instructors are assigned to specific courses during their course offering assignment.

Instructor sub system

The instructor subsystem of the DCM handles requirements relevant to instructors. Instructor registration is one major part of the system since instructors have to be registered into the system before they can be assigned courses to teach and can perform the creation and modification of content. The instructor subsystem also covers the process of assigning courses to instructors. Courses are assigned to instructors in a specific learning period. One or more instructors can be assigned to a single course.

The creation, usage and updating privileges are also addressed in the instructor subsystem. Instructors can update contents of only those courses that they have been assigned to in their course offering.

Student sub system

The student is the by far the most important individual of any e-learning system. Content is developed by instructors so that it can be availed to students. The student sub system addresses the basic student related activities. First and foremost, students have to be enrolled into the system and registered on each semester that they attend their education. Student registration can be carried out by administrator or by students themselves. When students register themselves, they should provide a registration key that will be given out in a classroom session by the instructor or via private mail. Their status will be pending and will require an activation approval by the system administrator before they can use the DCM system.

Content, Course and Concept map sub system

In the DCM system, the atomic knowledge element is given the name Content. Hence, a course is a structured organization of contents and a concept map is an arbitrary aggregation of content in a structure defined by the instructor.

This subsystem is the heard of the DCM system model. It addresses the requirements of defining, maintaining and teaching of courses. Also, creation, navigation and manipulation of concepts are addressed by this subsystem.

Question and Quiz sub system

One of the requirements of the DCM is that instructors should create and maintain questions and quizzes. The question and quiz subsystem focuses on the requirement of creating different types of questions and on the definition and manipulation of quizzes.

5.1   Implementing Security

In today's world of technology, the word "security" is used to mean many different things. However, the underlying concept behind the word is universal. It means to protect the system from unprivileged users to access the content and resource. In a multi-user system, different users have access to different functionalities and data. Defining access control for multi-user system needs to define for each user which operations they can access on which resources. These user privileges and user right access explains how the users are assigned to the roles and their accessibility level on the resources (e.g. an instructor can only edit the courses that are assigned). The DCM achieves such a tight security using the combination of Role based and Operation based security (see section 5.4.2 & 5.4.3 for details).

5.1.1 Users and roles Administration

The security application of DCM is designed in order to perform a certain activity in the system users need explicit access rights assigned by the system administrator. In most systems security tasks are related to the users, roles and their privileges.
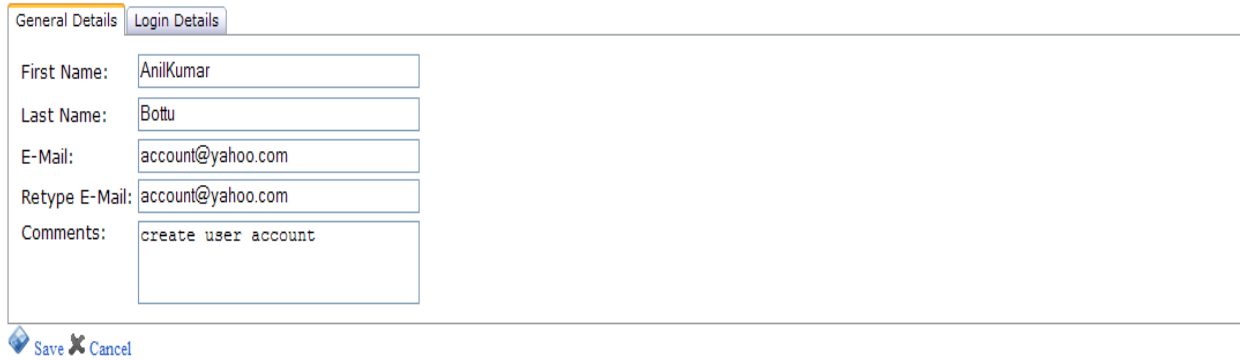
"*Users*" are people that are given access to use the resources of and work on the system. There are cases where users are grouped by some criteria (mostly by what they do) and that certain privileges be granted or revoked as a group. The security of DCM addresses such cases by defining entities known as *"Roles".* A "*Role"* is a collection of "*Users*" that are grouped by some criteria. The following rules govern the way "*Users"* and "*Roles*" interact with each other

- ➢ A user may belong to one, more than one role
- ➢ All the privileges given to a role will be given to every member of the group
- ➢ If a single member of a group is given access to certain functionalities, these do not reflect on the role
- ➢ If a user is deleted, the user is automatically removed from every role that she is a member of
- ➢ If a user is deactivated, the user cannot access the system until her user account is activated
- ➢ If a role is deleted, the membership of users to this role will be deleted. All privileges given to members as a role will be revoked.

User refers to one who may need to identify themselves for the purposes of logging and resource management. In order to identify oneself, a user has an account (a user account), username and password. Users employ the user interface to access systems and the process of identification is often referred to as authentication. A user account allows one to authenticate to system services. [20]

Creating a User

DCM allows users to create their own user accounts by providing general details and login details. General details contain personal information of the user and the login details contain authentication information.
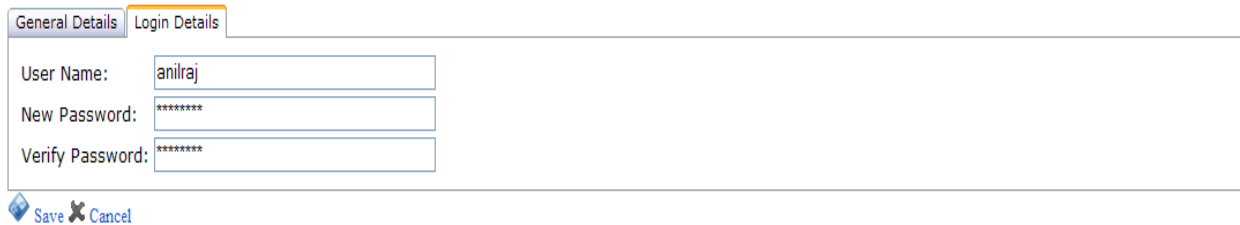
Figure 11 – General details

Figure 11 shows general details tab of the user account page with field's first name, last name, email, retype email and comments. Figure12 is login details tab contains the login information with user name, password and verify password.

Figure 12 – Login details

After providing the proper user account details clicking the Save link system saves that user information entered and generates a message confirming that "your details are successfully added and an email has been sent to you with your login details". In DCM we implemented the facility of sending automatic email confirmation as shown in the figure 13

You have been successfully been added into the DCM E-Learning system. An e-mail has been sent to you with your login details. Click here to login

Figure 13 – Shows email confirmation after creating a user account

5.1.1.1   Users Management

User Management enables administrator to manage the users and their access privileges on the resources. It empowers administrator to have full control on the users and user roles. Administrator can deactivate or delete a user when something is misused in the system. Figure 14 shows user management page with five actions search, add new user, activate, deactivate and delete. System administrator has the privilege of performing these five actions on the users.
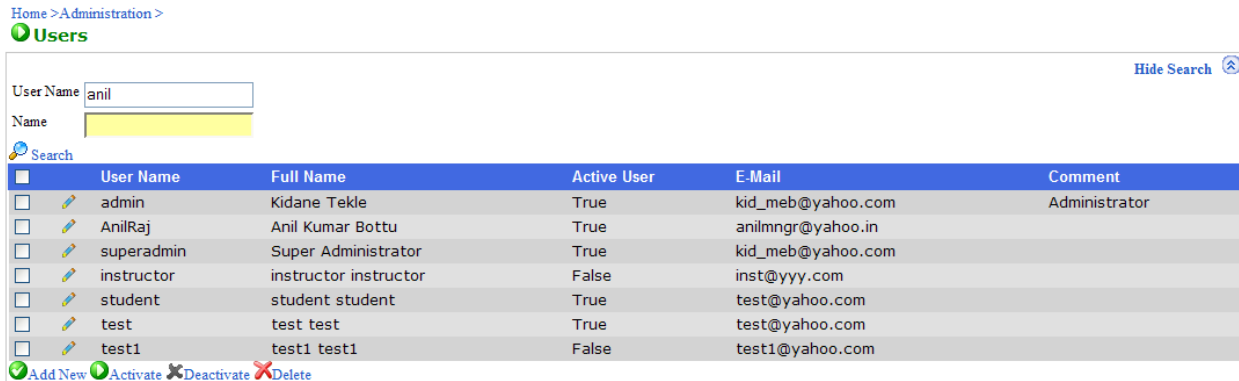
Figure 14 – User management page

Instead of searching a user by going through the whole users list administrator can perform a quick search by filtering with user name or full name of the user. To perform a search operation administrator has to provide username or full name of the user to search, clicking ⌕ Search link displays a filtered list with the names entered. Figure 15 shows a sample search performed on the users list by username "anil"
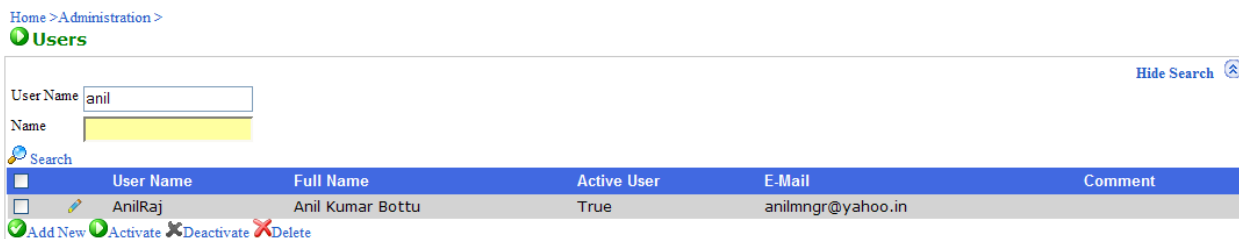
Figure 15 – Sample search on users list

Adding a user

Administrator can add a new user on special occasions using the ✔Add New link it redirects to a new user account page with empty details. Figure 16 is a user account page where administrator enters user details and saves into system.

