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Education

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1998 *Distributed Online Weighing System* Indonesia

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- Interfaced and networked weighing scales at a steel plant for online data acquisition

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Towards Standardisation of Distributed Open Learning Environments

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Abstract

The use of computer networks for educational purposes is now becoming common, creating what is called computer-based learning environments. However, there are still interoperability problems associated with these environments, limiting further growth in usage. One possible solution to these problems is standardisation of computer-based learning environments. This report presents the results of a project that aims to examine the role of standardisation in computer-based learning environments. The project proposes a high-level specification as a starting point for standardisation, using the Reference Model for Open Distributed Processing (RM-ODP) standard. This specification can be used as a reference architecture for further standards development. As a case study of current learning environments, Lotus LearningSpace was evaluated in more detail.

Keywords: computer-based learning environments, distributed open learning, standardisation, Lotus LearningSpace, RM-ODP.

Acknowledgments

This dissertation touches on the issue of life-long learning, which was already advocated some 14 centuries ago by The Prophet Muhammad (peace be upon him).

I would like to acknowledge the following people for helping me with this dissertation:

- Dr. Srba Cvetkovic, as my supervisor, for all the suggestions and encouragements.
- Dave Walter at CREDO, for guiding me through the ”black art” of Lotus Notes and LearningSpace.
- All my family, especially my mother and mother-in-law.

Sheffield, September 1997

To Dita and Aliya

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Declaration

All sentences or passages quoted in this thesis from other people's work have been specifically acknowledged by clear cross referencing to author, work, and page(s). I understand that failure to do this amounts to plagiarism and will be considered grounds for failure in this thesis and the degree examination as a whole.

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Chapter 1

Introduction

1.1 Background

Since the early 1970s, computer networks have been used in educational activities for course delivery (Harasim et. al., 1995). Later, the same networks were used to facilitate collaboration of learners. This type of application is commonly called computer-based learning environments. As computer networks grow, previously inaccessible learners, such as full-time workers or geographically dispersed populations, can be accommodated.

These computer-based learning environments were proprietary, in the sense that components or modules of one system are not interoperable with other systems. This means that:

- Learners must deal with each environment separately, consequently adding learning and adaptation effort.
- Educators are tied to one environment, unable of using other educator's work, resulting in duplication of effort.
- Conflicts with the ultimate goal of establishing a truly universal learning environment, accessible by anyone, anywhere, and anytime (Harasim et. al., 1995).

One way of eliminating this problem is to establish standards, a common way to represent computer-based learning environments (Schoening & Wheeler, 1997). Specifically, the environments should be broken down into components, where each component's interface is standardised. This would allow components from separate environments to work with each other. For example, some education providers could specialise in course contents, while others would concentrate on learner management.

1.2 Project Objectives

Although currently there are no established standard for the representation of computer-based learning environments, several activities are going on to define such standards. This project[1] will examine the role of standardisation for computer-based learning environments. Specifically, this project will define the term *distributed open learning environments* (DOLE) to generalise the current trend for computer-based learning environments. The project will also propose a high-level specification framework for standardising DOLE. This framework will be based on the Reference Model of Open Distributed Processing (RM-ODP) standard, and provide a starting

[1] See section 6.2.3 for WWW site.

point for a reference architecture. A case study using Lotus LearningSpace as one example of current DOLE will also be done. This case study will provide an overview of current advances in the use of computer networks for education purposes. Also, the case study will give an indication of how Lotus LearningSpace conforms to the goal of standards-based computer-based learning environments.

1.3 Report Overview

First, the second chapter reviews various existing computer-based learning environments and standardisation activities for these environments. It will give the background for the definition of distributed open learning and discusses the impact of standardisation to learning environments. The third chapter will present a standards-based specification for distributed open learning environments. The fourth chapter presents the case study using Lotus LearningSpace. The case study selected for this project is a short course on network design. The fifth chapter presents the conclusions reached in this dissertation and suggestions for further work. The final chapter lists all the references used in this project.

Chapter 2

Distributed Open Learning Environments

The approach taken for this chapter is to first define the unifying term distributed open learning, to be used in further discussion. The requirements for distributed open learning environments will then be identified. A review of existing environments will reveal how well they meet those requirements. Scope and objectives of current standardisation activities will be examined. As a conclusion of this chapter, directions of DOLE standardisation will be discussed.

2.1 Distributed Open Learning

The process of learning in the context of education has been well defined. Traditionally, learning process was done at special places, such as classrooms or schools. Distance learning was introduced to extend the learning process outside these places. The main problem with distance learning was that it still has the same paradigm as traditional learning: instructor-centred. This paradigm has the view that learning is one-way, from the educator to the learner. In contrast, the newer concept of learner-centred paradigm advocates that the learner explores the knowledge on their own, and set their own pace. The educator only facilitates during the process. When combined with co-operative or collaborative learning, where the learner forms small teams, there are added benefits such as (Marjanovic, 1996):

- higher achievement,
- deeper levels of understanding,
- development of higher order thinking skills, and
- positive attitudes.

If distance learning is conducted with the learner-centred paradigm, the learning process can happen anytime and anywhere, giving rise to the concept of open learning. Although many papers such as (Marjanovic, 1996), (Chou & Sun, 1996), and (Abdel-Wahab, 1996) still use the term distance learning, we believe that this term carries too many classical connotations with it. Indeed, some distance learning institutions now call themselves providers of distributed learning, most probably to appear modern and forward-looking. However, the term distributed learning is also used in other context, such as (Lotus, 1996), who define it as a ”technology-enabled, learning-team based focused education, facilitated by a content expert, and delivered anytime and anywhere.”

Since there does not seem to be a consensus on the term used (Sener, 1997) and to avoid confusion, we will define a unifying term: *distributed open learning*. This will include collaborative learner-centred paradigms, anytime - anywhere delivery, and distance learning itself. It also our intention that distributed open learning includes other important concepts such as lifelong learning (Slonim, 1996), sometimes also called continuing education, and just-in-time learning (Schoening & Wheeler, 1997).

We will further define computer-based learning environments that support distributed open learning to be *distributed open learning environments* (DOLE). For a perspective on these environments, the requirements need to be identified first. There are two types of requirement: technology and socio-economic requirements.

2.1.1 Technology requirements

Papers such as (Lotus, 1996), (Abdel-Wahab, 1996), and (Slonim, 1996) has listed many technological requirements for distributed open learning environments. The common requirements listed are:

- Collaborative technologies, enabling interaction between the learners.
- Standards-based systems, with features like platform independence and interoperability between components.
- Multiple delivery mechanisms, or multimedia, allowing for materials to be data, audio, video, or some other formats.
- Universal access, the network reaching as many learners as possible. This means that it has to be geographically transparent and scalable.

2.1.2 Socio-economic requirements

Alongside technological requirements, (Slonim, 1996) and (Arvan, 1997) also identified social and economic requirements, such as ownership or copyrights, cost, security, and privacy. The issue of cost is also discussed in detail in (Garson, 1996) and (Turoff, 1997). There is also the issue of ”education standards”, the measure of quality of education in one institution as compared to another (Vroeijenstijn, 1994). These socio-economic requirements of distributed open learning are out of the scope of this project and will not be discussed further.

2.2 Models of Distributed Open Learning Environments

There are two basic model for DOLE:

- Synchronous, the learning process takes place as a synchronised activity, where the learners attend specific scheduled events.
- Asynchronous, the learners does not have specific scheduled meetings, although they still follow a general course schedule of deadlines and assignments.

The classification of DOLE outlined here is based on two layers. The lower layer is the underlying communication layer, called communication and networking infrastructure. The upper layer is the application, further divided into Internet-applications-based and groupware-based. Each layer may consist of the synchronous and/or asynchronous model.

The examples of DOLE reviewed here is only a representation of existing environments. For an exhaustive look at the use of computer networks for learning, see (Harasim et. al., 1995). Unfortunately, it is biased toward the more classical, proprietary networks, instead of the current trend of using open networks such as the Internet.

2.2.1 Communication and networking infrastructure

This section will review examples of work involving communication and networking infrastructure for distributed open learning. Most of the literature in this area actually has titles and objectives that claims to design a fully functional learning environment. On deeper inspection, only communications or networking aspects of the environments are considered or emphasised. Nevertheless, communication and networking infrastructure is an important part of distributed open learning.

Agent technology

Agent technology is currently being proposed for doing the routine works during collaborative processes, or even assisting learners. For example, Grammar Collaborative Intelligent Learning Environment (GRACILE), as described in (Ayala, 1996) is an ”environment where intelligent agents communicate and cooperate by exchanging messages and providing the learners with access to a larger body of knowledge, finding assistance possibilities and promoting the effective collaboration in the learning group.” Another example is Multi-Agent Processing Environment (MAPE) (Shi, 1996), which is designed for computer-supported co-operative work (CSCW), but is applicable to learning environments. Agent technology originates from the field of artificial intelligence, and its application in distributed open learning is still at an early stage.

Virtual classroom

In these section examples of systems that extends classroom using computer networks are reviewed. Interactive Remote Instruction (IRI) as described in (Abdel-Wahab, 1996a), and DooRae-EDUS (Park, 1996), aims to provide facilities for multimedia-supported interactions (video, audio, data sharing), presentation tools, surveys, evaluation, homework, multimedia note taking, recording and playback of classes. These environments are certainly useful, but usually require a local area network (LAN) with high data rate. This means they are not suitable for large scale (either in terms of number of learners or distance) distributed open learning. An exception is (Tzeng, 1996) who described a course delivery mechanism designed for public broadband networks. However, the mechanism only deals with multimedia materials, with limited interactivity and no collaboration involved.