Figure 16 – Adding new user by administrator

Editing a user

Administrator can edit a user details using the ✏ edit button from a user row on the page, it takes administrator to user account page with user details of the user selected on the grid to update or edit as shown in figure 17.

Figure 17 – Editing user details by administrator

Activating and deactivating user

Every user created first time is an inactive user in the system. The registered users have to be approved by system administrator for authentication. When a user is approved by administrator, the user becomes an active user and can access the resources based on the role assigned.

While implementing the users and their functionalities we came through a conversation that, if a user discontinued for a period of time and came back again, requesting the same user account used previously for authentication. By considering this aspect we implemented two operations on users they are activating and deactivating users.
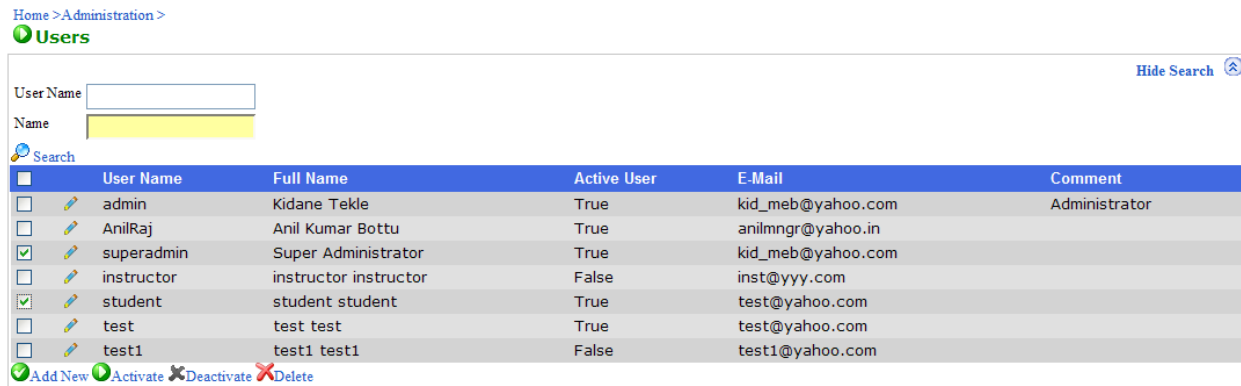
Figure 18 – Activating and deactivating users

A user is deactivated by selecting the user from the list of users using checkboxes clicking the **Deactivate** link an active user in the system changes to an inactive user as shown in figure 18. Activating a user is same process as deactivating, instead of using the deactivate link administrator uses **Activate** link. When a deactivated (inactive) user tries to login, an error message will be displayed saying "your account has been deactivated contact system administrator" as the shown in figure 19.
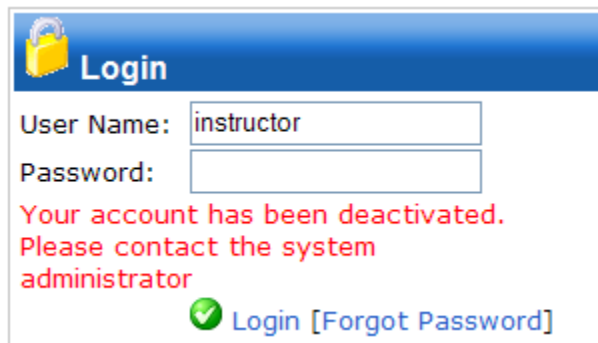
Figure 19– Error message when a deactivated user tries to login

Retrieving Password

In DCM users can reset their forgotten password using the [Forgot Password] link from the login page. It takes user to a retrieve password page asking for the username to reset a random generated password for logging. Figure 20 shows a retrieve password page with a username "test", clicking **Send Password** link system generates a message saying "password reset successfully check your e-mail for your new password" as shown in figure 21.

Retrieve Password

You can request your password by providing your UserName and the password will be sent to the email address you provided during registration.

Note that your password will be reset and a random password will be generated for you.

User Name: test

✅ Send Password

Figure 20 – Forgot password page

The DCM automatically sends an email to the user "test" with the new random generated password for logging into the system. After authenticating with new password users can change the random generated password by updating their login details.

Retrieve Password

Password reset successfully. Check your E-Mail for your new password

Figure 21 – System generated message confirming new password

5.1.1.2   Users Privileges and Access Rights

Privileges define the access level of the user, or what the user is allowed to do and the resources of the system which the user is allowed to see. Every user in the system has some sort of privileges based on the user type. In addition to controlling what a user can see, we can also control what actions a user is allowed to perform on the system. Different users have different privileges.

In DCM user privileges are assigned based on the operation they perform. These operations may be different kinds manage users, view courses, enroll students and manage content etc. Every operation in the DCM has some privileged users that can perform different actions according to the access rights assigned to them. Access rights controls the users level of operation on a particular resource.

Assigning privileges to the users is performed by system administrator. In that way, first administrator searches for the users that need to be privileged for an operation. A search can be a quick search on the username or a normal search. After the search is performed,

administrator selects the user from the list of users by clicking [>>] right arrow button the selected unprivileged user will be added to the privileged users list to perform that operation. Unassigning privileged users from an operation is accomplished by choosing the users from privileged users clicking the [<<] left arrow button the selected users will be added to the unprivileged users list. Figure 22 shows a user privilege page with some unprivileged and privileged users.
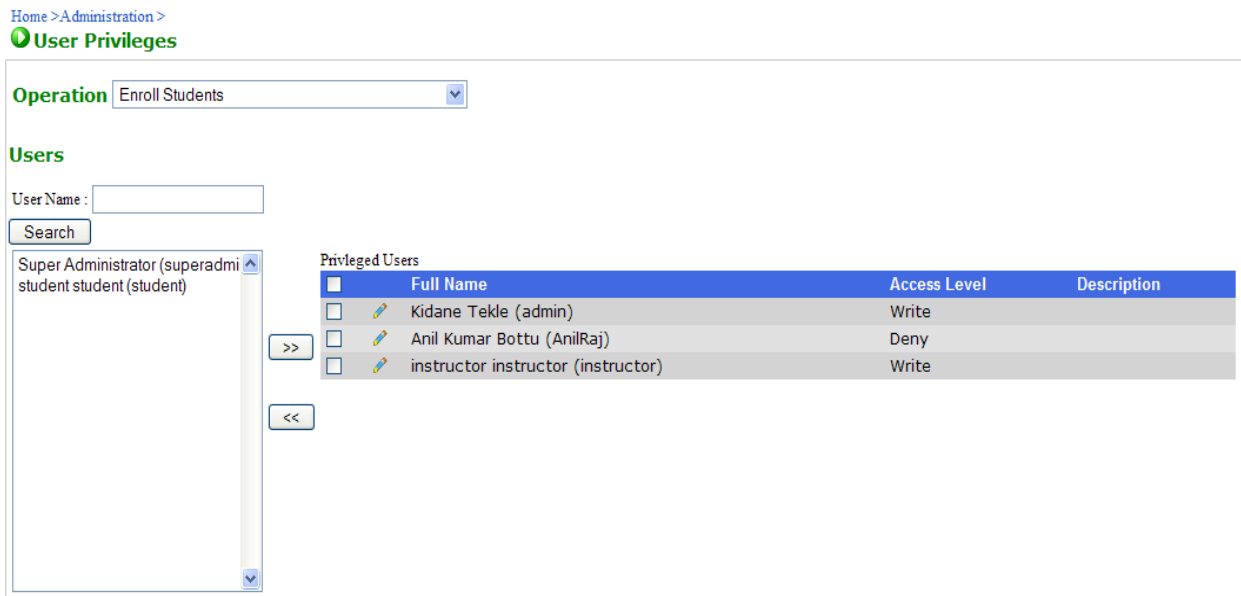
Figure 22 – User Privileges page

User Access Rights [21]
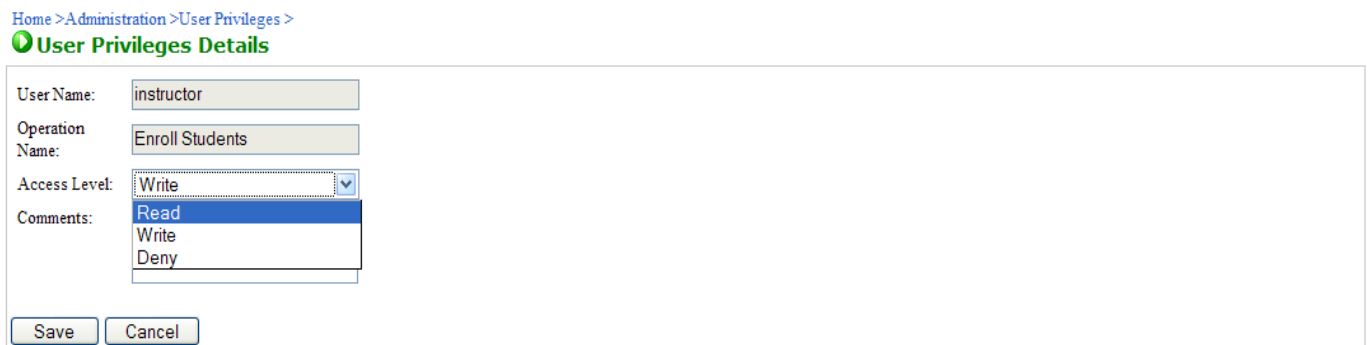
DCM implements three types of predefined access rights on the users. Each access right defines what a user is allowed to do. This kind of access rights feature tells how data is viewed and managed by different existing users throughout the system.

What you can see (Read Access Right) - Read access right enables administrator to hide pages, content, and resources from unprivileged users. When pages and resources are protected, unprivileged users cannot see links to them, as if they don't exist. Even if users have the privilege, they can't edit the content unless they have assigned to an appropriate access right.

What you can do (Write Access Right) - Write access right allows the users to have full control on the assigned operations. Write privileged users are responsible for all actions on resources they assigned like managing, editing and deleting the resource.

No permission (Deny Access Right) – Deny access right restricts the privileged users not to perform any action on the other users content. Two users belong to the same roles can have different access rights based on the operation assigned.

Figure 23 shows user privilege details of the username instructor. Clicking the ✏ edit button on the instructor row redirects the administrator to the user privilege details page with editable access rights and with masked user name and operation name that are not allowed to edit. Selecting an access level from the drop down box and clicking the ⬚Save⬚ button it returns back to the previous page with the new access level assigned.

Figure 23 – User Privilege Access rights

5.1.2 Role based security [22]

Role-based security can be used to restrict access to resources to only those users who have been granted a particular security role. Role based security is an approach to standardize the authorization process and make individuals be able to gain access to certain functionalities of the system by making them members of some roles. To restrict access we set up two kinds of tests that users must pass to access some resources: an *authentication process*, which determines the user's identity and role assigned, and an *authorization process*, which decides whether a user has the role membership necessary to access a particular resource.

A user is first tested against the authentication process. The authentication process is generally a login process, where the user is asked to provide a username and password. If the user succeeds in passing this challenge, the user is granted a set of identities: one identity is his username identity, the other identities are the set of roles that user has assigned.

In the authorization process, users are tested to see if they have been granted the required role to access the protected resource. If they have been granted the required role, they can access the resource; if they haven't, they are denied access.

In DCM role based security is implemented by the code given below with a method SecurePage (). Most of the pages in the system have this function given by some roles to access the resource. This function authorizes the users based on the roles assigned and redirects to the appropriate page.

```
protected void Page_Load(object sender, EventArgs e)
{
  SecurePage();
}
```

In the code given below only administrator and instructor will be authorized. Whenever a page loads it checks for the required roles, if the user assigned role is not the required role a message will be displayed saying "you are not authorized". If a user is authorized with required role, system allows that user to access resources available for that role. With this kind of authorization we can explicitly implement role based security on the roles assigned to users.

```
public void SecurePage()

{
EAS.Utilities.WebFunctions.RequireRolesAny(this.Page,newstring[]{ "Administrators", "Instructors" });
}
```

5.1.2.1   Role Management

Role management in DCM is operated only by administrator; system administrator can view everything in the system and can create, edit, and delete every kind of entry, from users to roles. The DCM has the following predefined roles as shown in figure 24

		Role Name	System Role	Comment
☐	✏	Administrators	True	
☐	✏	Instructor	True	
☐	✏	Student	True	
☐	✏	Super Administrators	True	

Home >Administration >
Roles
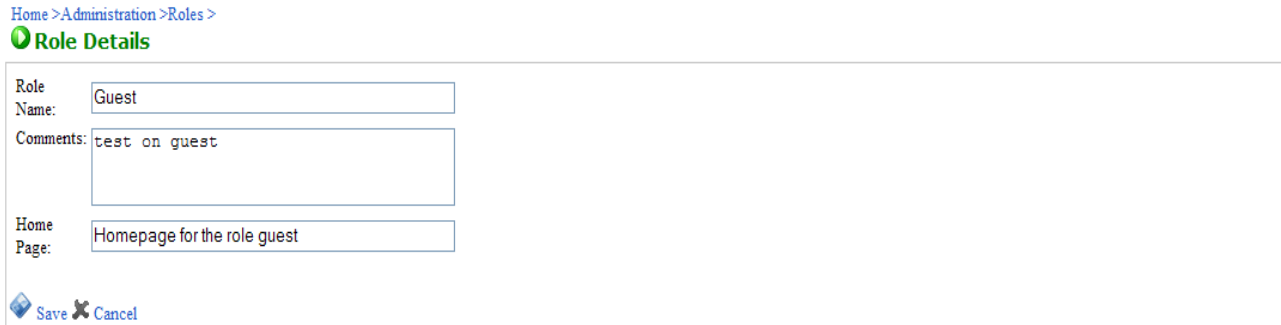
Add New Delete

Figure 24 – Roles Page

Administrator has privilege to add new roles to the system, if an administrator wants to add a guest role clicking the Add New link redirects to role details page showed in figure 25 asking to enter the details of role name, comments or remarks and a home page for the role. After entering the proper details of the role clicking the Save link system stores the information

and returns back to the previous page. Editing a role is implemented by clicking the ✏ edit button on roles list redirects to a role details page of the role selected on the grid for editing the information which is a similar figure as figure 25.
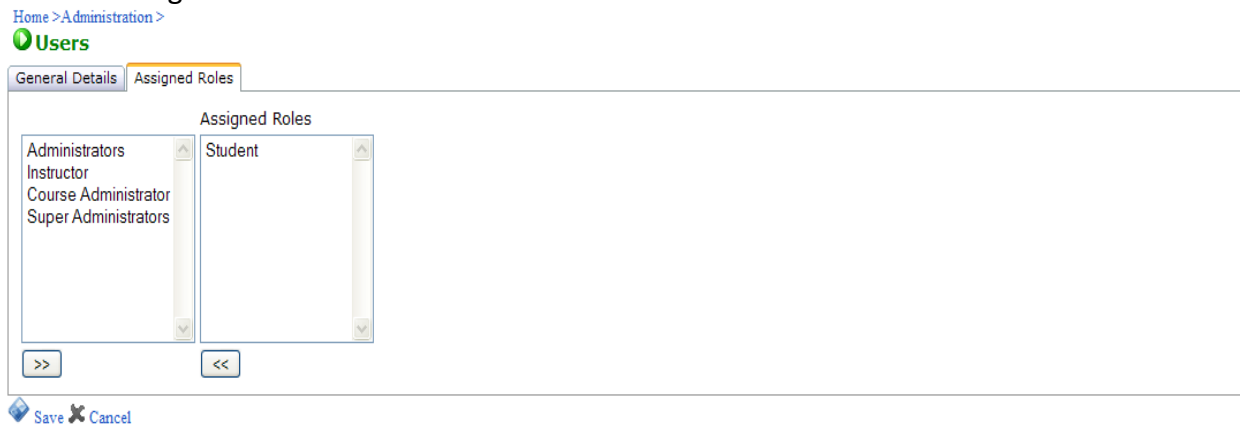
Figure 25 – Roles Details

Assigning roles to users

Every user in the system has different access level based on the roles assigned to them. When a user is created, assigning roles to the user is performed by the system administrator. Some special user may have more than one role assigned. The figure 26 shows how roles are assigned to the users created, it presents two list boxes one with unassigned roles and another with assigned roles. The administrator has an easy way of assigning roles to users; by selecting the required roles from the unassigned roles clicking 　>>　 right arrow button the selected roles moves to the assigned roles list of the user. Unassigning user roles is the same way as assigning roles instead of pressing right arrow button administrator uses 　<<　 left arrow button on the selected assigned roles.

Figure 26 –Assigning roles to users

5.1.2.2   Role Privileges and Access Rights

In DCM role privileges are assigned based on the operation they perform. These operations may be different types like content management, edit courses and manage students etc. Every operation in the DCM has some privileged roles assigned to perform different operation according to the access rights assigned to them. Access rights controls the level of operation the roles will perform on a particular resource.