Customized environments

The environments that are grouped into this category have more consideration of learning aspects, instead of concentrating solely on communication or networking technology. For example Learning Environment (LE) (Fretwell-Downing, 1996) is based on a repository of information, enabling learners to quickly locate and use course materials. However, LE does not support collaboration effectively. Environments such as Hyper-G (Skillicorn, 1996), and Co-operative Remotely Accessible Learning (CORAL) (Chou, 1996) provides hypermedia-based tutorial, with facilities for navigating, annotating and discussing the material collaboratively. CORAL also supports synchronous virtual classroom activities like audio and video conferencing, shared whiteboard, and chatting. Environments such as these may provide a starting point for generalised models of distributed open learning.

2.2.2 Internet Applications-based

The term Internet applications-based is used because the usual term Internet-based can be misleading. Customised environments as discussed in section 2.2.1, or groupware-based (see section 2.2.3) can (and most do) use the Internet as the underlying network fabric. When the literature says Internet-based they usually mean Internet applications such as World Wide Web (WWW), chat, electronic mail, Mbone, etc. The main underlying technology used is usually the WWW. These WWW-based learning environment seems to be current trend, as shown by the large numbers of current literature presenting it. The WWW is then either used on its own, for example (Dumont, 1996), or enhanced with other applications to improve collaboration, interactivity, and management. For the purpose of this project, we will focus on the latter type, as it is more closely related with the concept of distributed open learning.

Internet applications-based learning environment such as WebCT (Goldberg, 1997), Virtual-U (see *Virtual-U homepage* `<http://kochab.cs.sfu.ca:8000/>`), and Internet Learning Environment (ILE) (Lockledge, 1996) usually rely on scripts or programs that are run on the WWW server. Course materials are presented on WWW pages, and the environments provide support for discussion, either asynchronous (by posting messages to one or more ”conferences”) or synchronous (”chat”). Learners can access the environments by using any WWW browsers, and connecting via the Internet or campus network.

2.2.3 Groupware-based

A good definition of groupware is found in the classic paper (Ellis, 1991): ”computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment.” The literature on groupware concentrates mostly on using it to support business tasks such as office automation, meetings, and decision support systems. So there are less current research literature of using groupware to create a learning environment, compared to the WWW-based learning environments. It seems that the proponents of distributed open learning are touting WWW as ”the” solution. One notable exception is (Marjanovic, 1996), who advocates the use of groupware technology instead of WWW, arguing that ”groupware is designed to support interaction and collaborative problem solving” and ”offers rich media types, better security, object link maintenance, easier development of applications and full interactivity”. The issue of using either groupware or WWW will be elaborated more on section 2.2.4.

Currently it seems that the only example worth mentioning in this category is Lotus LearningSpace (Lotus, 1996), which is based on Lotus Notes, an established groupware product. The LearningSpace application is composed of interconnected modules, each of which is a Lotus Notes database:

- Schedule presents the instructional design and structure for the course as created by an instructor.
- MediaCenter, designed by the instructors, is the knowledge base that includes all course-related content as well as access to external sources.
- CourseRoom is an interactive environment in which students have discussions among themselves and with the instructor as well as collaborate on team tasks and assignments.
- Profiles module is a collection of student and instructor descriptions that includes contact information, photographs and information about education, experience, and interests.
- Assessment Manager is an evaluation tool for instructors to privately test and give feed-

back on participant performance.

Learners receive the Schedule, MediaCenter, CourseRoom and Profiles modules. Instructors and instructional designers receive these four modules plus the Assessment Manager module.

2.2.4 Combining groupware and WWW

The argument whether to use groupware or WWW for collaboration has surfaced many times, for example in (Borysowich, 1996) and (O'Connell, 1995), although usually not in the context of distributed open learning. However, some of the results of the comparisons are relevant, as it highlights the strength and weaknesses of each technology. One of the important issue is the support for occasionally-connected learner. Groupware technology usually supports some kind of replication technology, where clients can synchronise its database contents by connecting to the server. The synchronisation process is two way, where the client send its updates to the server and receives the server's updates. When the clients disconnect, they will have the same content as the server, so the learner can use it anywhere without being connected. However, to achieve this groupware usually uses their own proprietary software.

WWW-based environments require the learner to be well-connected. While it is possible to download the WWW documents, it is not the same as synchronisation. On the other hand, the fact that a learner only requires a WWW browser, now widely available on many platforms, to interface with WWW-based environments is appealing. So we believe that the question should not be whether to choose WWW or groupware, but rather how can we combine WWW and groupware.

2.2.5 Discussion

All the environments discussed meets most of the technology requirements stated on section 2.1.1, to a varying degree:

- The multimedia requirement was easily provided by all the environments, although integration may still be an issue. For example, multimedia in IRI or CORAL has a fully integrated interface with full navigational capabilities. In contrast, in WebCT it may mean downloading a video clip and using a separate player to view it.
- Collaborative technologies are also incorporated in many environments, either synchronous, asynchronous, or both.
- Universal access is can usually be translated to using the Internet as the communication network infrastructure.

However, one particular requirement that was not in the design of those environments is standards-based. Internet-applications-based environments, particularly WWW-based received more attention than other technology because it is seen as platform independent (browsers available on all platforms), and use a standard language (Hypertext Markup Language, HTML) for description of course material.

Unfortunately, this is where the standardisation stop. The WWW was originally designed only for information dissemination through distributed, hypertext-like documents. To add seamless multimedia capabilities to WWW pages, several approaches are now used, such as audio or video streaming, using Java language, or browser extensions. These approaches are not standardised, and not as widely available as browsers.

Furthermore, to meet collaborative requirements, more non standard extensions are made to the WWW server, making course developed on one WWW-based environment not usable on other environment. So even starting with what looked as a universal platform does not guarantee standardisation.

2.3 Standardisation Activities

In order for DOLE to be widely used, and to eliminate interoperability problems, some organisations are sponsoring or conducting activities to define standards. The standards activities outlined here are technical or computer standards, not educational standards. Technical standards address issues mainly related to software systems, while educational standards address issues such as curriculum contents and quality of education (see section 2.1.2).

2.3.1 IEEE P1484

This group is sponsored by the Institute for Electrical and Electronics Engineers (IEEE) Computer Society Standards Activity Board, intending to develop a series of standards for computer-based learning (Schoening, 1997). It will try to develop standards, guidelines, and recommended practices for the area of computer-based learning, with the goal of enabling tools, courseware, information, and services to be provided on a component basis. P1484 currently has nine working and study groups, with more groups expected:

- Reference Model/Architecture: Defining a framework to describe learning systems.
- Learner Model: Accommodate different views of the Learner Model.
- Glossary: Defining all terms in the area of computer-based learning
- Task Model: Specify syntax and semantics of all static aspects of a project.
- Learning Agreement: Specify the concepts to create a valid agreement between any learner and any institution of learning.
- Session Management Language: Defining a specification language's conceptual model, semantics, and syntax.
- Protocols for Tools/Agents: Address how existing tools can be made compliant with the standard, and ways of developing new tools that take advantage of the standard.
- Task Ontology: Specify types of problem-solving processes for intelligent-learning systems.
- Authoring Tools: Address guidelines for computer systems that let nonprogrammers build personal learning systems.

2.3.2 Reference Model for Open Distributed Processing (RM-ODP)

RM-ODP aims to achieve (Linington, 1995) and (ISO/IEC, 1995):

- portability of applications across heterogeneous platforms
- interworking between ODP systems, i.e. meaningful exchange of information and convenient use of functionality throughout the distributed system
- distribution transparency, that is hide the consequences of distribution from both the applications programmer and user

The reference model provides a "big picture" that organises the pieces of an ODP system into a coherent whole. It does not try to standardise the components of the system nor to unnecessarily influence the choice of technology. The RM-ODP standard is known as both ISO International Standard 10746 and ITU-T X.900 Series of Recommendations and will consist of four parts:

- Part 1: Overview and Guide to Use (ISO 10746-1/ITU-T X.901)
- Part 2: Descriptive Model (ISO 10746-2/ITU-T X.902)
- Part 3: Prescriptive Model (ISO 10746-3/ITU-T X.903)
- Part 4: Architectural Semantics (ISO 10746-4/ITU-T X.904)

Part 1 contains a motivational overview of ODP and explains the key concepts of the RM-ODP architecture. Part 2 gives precise definitions of the concepts required to specify distributed processing systems. Part 3 prescribes a framework of concepts, structures, rules, and functions required for open distributed processing. Part 4 describes how the modelling concepts of Part 2 can be represented in a number of formal description techniques.

Although originally designed for distributed processing systems, the RM-ODP standard is actually generic or abstract enough to describe any kind of application. This means that it may be possible to use RM-ODP to define a framework for DOLE. Using RM-ODP in such a way will eliminate the need to create another reference standard.

2.3.3 Open Integrated Learning System (OILS)

OILS (BESA, 1996) is a UK initiative, involving more than 30 companies and educationalists. It is a set of agreed rules governing the structure and operation of the underlying system of monitoring and recording, including methods for setting up workplans, gathering and assessing user responses and the format for storing data in disk files. See also *OILS Standard* `<http://www.besanet.org.uk/orgs/oils/>` for more information.

2.3.4 Computer Education Management Association (CEdMA)

CEdMA (see *CEdMA homepage* `<http://www.cedma.org/>`) is a US-based association for professional association for individuals who manage companies that produce computer-based education systems. CEdMA has an initiative titled Learning Architecture and Learning API Task Force. This initiative is a component-based approach for standardising computer-based learning environments, focusing on independent Learning Objects.

2.3.5 Instructional Management System (IMS)

IMS (see *IMS Project* `<http://www.imsproject.org/>`) is a project by the National Learning Infrastructure Initiative (NLII), which is in turn sponsored by Educom. Both NLII and Educom are US-based organisations. IMS will create standards that enable WWW-based instructional objects to interoperate, with common mechanisms for organisation and retrieval.

2.3.6 Aviation Industry CBT Committee (AICC)

This committee (see *AICC site* `<http://www.aicc.org/>`) has published guidelines and recommendation to enable the interoperability of computer-managed instruction (CMI) systems. This means that a given CMI system can manage computer-based tutorial (CBT) lessons from different origins. Also, a given CBT lesson can exchange data with different CMI systems.