Administrator selects a role from the list of roles clicking the [>>] right arrow button, the selected unprivileged role moves to privileged role list. Unassigning roles from the operations is performed by selecting a role from the grid and using left arrow button [<<] privileged roles changes to unprivileged as shown in figure 27.
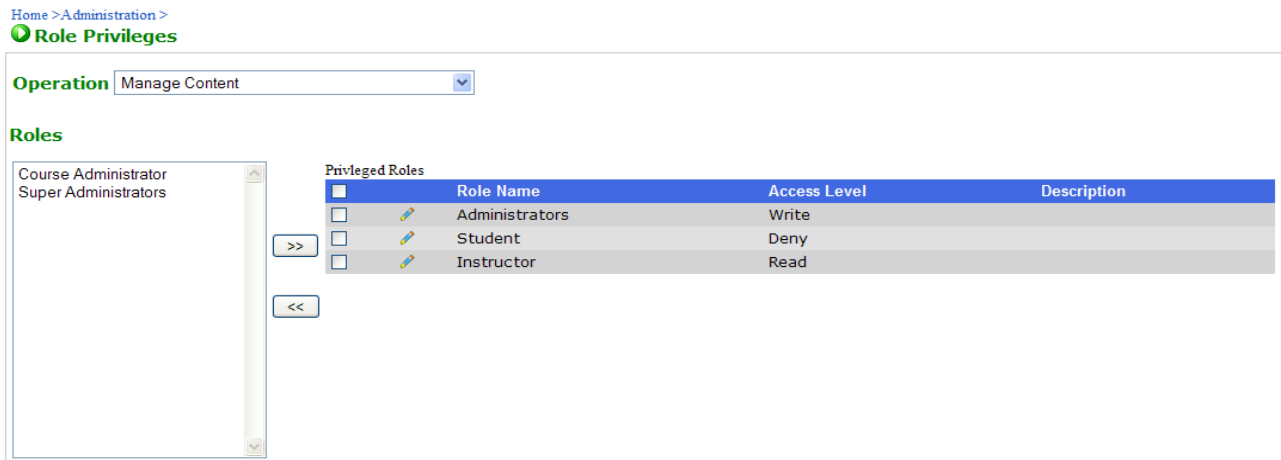
Figure 27 – Role Privileges

Role Access Rights
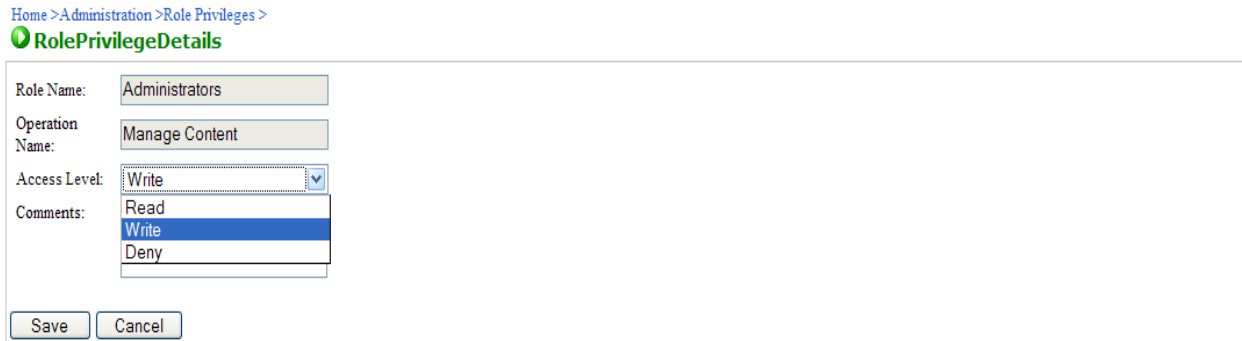
DCM implements three different types of predefined access rights on the roles. Each access rights define what a role is allowed to do and not allowed to do.

Read — Roles having read access right are allowed only to view resource

Write — Roles having the write access level on an operation are considered as owners for that resource.

Deny — Roles that are not allowed to view and edit

Figure 28 a role privilege details page with editable access rights and with masked role name and operation name that are not allowed to edit. Selecting the access level from the drop down box then clicking the [Save] button it redirects to the previous page with the new access right assigned. Clicking the ✏ edit button administrator can edit the access level of the role selected.

Figure 28 – Role Privilege Access rights

5.1.3 Operation based security

In DCM user and role privileges are assigned based on the operations they are allowed to perform. Every operation in the DCM has some privileged users and roles that can perform different operations according to the access rights assigned to them. Access rights controls the users and roles level of operation on a particular resource. Controlling users and roles based on the operations performed by them using different access levels is called as operation based security. These operations are defined by the system administrator, figure 29 shows three operations view courses, manage content and enroll students.

Figure 29 – operation based security

Please refer section 5.1.1.2 and 5.1.2.2 for more detailed explanation of operation based security on users and roles.

5.2   Question and Quiz Generation

The most e-learning systems focus on the interaction of the student and instructor via the availability of various resources and activities. The educator avails various resources to the learner during the running period of the courses she is giving. The Instructor can create questions to a course she is assigned, or she can choose a question from the already existing questions related to the same content.

An instructor can provide questions with a specific answer feedback. For example, in True/False question an instructor can give feedback on the correct answer explaining the reason why the answer is correct?

5.2.1 Question and its relation to Content

In our model, questions are related to the small units of knowledge. There could be a one-to-many relation of questions to the atomic knowledge material since a single question may address issues covered by more than one unit of the knowledge pool.

Every learning material has some public/private questions that are already created or an option to create new questions by the instructor according to the course assigned. These questions may be analytical, fill in the blanks, multiple or True/False depends on the instructor interest of making a question paper to students depends on the student progress.

In DCM questions are related to content, by this relation questions can be reused in more than one course. Questions are declared as *public* or *private*, *public* question are used to practice for the quizzes and also for examination. *Private* questions can be used for evaluation purposes like creating quizzes and obligatory exercises. Questions in this system are categorized into three levels Easy, Medium and Difficult. Based on the students progress follow up, student will have the different level of the questions to practice.
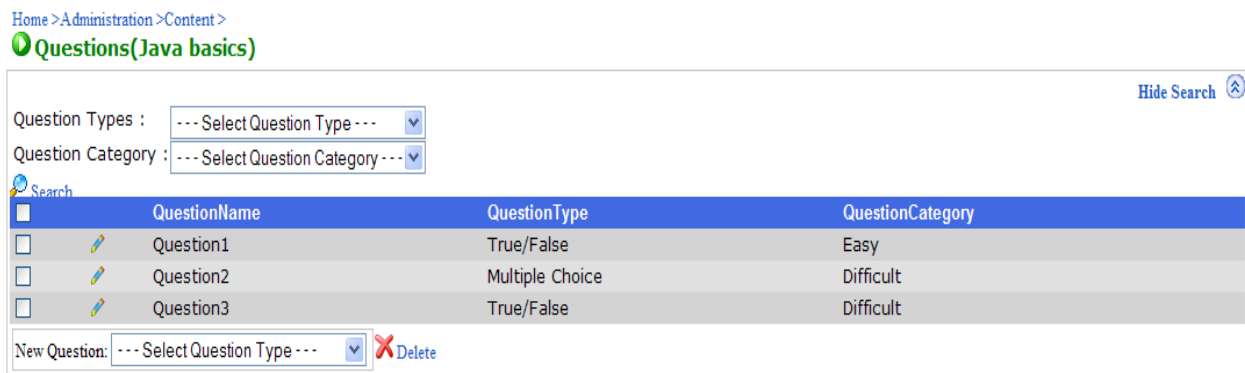

Figure 30 – Question Page

All questions that are created are automatically stored in the question database. Since the question database could contain many questions, they are organized based on the question category and question type. The question page in DCM contains a search based on question type and question category, list of questions, adding new question and a delete question link as shown in figure 30.

To make the user comfortable and easy to perform actions on the questions we implemented two types of search one with the question type with a 🔍 Search link as shown in figure 31.
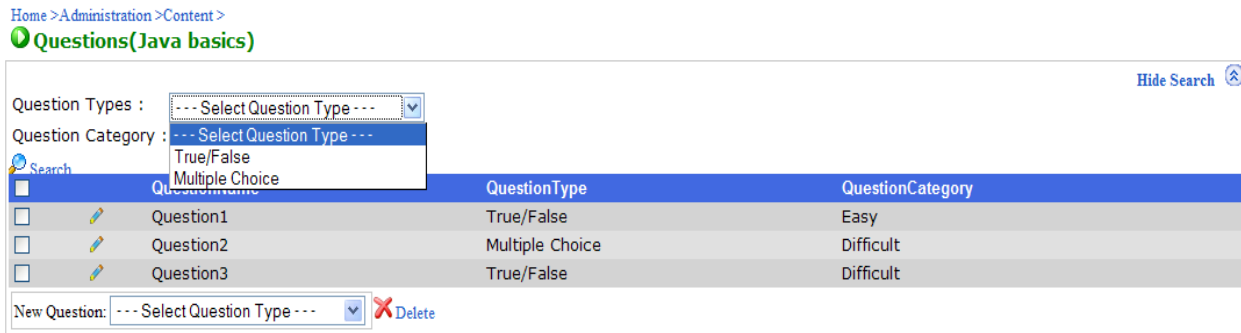
Figure 31 – Searching questions using question type

Another search is with question category as shown in figure 32. While creating a quiz or an exam instructor have the facility to search question based on the question type, question category and selects questions according to the student knowledge level to make the students progress more successful.
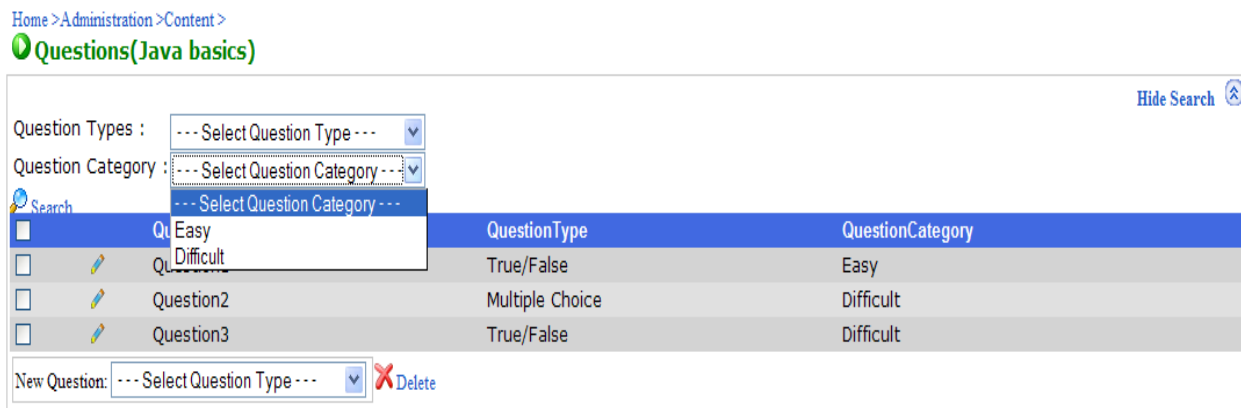
Figure 32 – Searching questions using question category

Figure 33 shows how a new question is created in the question database. By choosing the question type from the new question drop down it redirects to the new question type page which are explained in the next section (see section 5.5.2.1 & 5.5.2.2 for details).
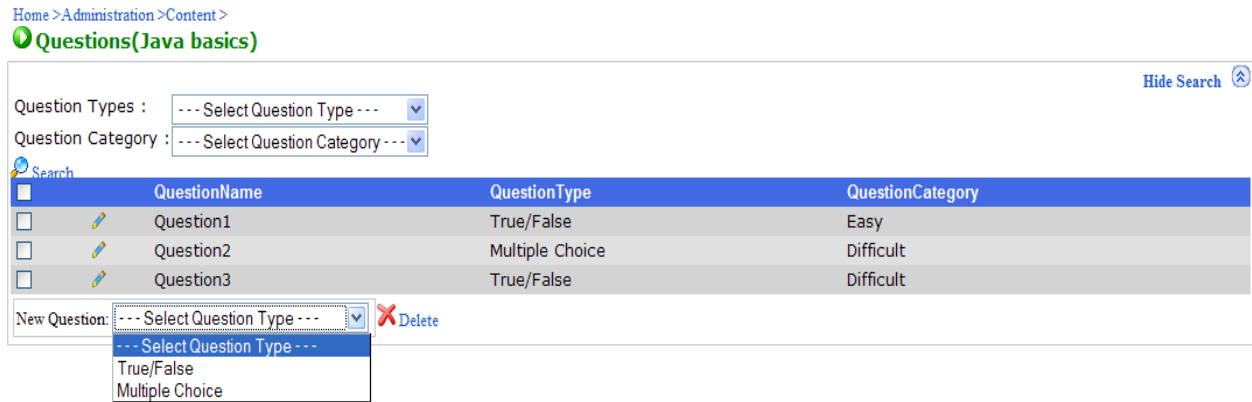
Figure 33 – Adding a new question

If an instructor wants to edit a question, by clicking the ✏ edit button on the gird shown above it takes to the appropriate question edit page with question details for editing.

5.2.2 Different Types of Question

In DCM system true/false and multiple choice questions are implemented, more different types of questions can be enhanced and added. DCM uses FCK editor for the question description in true/false and multiple choice questions which is an advanced editor where instructor can upload images, create tables and can upload a video file.

5.2.2.1 True/False question

True/False questions present students with a question with only two possible answers — true or false. They are helpful assessment tools to facilitate students' comprehension of their learning materials. While creating the question instructor can provide correct answer with true feedback and the wrong answer with a false feedback. Figure 34 shows how a true/false question implemented. The page contains the following fields

Question name – Name of the question

Question category – Category in which question belongs

Question description – Question in detail

Correct answer – Correct answer for the given question

True and false feedback – Feedback for the correct and wrong answers

Figure 34 – True/false Question

When an instructor is finished with defining a question clicking Save link saves the question into question database based on the category chosen form the question category dropdown.

5.2.2.2 Multiple choice question

Multiple choice questions are very useful to assess students' conceptual knowledge in a fun and quick way. A Multiple choice question presents students a question with a maximum of five possible answers choices which is a setting in configuration file of the system. The number of choices can be selected by instructor choosing a number from the "number of choices" dropdown which automatically generates the choice boxes according to the number selected.

Adding a new multiple choice questions redirects to this page as shown in figure 35 without question details. When an instructor wants to update or edit an existing question in the system. Clicking the edit button on the question gird row redirects to the figure 35 which is an edit mode of the question with the question details populated to edit. Figure 35 shows a multiple choice question with three choices, if an instructor wants to edit the number of choices from three to five by selecting the number five from the number of choices system adds two more boxes keeping the three choices as it is. After entering the two more choice details clicking Save link system saves the question with updated choices.

Figure 35 – Multiple choice questions

A multiple choice question in the system contains the following fields

Question name – Name of the question

Question category – Category in which question belongs

Question description – Question in detail

Number of choices – Number of choices required for the question

Choices – Choice boxes

Correct Answer – Correct answer for the question given

5.2.3 Quiz and its relation to Course

Quiz is usually a form of student assessment, but often has fewer questions of lesser difficulty and requires less time for completion than a test. Feedback on performance of a student in a quiz is a critical part of a learning environment and assessment is one of the most important activities in education. We can't tell what's going on inside the heads of students, so we need a way for them to demonstrate what they understand and what they don't. A well-designed test, even a multiple-choice test, can give you critical information about student performance. [23]

 A quiz is a collection of questions based on some organization of the knowledge materials in the form of a course or a topic specific knowledge map. Quizzes are related to courses in our system which means there is no tight coupling between quizzes and question that implies reusability of questions can be achieved in more than one quiz.

Home >Administration >Course >

Quiz for the course: MOD250

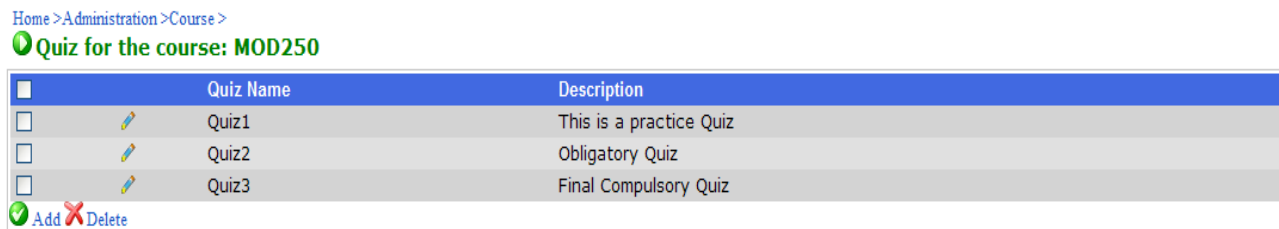|		Quiz Name	Description
☐			
☐	✎	Quiz1	This is a practice Quiz
☐	✎	Quiz2	Obligatory Quiz
☐	✎	Quiz3	Final Compulsory Quiz

Add Delete

Figure 36 – Quiz related to a course

Figure 36 shows a list of quizzes that are created under the course MOD250. If an educator wants to add more quizzes to an assigned course clicking the   Add link redirects to a quiz editor page where an instructor can create a quiz by entering quiz details and adding questions to quiz. Instructor has the privilege of deleting a quiz form the list of existing quizzes which are out of date. Selecting a quiz from the list of quizzes clicking the Delete link removes that quiz from the list of quizzes created under a course.

Figure 37 displays how a quiz editor page is organized in the system. A quiz editor in DCM consist of two tabs, one tab with quiz details like quiz name, time limit and allowed attempts etc and the other tab with a grid displaying the list of questions that are added to a quiz. A privileged instructor is allowed to add quiz details before or after adding questions to the quiz.