2.3.7 Component-based software architectures

There is an effort by major software companies to produce component interoperability, such as ActiveX from Microsoft and Java from Sun Microsystems (Roschell, 1996). Currently these architectures are still focusing on language issues, and not yet considering higher-order application components. Work is also being done by the software engineering community to provide reusable software architectures (Meyer, 1997, chap. 4).

2.4 Impact on DOLE

2.4.1 Limited impact

The guidelines and recommendation of AICC are very basic and specific, and AICC only has influence on the aviation industry. Component software architecture is currently focusing on overcoming language and platform barriers, so they are still at a very low level of software systems. OILS have a very practical approach to standardisation, basically focusing on file formats, and expand from there. IMS has a wider scope, but still it only focuses on WWW-based environments. This means IMS is too technology-dependent and only affects a subset of DOLE. Nevertheless, all the activities mentioned here will be useful as an input to wider standards activities.

2.4.2 Medium impact

Both RM-ODP and CEdMA have a potentially large impact on DOLE. RM-ODP is an established international standard, specifically designed to accommodate instances of application domain frameworks. Currently no effort has been made to use RM-ODP to describe DOLE. CEdMA has a wider scope than IMS or OILS, and is on the right track to creating a framework for distributed open learning environments. Like OILS, CEdMA follows a practical and therefore limiting approach to standardisation. So RM-ODP and CEdMA are classified as having medium impact on DOLE.

2.4.3 Large impact

IEEE P1484 is probably the most ambitious activities, with an aim to create a standard for every imaginable aspect of computer-based learning. Backed by IEEE, widely known for its role on other technical standards, it has the chance to have the largest impact on distributed open learning, compared with other activities. However, it has been noted in the P1484 discussion groups that its effort originates from academic research and currently lacks support from the commercial world.

2.5 Directions for Standardisation

The standardisation of DOLE are driven from two directions: from the bottom-up and top-down. The bottom-up direction is standardisation of the communication and networking infrastructures. The top-down direction is standardisation of the software systems used for learning. Since one of the goal of DOLE is universal access, it is also important that both directions of standardisation considers scalability issues.

2.5.1 Bottom-up standardisation

The standards for computer networks are largely in place. Standards (both *de facto* and ratified international standards) for local area networks (LAN), metropolitan are networks (MAN), and wide area networks (WAN) exist. Protocols used on those networks, although numerous, has boiled down to one or two major protocol. One often cited example of an accessible and very large scale network is the Internet and its corresponding *de facto* protocol, TCP/IP[1]. Computer networks of the future will be faster (Asynchronous Transfer Mode, Gigabit Ethernet) and smarter (active networks). As the underlying infrastructure for DOLE, standards in this area are important.

Standards in communication activities such as synchronous audio and video conferencing are emerging (Ginsburg, 1996, chap. 2). Besides the usual international standards body such as International Standards Organisation (ISO) and International Telecommunication Union (ITU), other organisations such as Asynchronous Transfer Mode (ATM) Forum and Digital Audio Video Council (DAVIC) are also trying to achieve standards in this area.

Since most of the networking standards are established, a large commercial networking market is in place. There already numerous companies producing communication infrastructure for DOLE, in the form of conferencing systems, groupware, and hardware. This market is a powerful driving force towards better networking standards.

2.5.2 Top-down standardisation

Standards for software applications that drives DOLE is still lacking. As discussed in section 2.3.7, there is still no agreement on how to break a software into components, and make them interoperable. Terms like components, frameworks, and patterns are being used to describe research in this area (Johnson, 1997).

The main driving force in the top-down standardisation of DOLE is likely to be the academic research community, as shown by the ambitious goals of IEEE P1484 (described in section 2.3.1. Other areas such as research in intelligent tutoring systems (ITS) aims for ”smarter” DOLE. ITS aspects that needs to be standardised include learner models and task definitions.

[1]TCP/IP: Transmission Control Protocol and Internet Protocol

Chapter 3

Specification of Distributed Open Learning Environments

3.1 Standards-based specification

In order to develop standards for distributed open learning environments (DOLE), a specification is needed. This specification will function as a reference architecture, identifying necessary standards and their relationship to each other. This chapter presents a high-level specification of DOLE, and may be used as a starting point for a standardised reference architecture.

The specification described here will use language and concepts standardised in RM-ODP (described in section 2.3.2). We can use RM-ODP because DOLE are essentially distributed systems, and RM-ODP provides the necessary modelling and abstraction techniques for such systems. The advantage of using RM-ODP is that there is already significant amount of work and knowledge on distributed systems put into it. There is no sense in duplicating the effort to define another framework or specification technique. The resulting specification will also be *standards-based*, an important starting point toward standardisation of DOLE. The disadvantage is that because of its generic approach RM-ODP may not fit exactly for the purpose.

The specification describes a generic distributed open learning environment using two viewpoints: the *enterprise* and *information* viewpoint. This will give a high-level specification, and further refinement can be achieved by specifying the remaining three viewpoints: computational, engineering, and technology. The next section will provide a general description of a generic DOLE, which in RM-ODP language represents a *community*.

3.2 General Description

As discussed in section 2.1, distributed open learning environments (DOLE) enable one or more learners that are physically distributed to have access to learning materials. These learning materials are called courses. The environment will be operated by an education provider (EP). Courses will be provided to the education providers by specialised course authors. During and after the course, learners will be assessed by assessors, which may also be separate entities, such as national accreditation bodies.

Learners will be able to register at one or more education providers. Learners will also be able to interact with each other, and with the instructor. Furthermore the environment allows learner to be either directly connected to the education provider (online) or only occasionally connected

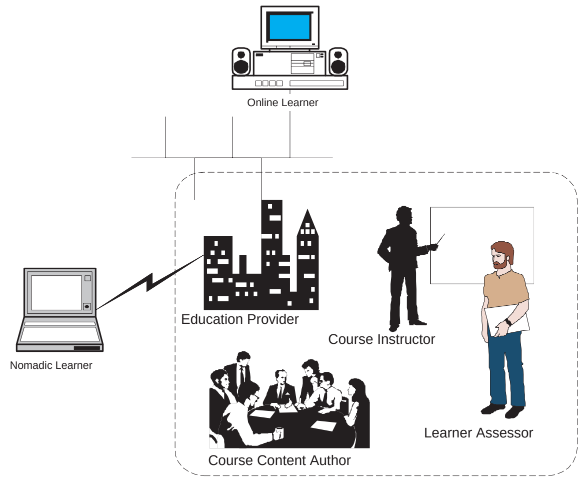

Figure 3.1: Distributed open learning environment

(nomadic). Learners that are connected can interact in real-time through multimedia services such as audio, text, and video. Learners that are occasionally connected can collaborate through asynchronous conferencing system.

Both type of learners have access to the same learning resources. For example, lectures by instructors are attended in real-time by online learners, and are also archived. This lecture archive can be accessed by nomadic learners when they connect to the environments. Discussion forums, both moderated and unmoderated are also available.

The environment will store learning material, schedule of courses, learner details, and learner progress. Archives of learner activities will also be available. All learner activities and progress are stored as *learner profiles*, which should be portable between education providers. This portability would be important in supporting the idea of continuing education throughout life. A learner profile consists of several parts:

- Private profile, contains personal data and private annotations. The learner can control access this part, and may choose to make some sections public.
- Public profile, contains publicly accessible learner information. This may be used as a kind of résumé or *curriculum vitae* (CV).
- Protected profile, contains course certificates attained by learners and learner's progress through the course. This part may only be modified by education providers. This is to avoid fraudulent certificates and progress reports. However, learners can control whether to make certificates visible in the public profile.

Thus, the learner profile may only be updated by either learners or EP. A typical DOLE is depicted in Figure 3.1.

3.3 Enterprise Specification

This section describes DOLE from the enterprise viewpoint. The issues addressed are identification of entities, called enterprise objects and their roles, and policies regarding all objects involved. From the general description, we can identify several objects. The enterprise objects and their overall relationship are shown in Figure 3.2. While generally each object may have several roles, for the purposes of this specification each object has only one role. We will now

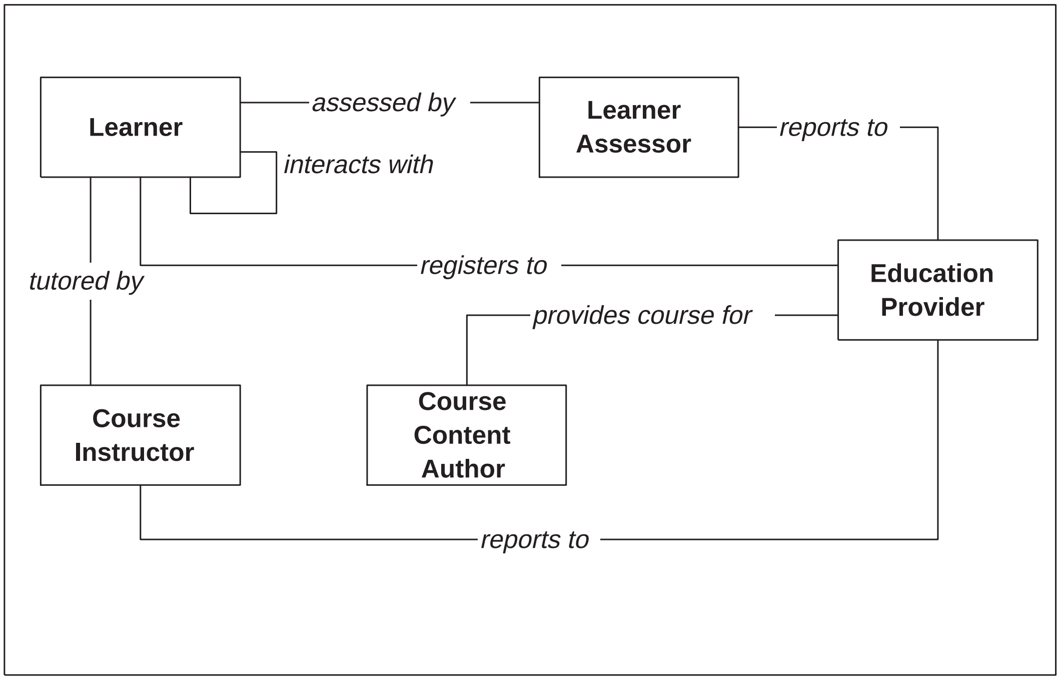

Figure 3.2: Enterprise specification

define each role individually, and present their specification.