Home > Administration > Course > Quiz Editor >
Quize Details

Quiz Details | Questions

Quiz Name :   Quiz1
Quiz Description :

This is a practice Quiz

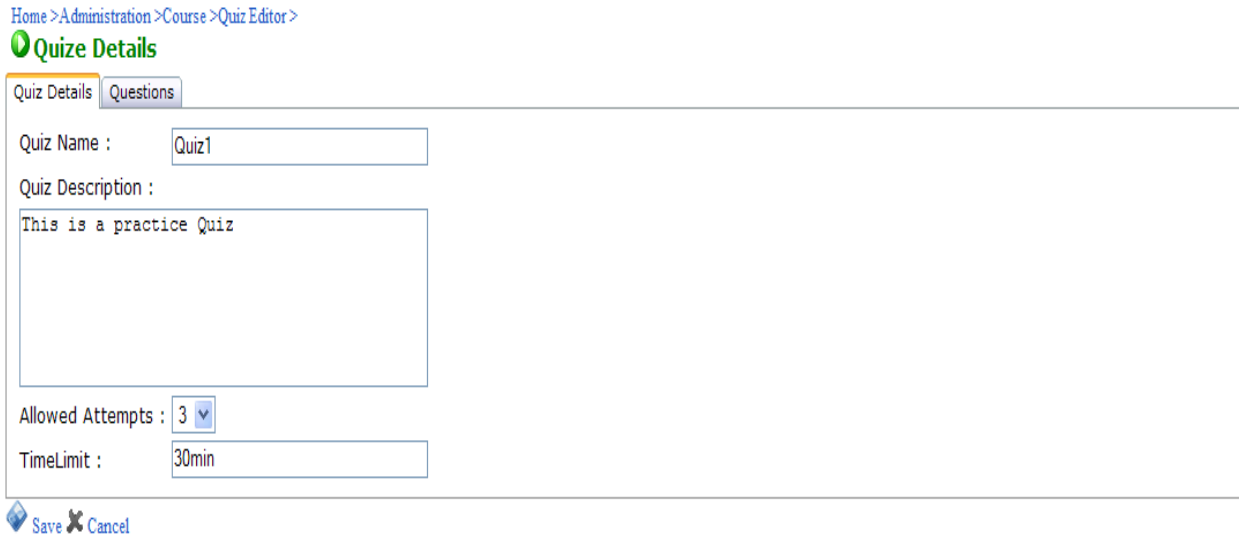Allowed Attempts : 3
TimeLimit :   30min

Save Cancel

Figure 37 – Quiz editor with details of the quiz

The quiz details tab on quiz editor page is organized under four headings

Quiz Name – Name of the quiz

Quiz description – Description about quiz

Quiz Attempts – Number of allowed attempts

Time Limit – Time limit for the quiz

Home > Administration > Course > Quiz Editor >
Quize Details

Quiz Details | Questions

Questions

		Question Name	Question Type	Category
☐	✎	Question1	True/False	Easy
☐	✎	Question2	Multiple Choice	Difficult
☐	✎	Question3	True/False	Difficult

Add Question Delete Selected Question

Save Cancel
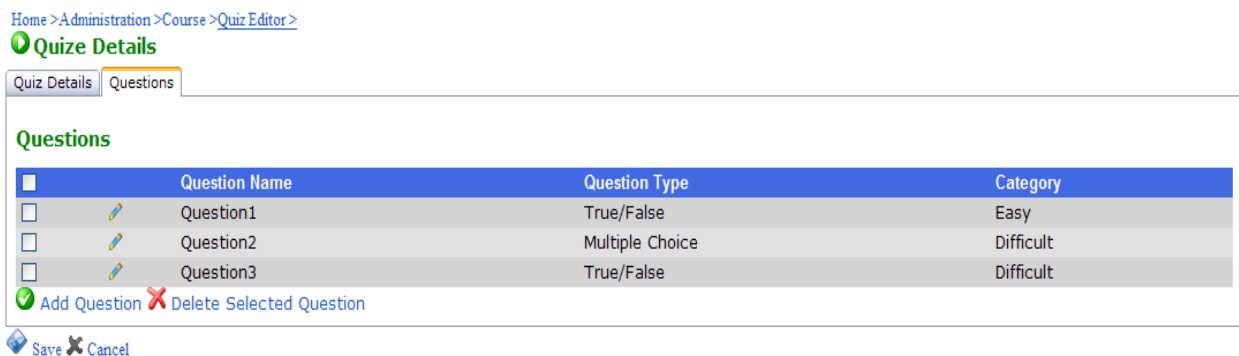
Figure 38 – Adding questions to quiz

The system allows the teacher to design and set quizzes with different question types and question categories. When an instructor wants to add questions for a quiz clicking the **Add Question** link, a question picker page displays with the list of existing questions. A question picker is a picker that picks all the questions that are in the question database.

Choosing the required questions from the question picker clicking ⊘Accept link system adds those selected questions under the quiz details of the quiz. Instructor can delete a question from the quiz by using the ✖ Delete Selected Question link. Figure 39 shows how a question picker displays questions.
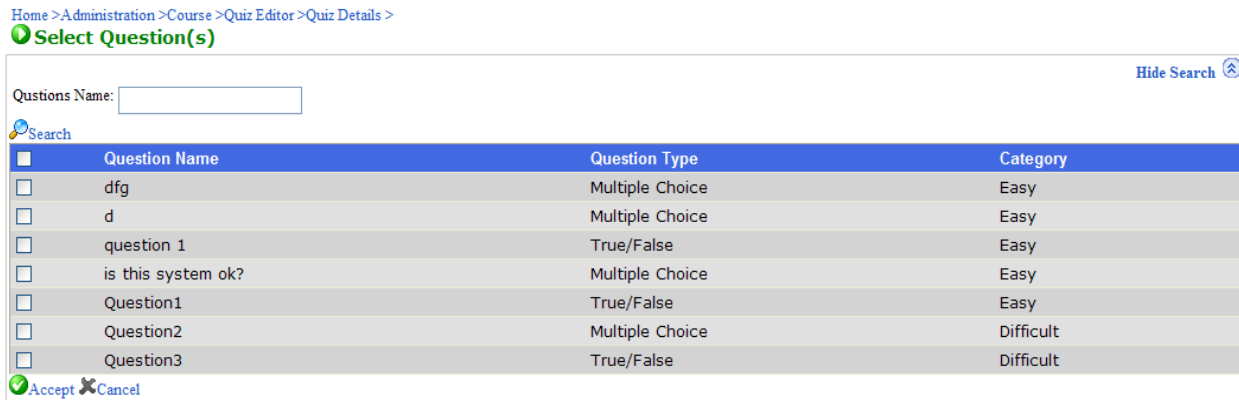

Figure 39 – Question picker

When creating a quiz is completely finished by proving quiz details and added questions to the quiz clicking the 🔷 Save link system adds the quiz under quizzes list. An instructor can update or edit the details and questions of a quiz using the ✏ edit button.

5.3   Student Registration

In the current DCM system student register themselves by using an enrollment key given by the instructor either directly in a class or via e-mail. By using this enrollment key students can access the user account page to create their own login account by providing their general details and login details as shown in figure 40 and 41.

Figure 40 – General details

Figure 41 – Login details

After a student is registered successfully, system administrator has to assign them to a learning period (semester) to access the courses.

5.3.1 Semester registration

The semester registration of the student's in DCM is operated by system administrator. When a student is registered administrator has to assign her to a learning period. After a student is assigned to a learning period (semester) then only she can able to see the courses available or offered for that learning period.

The security is strictly implemented that students can only see the course available for the learning period they are assigned. Students register themselves for the courses offered in the learning period.

Figure 42 – Semester registration

Figure 42 shows how the students are registered to a semester by the system administrator. Administrator selects the learning period and the faculty from the two dropdown lists clicking the ⊘ Register New Students link a student picker page displays with the list of students. Selecting the students from the student picker page clicking the ⊘ Accept link, students will be added under list of students for that learning period and faculty. Figure 43 is a student picker with students list.

Administrator has the privilege to undo semester registration of a student when it is required. Undo registration can be done by selecting the students from the list and clicking the ✖ Undo Registration link the students cannot access the courses anymore.
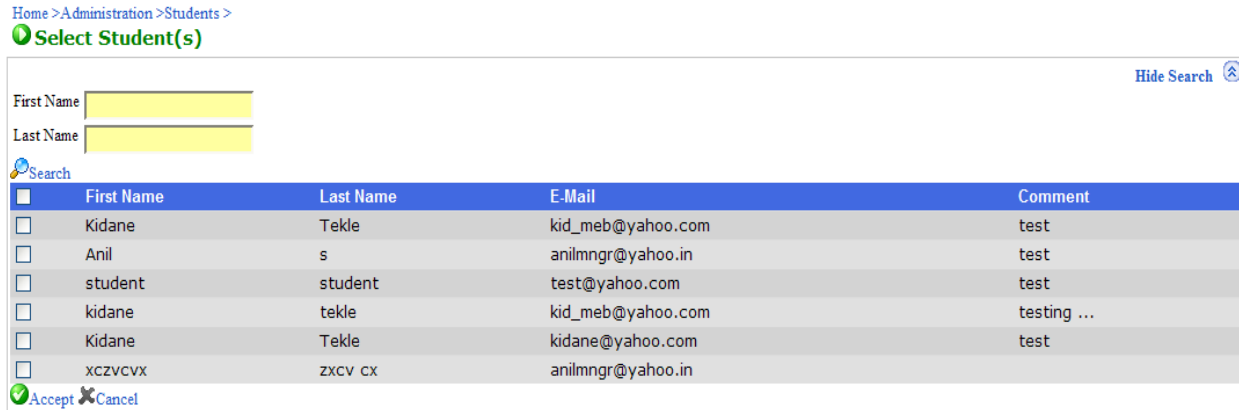

Figure 43 – Student picker page

5.4   Instructor Course Assignment

System Administrator has the responsibility of assigning instructor to a course offered for a learning period. Instructor has given full privilege to design the course by adding content material into the course structure. Instructor cannot access the resources of the other courses that are not assigned to them.
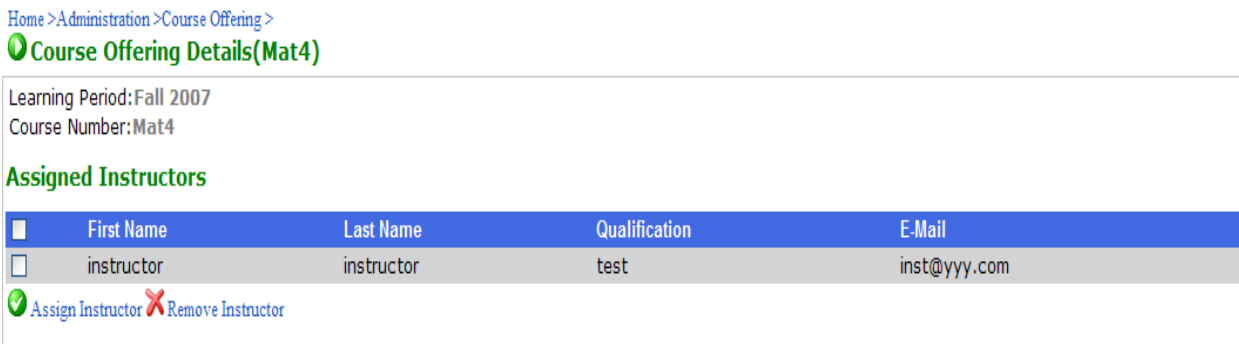

Figure 44 – Instructor course assignment

Figure 44 shows how the Instructors are assigned to a course named Mat4 for the learning period fall 2007. Administrator selects instructors by clicking the ✓ Assign Instructor link an instructor picker page displays with the list of instructors. Administrator selects instructors from the instructor's picker page and clicking a ✓ Accept   link the instructors will be added to a

course offered in a learning period. Figure 45 is an instructor picker page displays the list of instructors.

The system administrator has the facility to remove an existing instructor when an instructor is replaced by another instructor. Using ✖ Remove Instructor link administrator can remove instructs from the courses they are assigned.
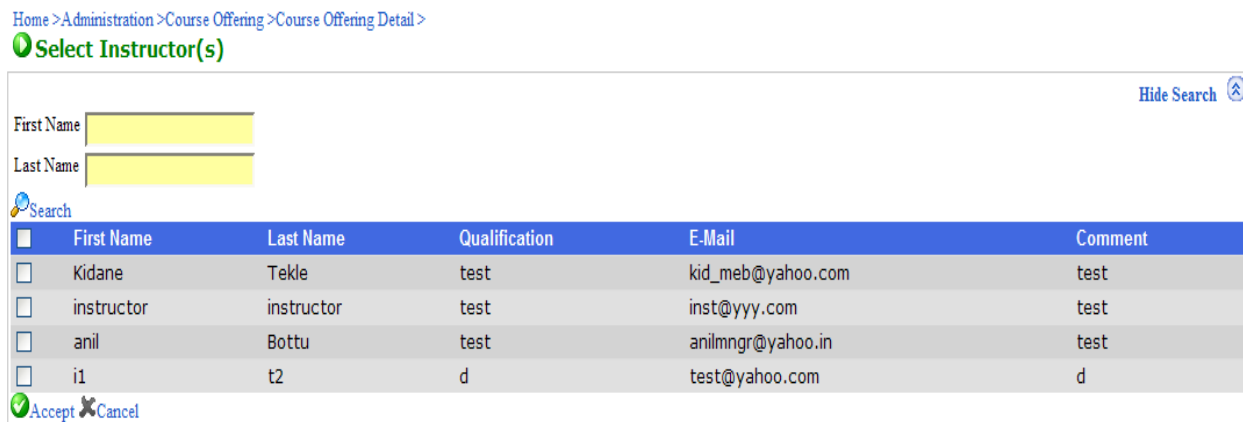

Figure 45 – Instructor picker page

5.5 Error reporting facility

The DCM system has an error reporting facility to improve the system when it is used in the real time. Students or people using the system can report a problem they faced while working with system. The error reporting link will be displayed to the users on the left side quick links menu with a link ⚠ Report a problem.
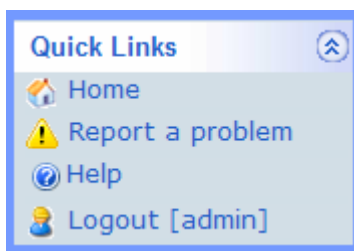
Figure 46 shows how a problem is reported, it has two text boxes asking for what's the user is working on and a description about the problem. Entering the details of the problem using Submit link users submits the problem to system.

Figure 46 – Error reporting page

System administrator has the responsibility to clarify the problems reported by the users. The administrator has a Reported Problems link, by clicking that link it displays a reported problems page with name of the user, description of the problem, time and status as shown in figure 47. Administrator sends an email to the users with a solution on their reported problems. When a problem is completely solved, administrator can delete the problem from the list by using the Delete link.

Figure 47 – Reported problems page

5.6   File Management

The file management in the system is well organized and its user interface allows people to manage their files without much technical knowledge. When a user is registered and approved by assigning some role system creates a folder for the users where they can have their own space to store their files and content. The system administrator allocates storage capacity of the users based on the roles.

By using this file manager user can upload and store files on their directory. This file manager allows users to create new folders, which means user can organize their files in different folder to get a clean separation between files. It allows users upload files from the local machines they are working on and have the facility of zipping files. It has different functionalities like renaming files, deleting, copying files to folders and multiple selection checkboxes as shown in figure 48.

The security of this file manager is strictly implemented that means users can access only their directory and cannot access the other user's directory. Even if some user's tries to access other peoples material system will not allow them to perform such actions. System administrator has the privilege of managing user directories and the content they are uploading.
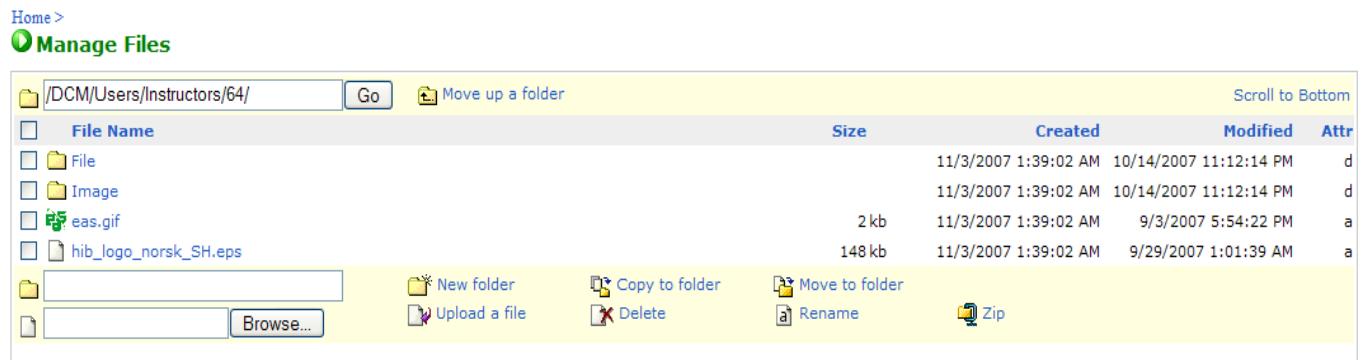
Figure 48 – File Management

6 System Testing [24]

System testing is testing conducted on a complete system to evaluate the system's compliance with its specified requirements. System testing is actually done to the entire system against the Functional Requirement and Non-functional Requirements. The system testing is an investigatory testing phase, where the focus is to have almost a destructive attitude and test not only the design, but also the behavior of the system.

6.1 Smoke Testing [25]

Smoke testing is non-exhaustive software testing, ascertaining that the most crucial functions of a program work, but not bothering with finer details. The term comes to software testing from a similarly basic type of hardware testing, in which the device passed the test if it didn't catch fire the first time it was turned on.

Smoke testing describes the process of validating code changes before the changes are checked into the product's source code. Smoke tests ensure that the primary critical or weak area identified either by code review or risk assessment is primarily validated. Code reviews in smoke testing is the most cost effective method for identifying and fixing defects in software. Smoke tests are designed to confirm that changes in the code function as expected and do not destabilize an entire build.

Smoke testing is implemented while developing DCM by reviewing the code before applying the changes made and also by observing the behavior of the system after the changes applied. This testing is implemented before running the program checking thoroughly what the changes are made to the code and how it will affect the system.

6.2 Regression testing [26]

Regression testing is which seeks to uncover regression errors. Regression errors occur whenever software functionality that previously worked as desired, stops working or no longer works in the same way that was previously planned. Typically regression errors occur as an unintended consequence of program changes. Common methods of regression testing include re-running previously run tests and checking whether previously fixed faults have re-emerged.

Regression testing is an integral part of the extreme programming software development method. In this method, design documents are replaced by extensive, repeatable, and automated testing of the entire software package at every stage in the software development cycle.

The regression testing in the system is implemented by checking the changes made to the code did not change the behavior of the system. As the system developed from scratch, at different stages we improved the code by refactoring and also observed that the code did not alter the functionality of the system.