3.3.1 Learner

Definition: Learners are divided further into:

- Online Learner: a person that is directly connected or present at the education provider.
- Nomadic Learner: a person that is only occasionally connected to the education provider.

This is one of the main role in DOLE. To start a course, learners need to register at an EP. It is also possible that learners are attending courses offered at several EPs at the same time. After registering, learners are allowed to attend courses. After the course finishes, learners may receive certification from the EP, based on assessment results. This certification will be recorded in the protected part of their learning profile. The specification for the learner role is summarised on Table 3.1.

3.3.2 Course Instructor

Definition: A person or group that delivers the course to the learner, and facilitates the learning process.

Facilitating means that course instructors are not only teacher or lecturers, but may also become moderators, tutors, and counselors. The specification for the course instructor role is summarised on Table 3.2.

3.3.3 Course Content Author

Definition: A person or group that writes and develops the course contents.

Course content authors are usually specialists in their field. After providing the initial course to the EP, they must keep the course up to date. This means that authors may access their courses

Obligations
Must be registered on one or more course at one or more EPs.
Provide the EP with previous learning profiles, if available.

Permissions
Interact with course instructors.
Accessing one or more courses that they are registered on.
Access public section of their own learning profile.
Access and modify private section of their own learning profile.

Prohibitions
Cannot modify protected section of their own learning profile.

Table 3.1: Learner Role Specification

Obligations
Facilitates learning by interacting and providing guidance for learners.
Reports course progress to EP.

Permissions
Access and manage discussion forums.

Table 3.2: Course Instructor Role Specification

in DOLE. The specification for the course content author role is summarised on Table 3.3.

3.3.4 Learner Assessor

Definition: A person or group that assess the learners.

The assessment process is an important part of learning. Assessment results will determine the progress of learners. The assessor is responsible for providing EP with assessment materials. The assessor will also be responsible for conducting or supervising the assessment process. The specification for the learner assessor role is summarised on Table 3.4.

3.3.5 Education Provider (EP)

Definition: An organisation that manages one or more courses and enrols learners.

Obligations
Provide course material to EP.
Update course material as needed.

Permissions
Access and update courses authored.

Table 3.3: Course Content Author Role Specification

Obligations
Provide assessment materials to EP.
Evaluate progress of learners at one or more EP.

Permissions
Access assesment results at one or more EP.

Table 3.4: Learner Assessor Role Specification

Obligations
Provide course content to registered learners.
Issue course certificates to registered learners.

Permissions
Acesss previous learning profiles of registered learners.
Add course certificates to protected part of learner profile.

Table 3.5: Education Provider Role Specification

Essentially this organisation will operate the distributed learning environment. Course instructors, content authors, and learner assessors are responsible to the EP. The EP may issue course certificates for qualified learners at the end of a course. The specification for the education provider role is summarised on Table 3.5.

3.3.6 Discussion on Enterprise Specification

The enterprise specification outlined above deliberately omit at least one aspect: financial issues, such as course fees or salaries for course instructor. This was done to avoid cluttering the high-level view of DOLE unnecessarily. Financial issues can easily be added from the computational viewpoint. For the purposes of this enterprise specification, financial issues are implicitly assumed in the behaviour of each object. For example, fees for learners (if any) are part of the course registration. For course instructors, as part of reporting progress of courses.

3.4 Information Specification

This specification examines DOLE from the information viewpoint. It contains information schemas that specify what should be stored in DOLE, and the relationship between them.

The information schemas can be divided into several categories, according to events in the learning process:

1. Pre-learning session, when the learner first registers to an education provider.
2. Learning session, when the learner is attending a course.
3. Post-learning session, when the learner finishes a course.

On the following sections, we will outline the information schemas, using a notation summarised in Figure 3.3. The information entity represents something stored, and the relationship entity is usually built by combining informations from several entities. From now on, we will refer to information entities simply as entities.

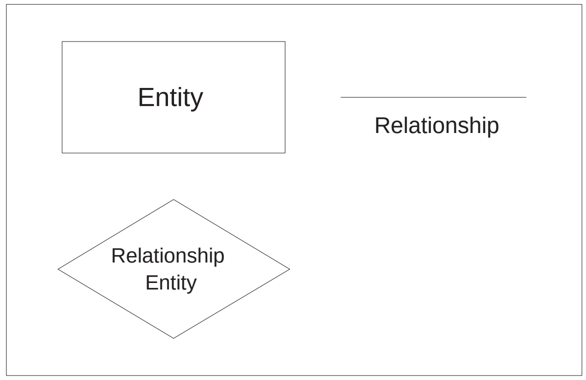

Figure 3.3: Information schema notation

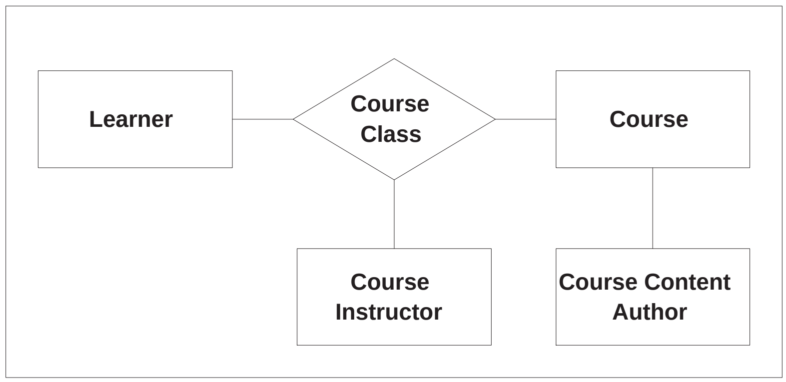

Figure 3.4: Pre-learning session schema

3.4.1 Pre-learning session

At this stage, the main issue is registering learners to courses. This will result in course participants, and together with assigned course instructors, constitutes a course class. Registering learners also means constructing the learner master data, gathered from learner's personal information (name, address, etc.). The schema is presented on Figure 3.4. The Learner, Course, and Course Instructor entities builds a Course Class relationship entity. Since the Course entity is also provided by a Course Content Author entity, the schema also shows a relationship between the two entities.

3.4.2 Learning session

During the learning session the most important information will be the learner's progress. This progress is measured against the course plan. It also includes forum participation and interim assessments. The learning session schema is presented on Figure 3.5. The learner's progress is represented as a Learning Profile entity (discussed in section 3.2), and is built by the Course Plan, Interim Assessments, and Learner entities. The Discussion Forum entity stores information about all the discussion forums available. When combined with the Learner entity, it can build the Forum Participation relationship entity.

3.4.3 Post-learning session

After completing a course, a final assessment will be done, to determine the level of proficiency of learners. Assessment can also be done during the course as interim assessments (see section

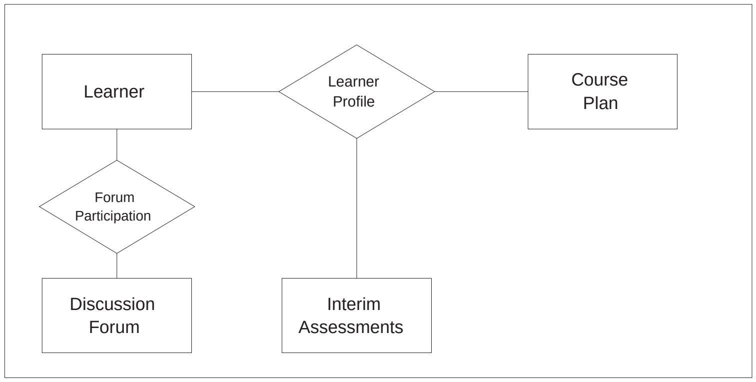

Figure 3.5: Learning session schema

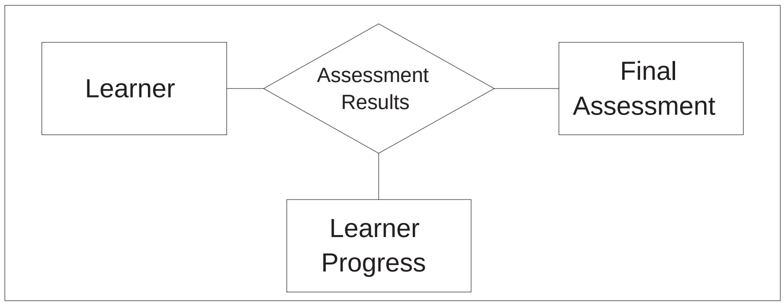

Figure 3.6: Post-learning session schema

3.4.2). The assessment results are the main information at this stage. The schema is presented on Figure 3.6. The Assessment Results entity are built by the Learner, Final Assessment, and Learner Profile entity. The information from Learner Profile used is the learner progress.

3.5 Discussion

3.5.1 Consistency of viewpoints

One of the requirements of the RM-ODP standard is that viewpoints are consistent with each other. This is done by defining relations between key terms in each viewpoint. For the DOLE specification, the enterprise viewpoint needs to be consistent with the information viewpoint. This consistency is demonstrated in Figure 3.7. The enterprise viewpoint is represented by the Enterprise Specification (ES), and the information viewpoint is represented by the Information Specification (IS). The ES was described in section 3.3 and the IS in section 3.4. Each enterprise objects in the ES has a relationship with one or more information entities in the IS. For example, the Course Content Author object in the ES builds and maintain the Course Content Author, Course Plan, and Course entities in the IS.