6.3   Performance Testing [27]

Performance testing is testing that is performed, from one perspective, to determine how fast some aspect of a system performs under a particular workload. It can also serve to validate and verify other quality attributes of the system, such as scalability, reliability and resource usage. Performance testing is a subset of Performance engineering, an emerging computer science practice which strives to build performance into the design and architecture of a system, prior to the onset of actual coding effort.

In performance testing, it is often crucial for the test conditions to be similar to the expected actual use. This is, however, not entirely possible in actual practice. The reason is that production systems have a random nature of the workload and while the test workloads do their best to mimic what may happen in the production environment, it is impossible to exactly replicate this workload variability - except in the simplest system.

With underlying structure of the DCM system, system is performing well without any errors in real-time use, for better performance we used error reporting facility to know how good the system performs when people uses in real-time under load conditions.

6.4   Stress Testing [28]

Stress testing is a form of testing that is used to determine the stability of a given system or entity. It involves testing beyond normal operational capacity, often to a breaking point, in order to observe the results.

In software testing, stress testing often refers to tests that put a greater emphasis on robustness, availability, and error handling under a heavy load, than on what would be considered correct behavior under normal circumstances. In particular, the goals of such tests may be to ensure the software doesn't crash in conditions of insufficient computational resources (such as memory or disk space), unusually high concurrency, or denial of service attacks.

The DCM system is a light weighted and a simple content based e-learning system. As the DCM is in developing phase stress test is implemented by using a course named MOD250 with 32 students and 2 lectures by Hogskolen I Bergen.

7   Summary and Conclusion

7.1   Status of the System

Development of the core functionalities of the DCM system was finalized and the system was deployed for testing in the fall semester of 2007. The course MOD 250 (modern software development techniques) was selected as a test course with a class of 25 students and two instructors. This sample usage of the DCM system served as a proof of concept for the logic behind the DCM solution and as a firsthand experience of usage in a real learning environment. It was observed that users did not need any training to start using the system.

7.2   Further Work

The DCM system will need to undergo some iteration through the incorporation of new requirements and the enhancement of implemented functionality. Currently, more emphasis is given to the realization of the core system functionalities and to achieving initial operational capability. There still remain lots of subsidiary functionality requirements that need to be implemented if the DCM system is to be used to its full potential. Following, some of the requirements that could be incorporated into the DCM system are described.

7.2.1 Student content coverage follow-up

Student content coverage follow up is very essential for the overall quality of the learning process. By incorporating this feature, the DCM system could give the educator more information on the content coverage of the student so that she can be able to prepare better suited learning material. It also enables the identification of learning trends and patters and could be a source for further analysis and research on student learning behavior.

7.2.2 University structure awareness

Currently, the DCM system is designed as a single installation, single deployment system. It uses a common students and instructors model without giving much emphasis to the structure of the university or the learning environment. The users modeling and security structure of the DCM system could be further enhanced so that it takes into account the different faculties and departments and the enrollment of students. Also, the DCM system could be enhanced so that it can be deployed in more than one institution with a regulated and standardized mode of content sharing.

7.2.3 More graphical presentation

The DCM system is designed in a way so that more enhancements can be done to the way the learning material is presented and updated. The inclusion of multiple views to a course is one graphical enhancement that could make the DCM more useful and user friendly to the learner. Weekly views, summary and categorized views of the learning material could be presented to the user in addition to the table of content view that is currently implemented in the system. A richer graphical presentation needs to be incorporated in the navigation and display of concept maps. Graphical representation of such a dynamic and arbitrary aggregation of knowledge elements is quite challenging and is a good area for further research and development.

7.2.4 Integration with other systems

The DCM system captures only the core operations and components of the content based, reusable E-Learning. There are lots more functionalities that need to be incorporated into the system if it is to be mature enough to be used in a large scale learning environment.

The DCM system is designed so that it can be integrated with other systems and use existing functionalities. One proposed integration mode is the implementation of security and utilities interface so that it can be integrated into existing popular content management systems (CMS). By integration with existing content management systems, the DCM benefits the usage of functionalities like: discussion boards, blogs, news, photo galleries, publications management and much more. Dotnetnuke (DNN) [19] is one of the most promising Content Management Systems into which the DCM can be integrated with relative ease.

7.2.5 Information exchange

There are many software systems that are put to use in the learning environment. As such, much information and resources are found distributed throughout these systems. Being able to extract information from existing systems and to make its resources and functionalities available to others is one measure of maturity and usability of a system. The DCM can be further enhanced so that it accepts students' information from dedicated student record management systems. Also, interfacing the DCM with systems currently being used for conduction of learning (MySpace in the case of University of Bergen) is one direction of enhancement to achieve more flexibility and usage.

7.2.6 Student modeling

The current DCM system uses very elementary modeling for students learning. It puts the student in a default category with regards to a certain course at first and the instructor updates the level of the student based on her assessment. We believe that the learning environment and the interactions within could be best modeled by employing the concepts of agent oriented

software engineering. The learning environment could be modeled as an adaptive, collaborative multi-agent system [18]. Application of multi-agent system modeling and development in the area of e-learning is still at its infancy. Much work could be done on in this direction as a further enhancement of the DCM system.

7.3 Conclusion

Most of the commercial e-learning systems of today have a lot of facilities, but lack a solid underlying pedagogical structure. This means that the major challenge for e-learning systems is to develop a pedagogical structure of the system and develop a more structured and sound modeling – not to develop further its technical functionality.

Development of the DCM system has demonstrated its underlying foundation and has matured enough to be put to initial use in the short time period since its staring. It is developed using state of the art technology and developed following the most advised development techniques. Thus, it is very open for extension and further development to incorporate more functionalities and refinement. Also, provision for its integration with content management systems (CMS) and information exchange with other systems gives some directions by which the DCM can be made more useful.

I believe that open, flexible and interactive web-based learning in the future best can be achieved by using different types of intelligent agents supporting the users in the learning process [17, 18]. In such systems an intelligent agent, representing the learning profile of the users, could model each user. User profile agents collaborate with other agents to get the best-adapted learning materiel for each student. This means that the learning process can be realized as collaboration between different agents and users, constructed as a multi-agent system

References

[1] http://lyon.chin.gc.ca/tael-pte/module1/m01t03p01_e.asp - date accessed 02.11.2007

[2] Kristensen, T. The "Gudmunstad" School Project. Proceedings of The Fourteenth International Conference on Technology and Education, vol 2, Oslo 1997.

[3] Kristensen, T. The "Gudmundstad" School Project. The Learning Highway. Editors Owen,T., Owstone,R. Key Porter Books, Toronto, Ontario, 1998.

[4] http://www.itsolutions.no

[5] http://moodle.org/

[6] James Robertson , Content reuse in practice , Step Two Designs Pty Ltd - September 2004

[7] Joseph D. Novak , Alberto J. Cañas: The Theory Underlying Concept Maps and How to Construct Them

[8] Raymund Sison, Masamichi Shimura, Student Modeling and Machine Learning International Journal of Artificial Intelligence in Education (1998), 9, 128-158

[9] Karen Stauffer, Student Modeling and Web-based Learning Systems , Athabasca University http://ccism.pc.athabascau.ca/html/students/stupage/Project/initsm.htm

[10] Joseph D. Novak , Alberto J. Cañas: The Theory Underlying Concept Maps and How to Construct Them

[11] Ivar Jacobson, Magnus Christerson, Patrik Jonsson, Gunnar Overgaard Object-Oriented Software Engineering: A Use Case Driven Approach (ACM Press) Addison-Wesley, 1992, ISBN 0201544350

[12] I. Jacobson, M. Ericsson, A. Jacobson, The Object Advantage: Business Process Reengineering With Object Technology (ACM Press), 1994, Addison-Wesley, ISBN 0201422891

[13] Bernd Bruegge. Object-Oriented Software Engineering: Conquering Complex and Changing Systems, Prentice Hall, 1999. ISBN 0-13-489725-0

[14] Bernd Bruegge, Allen H. Dutoit. Object-Oriented Software Engineering: Using UML, Patterns and Java, Pearson Education, 2004. ISBN 0-13-191179-1

[15] Ian Sommerville, Software Engineering ,7th Edition

[16] http://www.agilealliance.org/articles

[17] Shoham, Y.. An Overview of Agent-Oriented Programming. In Jeffrey M. Bradshaw, editor, Software Agents. AAAI Press and The MIT Press, 1997.

[18] Michael Wooldridge ,An Introduction to Multiagent Systems. Published in February 2002 by John Wiley & Sons, ISBN 0 47149691X.

[19] http://www.dotnetnuke.com/

[20] http://en.wikipedia.org/wiki/User_(computing)

[21] https://www.nish.org/Common/_NISH/help/UserGuide/portalexpress.htm#Control_user_

privileges.htm

[22] http://edocs.bea.com/workshop/docs81/doc/en/core/index.html

[23] http://docs.moodle.org/en/Quiz_module

[24] http://en.wikipedia.org/wiki/System_testing

[25]http://msdn2.microsoft.com/en-us/library/ms182613(VS.80).aspx

[26] http://en.wikipedia.org/wiki/Regression_testing

[27] http://en.wikipedia.org/wiki/Software_performance_testing

[28] http://en.wikipedia.org/wiki/Stress_testing