3.5.2 Suitability of RM-ODP

During the development of the enterprise and information specification described above, it became clear that the concepts and language in the RM-ODP standard are quite rich and powerful. The standard tries to be ”everything to everyone”, so extracting the relevant information was not straightforward, and can be distracting. However, the richness of the standard certainly can be used to specify DOLE in a detailed manner. This detailed specification can assist the standardisation efforts on DOLE.

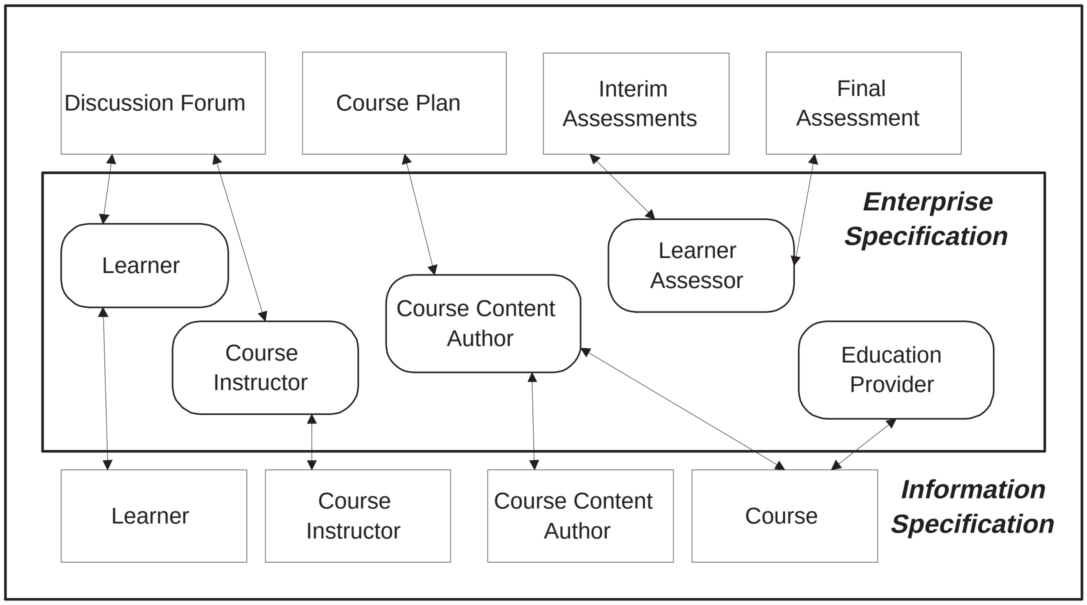

Figure 3.7: Viewpoint consistency

3.5.3 Completeness

As it is, this particular specification of DOLE is not complete. It only provides a high-level view of DOLE. However, we can already see some reference points that needs to be standardised:

- Communication between enterprise objects
- Access interfaces for objects in the information specification

To use the specification, further work will need to be done on developing the remaining three viewpoints. The primary tasks that needs to be done on each viewpoint are:

- **Computational viewpoint**: Define further the decomposition of DOLE, and the distribution of components.
- **Engineering viewpoint**: Define how the objects interact with each other.
- **Technology viewpoint**: Specify the implementation of DOLE, using available hardware and software technology.

Chapter 4

Case Study: Networks Design Course

4.1 Objectives of the case study

In this chapter, we will go through the process of designing a course for distributed open learning. This design will not be too detailed, only enough to allow implementation using Lotus LearningSpace, an example of groupware-based DOLE (see section 2.2.3 and 2.2.4). By implementing this prototype course, an evaluation of Lotus LearningSpace can be conducted.

Since the main purpose of this project is examining DOLE, the evaluation will be limited to Lotus LearningSpace. The course itself will not be evaluated in depth, as it was not complete and never delivered to real learners. However, we believe the process of designing a distributed open learning course is important to standardisation efforts, so it will be done methodically.

4.2 Course Description

4.2.1 Summary

This advanced course is intended provide guidelines and methodology in designing computer networks, specifically local area networks (LAN). As no single network will fit all purpose, the course will be based on case studies, and aim at maintainable network designs. The learners will be expected to work in teams. Each team will consist of several roles such as hardware engineer, protocol specialist, application analyst, etc., played by the learner. The target learner for this course is assumed to be familiar with the basics of computer networks and internetworking. The duration of the course is three days when done full-time and two weeks when done part-time.

4.2.2 Aims

The aims of this course are:

- to examine various scenarios where a computer network is needed; and
- to understand design principles and guidelines for computer networks.

4.2.3 Objectives

By the end of this course, the learner should:

- be able to design a maintainable LAN for a specific scenario; and
- be able to produce the necessary specification and documentation.

4.2.4 Course Outline

The content of the course is adapted from (Charles, 1997) and (Smythe, 1995, chap. 15). In developing it we use a hypertext instructional design methodology from (Mengel & Adams, 1996). It is particularly appropriate for this course since it will be implemented in Lotus LearningSpace as a hypermedia document. Indeed, as most DOLE are based on hypermedia documents, it would seem that choosing a common methodology when designing courses is an important step towards standardisation of DOLE. The steps of the methodology are as follows:

1. State the thesis of the course in a single sentence.
2. Expand the sentence into a high level paragraph.
3. Identify key concepts.
4. Identify key relationships between key concepts and the paragraph theme.
5. Review and revise.
6. For each new concept, repeat steps 1-5 as needed.
7. Encapsulate related concepts in a single-object module.
8. Implement text links in hypertext.

4.3 Requirements stage

At this stage we focus on determining the scope of the course.

4.3.1 Thesis sentence of the network design course

Following these steps, we first state the thesis sentence of the network design course:

> Network design is the process of designing and implementing LANs using components that provides the users with the necessary level of service and high maintainability.

The corresponding expanded paragraph of the above statement is:

> Network design is the process of designing and implementing LANs using components that provides the users with the necessary level of service and high maintainability. *LAN components* are chosen based on evaluating their specification against the required criterias. *Providing service* means the users are getting what they need. *High maintainability* can be achieved by specifying and documenting the LAN.

From the expanded paragrah we can extract the key concepts:

- Concept 1: Choosing LAN components — evaluate;
- Concept 2: Providing necessary level of service — analyse;
- Concept 3: Specifying and documenting — document;

For each of these concepts, we will repeat steps 1-5.

4.3.2 Concept 1: Choosing LAN components

The thesis sentence for the concept of choosing LAN components is:

> Choosing LAN components is the process of assessing and evaluating commercial-off-the-shelf (COTS) products.

The corresponding expanded paragraph of the above statement is:

> Choosing LAN components is the process of assessing and evaluating commercial-off-the-shelf (COTS) products. The LAN components that needs to be evaluated include:
>
> - Cable plant
> - Intelligent hubs
> - Network operating systems and servers
> - Network interface cards
> - Printing
> - Messaging and office automation
> - Domain-specific applications
> - Network administration and management tools

From the above paragraph we extract the eight component categories listed, and make each category a separate topic. As the topics are specific enough, we do not need to decompose further.

4.3.3 Concept 2: Providing necessary level of service

The thesis sentence for the concept of providing necessary level of service is:

> To provide the level of service required, a requirements analysis needs to be done. This involves gathering from the user three kinds of requirements: functional, operational, and performance requirements.

The corresponding expanded paragraph of the above statement is:

> A requirements analysis involves gathering from the user three kinds of requirements: functional, operational, and performance requirements. *Gathering functional requirements* means finding out the set of LAN functions needed to support user activities. This consists of physical (such as cabling) and logical (such as office automation) functions. *Gathering operational requirements* means finding out how to operate the network. This includes management, security, and recovery aspects. *Gathering performance requirements* means finding out the operating parameters needed from the LAN. For example, parameters such as throughput, number of users, and expected data storage must be determined.

The key concepts extracted from the above paragraph are:

- Gathering functional requirements
- Gathering operational requirements
- Gathering performace requirements

Since these topics are specific enough, we will not decompose them further.

4.3.4 Concept 3: Specifying and documenting

The thesis sentence for the concept of specifying and documenting is:

> Documenting the design and implementation process is an essential step towards high maintainability.

The corresponding expanded paragraph of the above statement is:

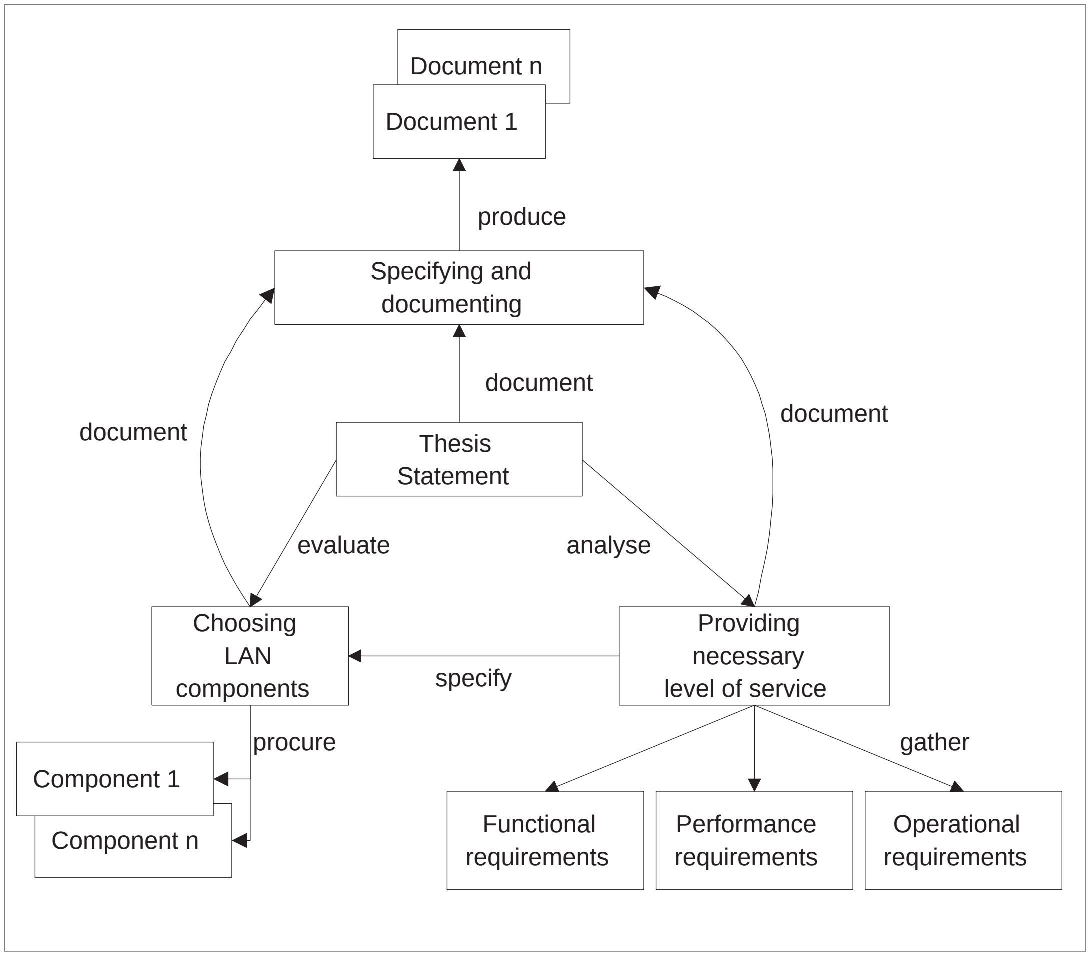

Figure 4.1: OOTD graph for the networks design course

Documenting the design and implementation process covers creating, refining, and formalising the following deliverables:

1. Configuration management plan
2. Quality assurance and test plan
3. Training plan
4. LAN transition plan
5. System operations and configuration manual
6. User's manual

The concept of producing the above deliverables are specific enough, and need not be decomposed further.

4.3.5 Concept linking

All of the above concepts can now be linked together, as shown in Figure 4.1. This diagram is called an object-oriented text decomposition (OOTD) graph. The OOTD graph will be refined further in the next stage, the specifications stage.

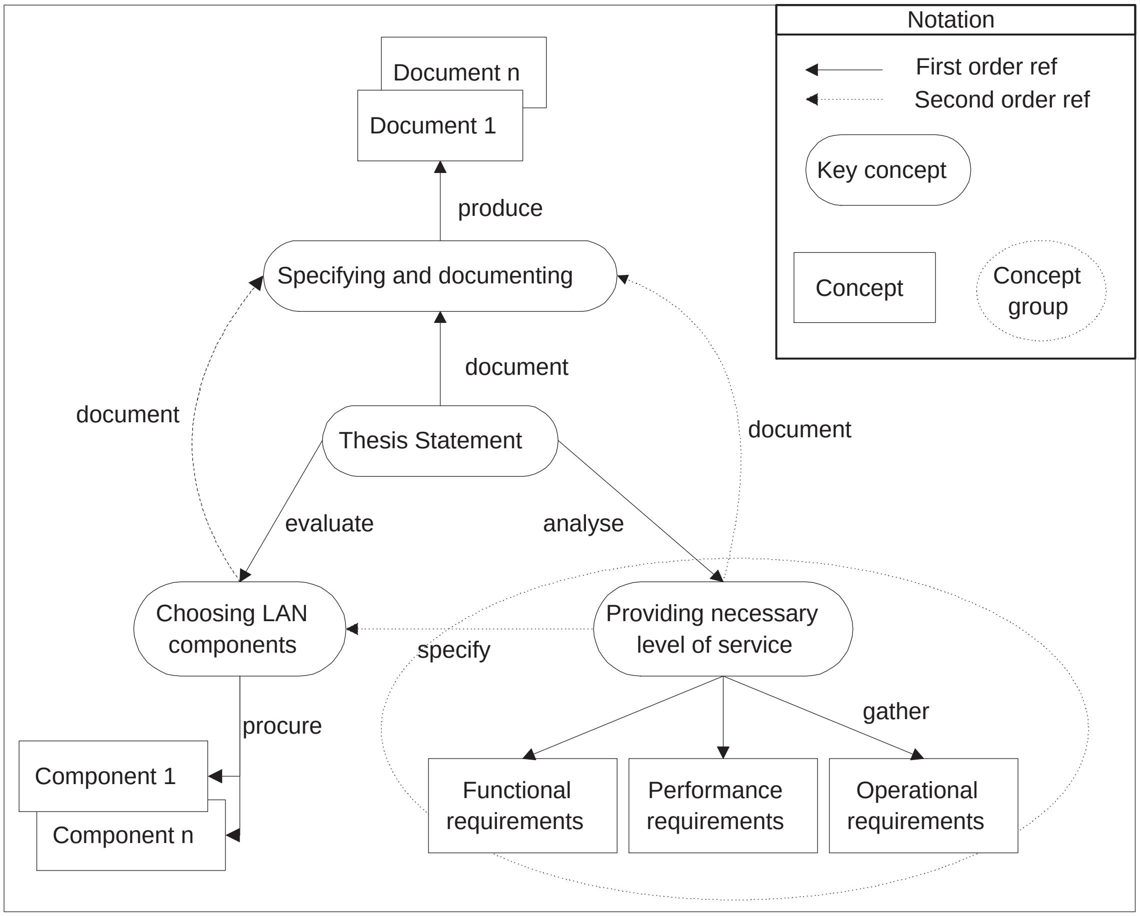

Figure 4.2: Concept map for the networks design course

4.4 Specifications stage

In this stage, the OOTD graph will be refined to make it suitable for hypertext format. The steps in this stage are:

1. Classify links in the graph as first-order or second-order. First-order links are the path which a learner must follow in order to understand the course. Second-order links are there to connect related concepts, and assist the learner during the course.
2. Identify key concepts.
3. Concepts are grouped together according to their instructional theme. This grouping structures related concept close together, resulting in continuity to the learner.

Figure 4.2 shows the results of the refinement steps above. There is one concept grouping, for the requirements gathering concept. The three concept from the first decomposition are identified as key concepts, and their links from the main concept are first-order links. This map may be refined further with additional notes to allow for instructional and administrative issues or used as it is.

4.5 Collaborative Activities

The hypertext instructional design methodology used above covers designing course materials from scratch, and resulted in graphs suitable for implementation in DOLE. However, the methodology does not cover designing collaborative activities, one important requirement for

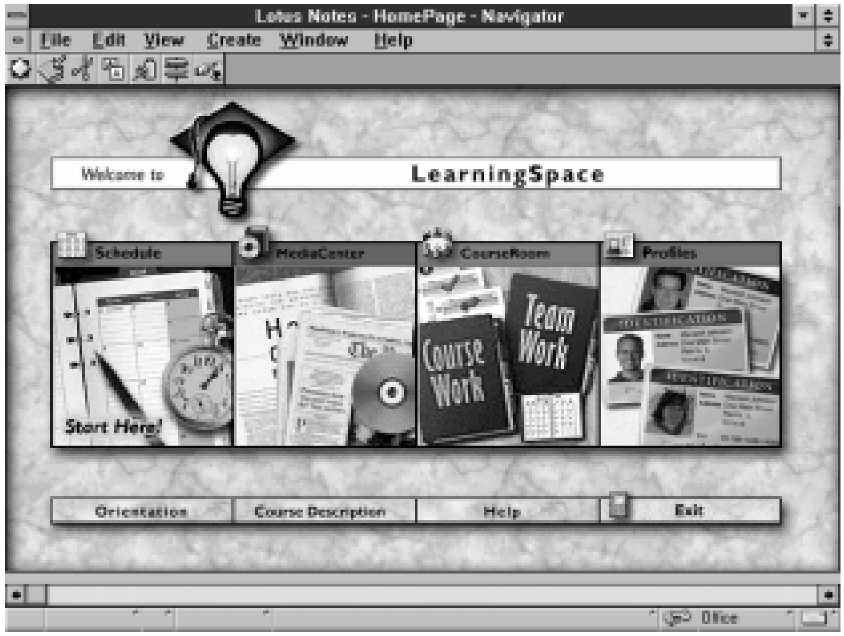

Figure 4.3: LearningSpace main navigation screen

DOLE.

For the networks design course learners will work in teams. Each team will be given a scenario, and will be required to deliver a complete networks design specification at the end of the course. Collaboration among members of a team is important, because the required design specification will be too large for a single learner or even several uncoordinated learners.

4.6 Implementation in Lotus LearningSpace

The course described above was implemented in a beta version of Lotus LearningSpace. The features are similar with release 1.0. Currently Lotus is already shipping release 2.0. This release has additional features, most notably allowing WWW access for learners. With the version used in this case study, all interaction with Lotus LearningSpace is still done through Lotus Notes Client software, a proprietary product.

Implementing a distributed open learning course in Lotus LearningSpace involves setting up at least the four main modules: Schedule, CourseRoom, MediaCenter, and Profiles. If required, the Assessment module may also need setting up. The main navigation screen of Lotus LearningSpace is shown in Figure 4.3. This screen is actually part of the Schedule module, and is the entry point for learners. To illustrate the implementation of the networks design course, we will look at the process from several point of views:

- Course Content Author
- Course Instructor
- Learner Assessor
- Learner

These point of views corresponds to some of the roles in DOLE we specified earlier in section 3.3. For each role, we will look at how they used Lotus LearningSpace to implement the course. The description below is a typical path for configuring Lotus LearningSpace.

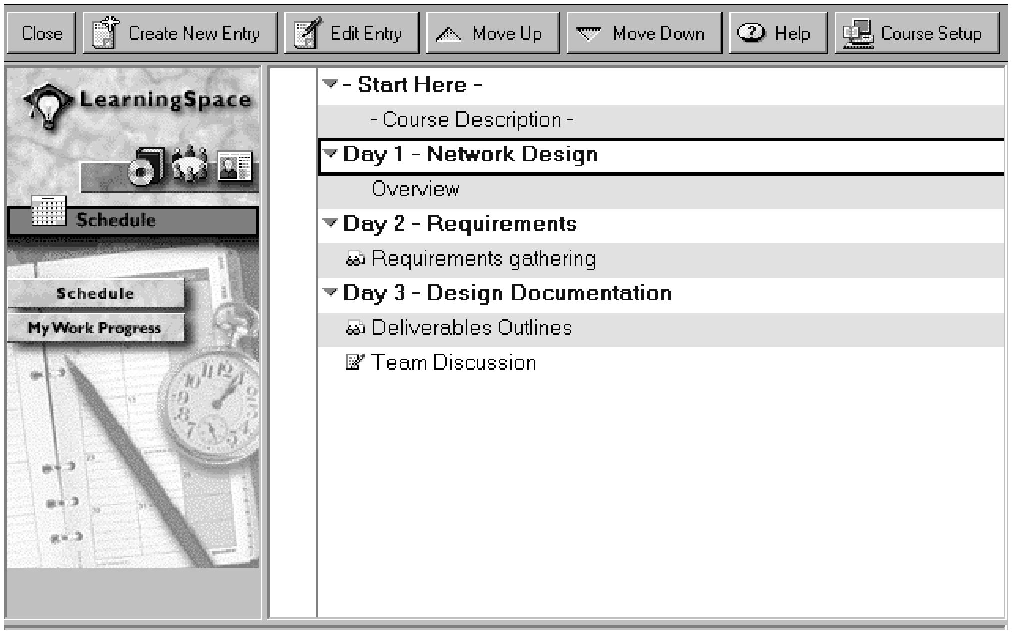

Figure 4.4: Schedule module

4.6.1 Course Content Author

The course content author will play one of the most important role in setting up the course. The content author will decide how to structure the course, provide all initial learning materials, and also decide how to structure the course delivery. This means the main task of a content author is setting up Schedule, CourseRoom, and MediaCenter.

Schedule

The first thing to do is setting up the Schedule module (Figure 4.4), as this module is the controlling module of other modules. It is also the starting point for learners. The steps outlined below will shows a typical path of setting up Schedule:

1. Course setup. This involves naming the course, giving a description, and setting the paths to the other modules as shown in Figure 4.5. The course can be organised in several ways, such as per unit or per day. The networks design course is organised as consisting of several days.
2. Adding schedule entries. Schedule entries are in divisions as specified in the course setup (units, days, etc.). Entries are added using a form shown in Figure 4.6. A schedule entry can contain links to CourseRoom or MediaCenter.

CourseRoom

The CourseRoom is setup by creating initial discussion forums. Discussion forums can be designated as a global forum for every learner or specific for each learner team. The forums will be used by course intructors and learners to interact with each other. Figure 4.7 shows a forum setup for one team's discussion in the networks design course. This forum may be used for the team's to collaborate on creating the design deliverables. A forum may also be an assignment from the Schedule. For example, the entry `Team Discussion` in Figure 4.4 will take the learner to the `Documentation` forum in CourseRoom (Figure 4.7).

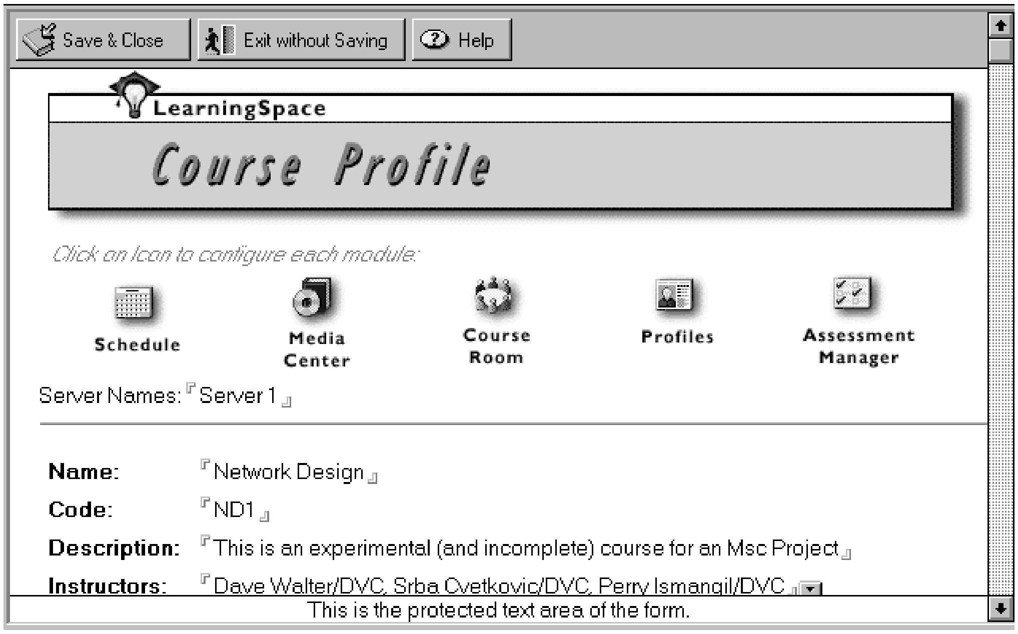

Figure 4.5: Course setup

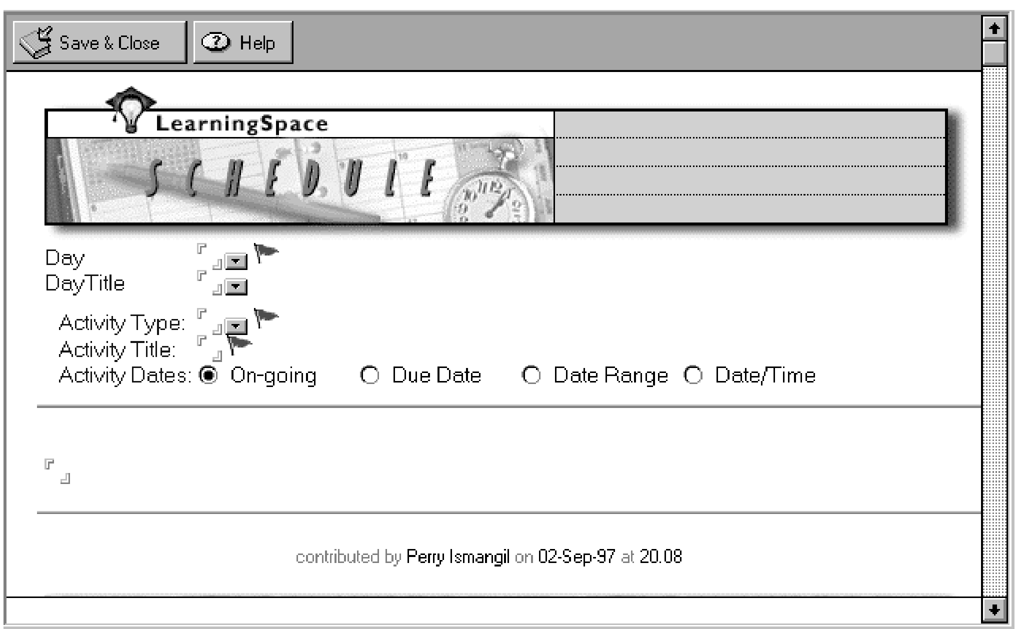

Figure 4.6: New schedule entry

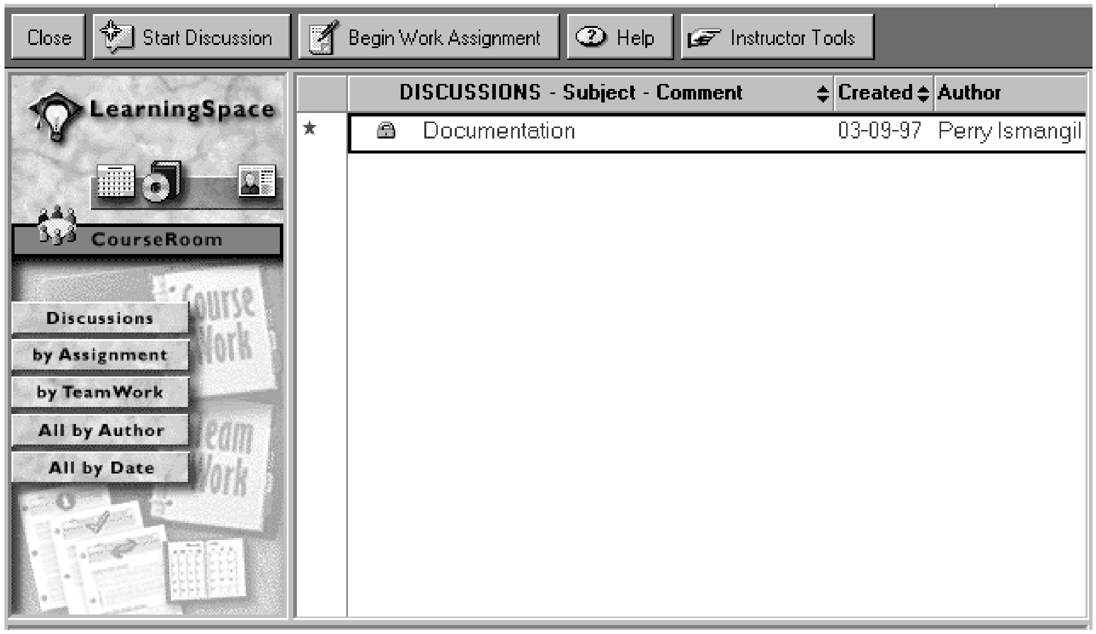

Figure 4.7: CourseRoom module

MediaCenter

Since this module is the repository for all information relevant to the course, the main learning material is stored here. The author create entries in this module that corresponds to material that learners must access and comprehend (Figure 4.9). Each entry is a hypermedia document that allows text, pictures, and other data to be integrated, either directly embedded or as links. The learner usually accesses the MediaCenter documents through a Schedule entry. So the `Overview` entry in Schedule (Figure 4.4) will take the learner to the `Network Design Overview` document in MediaCenter.

4.6.2 Course Instructor

Course instructors will setup the Profiles module (Figure 4.10) to include all participants and mainly use the CourseRoom (Figure 4.7) to interact with learners.

Profiles

Course instructors creates entries in this module for all learners in the course (Figure 4.11). This in effect enrols the learner to the course. Learner teams are also created here. The course instructor creates as many teams as needed, and assigns enrolled learners to each team.

CourseRoom

Course instructors can monitor and facilitate discussions on this module. They can also create new discussion forums as needed.

4.6.3 Learner Assessor

The learner assessor will be responsible for setting up the Assessment module (Figure 4.12). Assessments can be a quiz, survey, exam, or self-assessments (Figure 4.13). Assessments are usually listed as Schedule entries, and once marked as done, the learner will not be able to

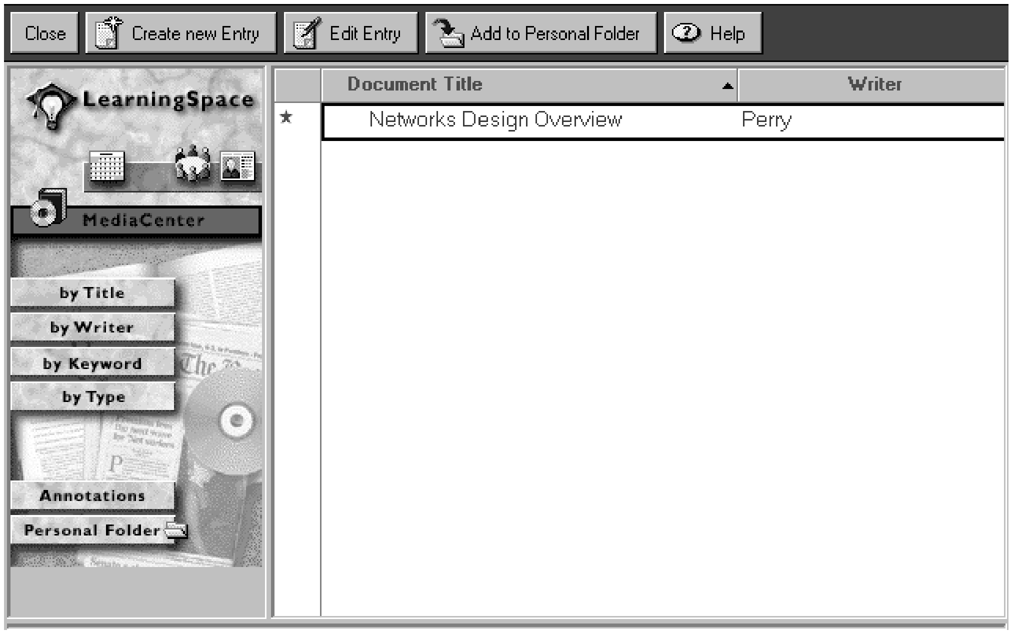

Figure 4.8: MediaCenter module

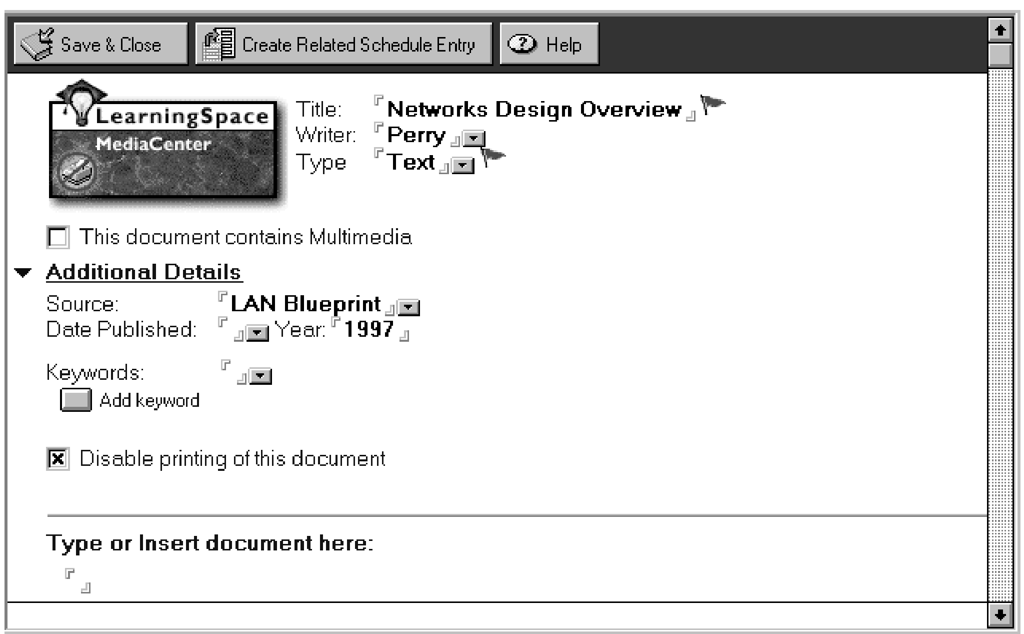

Figure 4.9: New MediaCenter entry

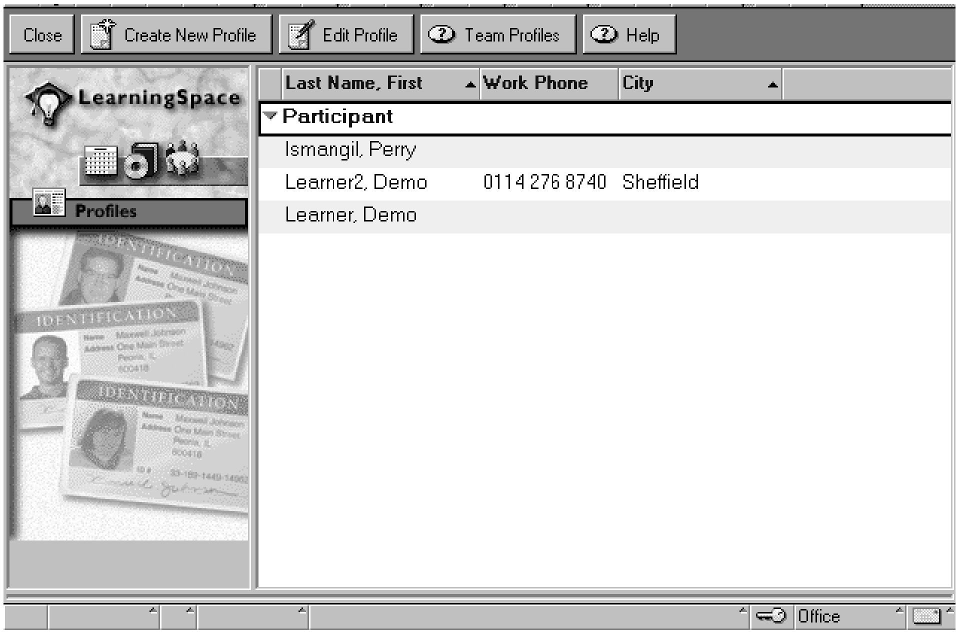

Figure 4.10: Profiles module

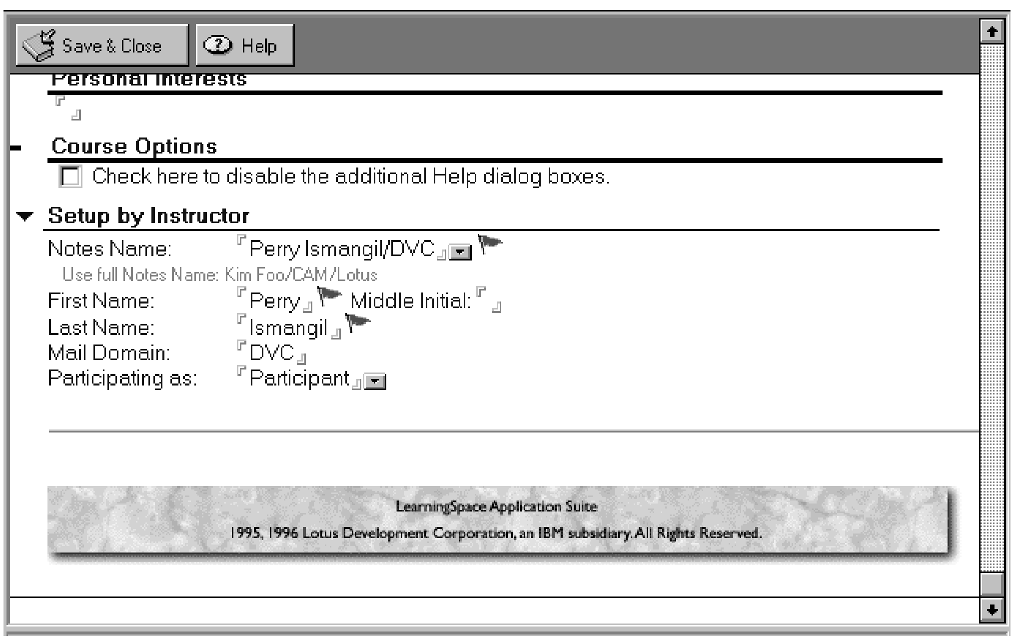

Figure 4.11: New Profiles entry

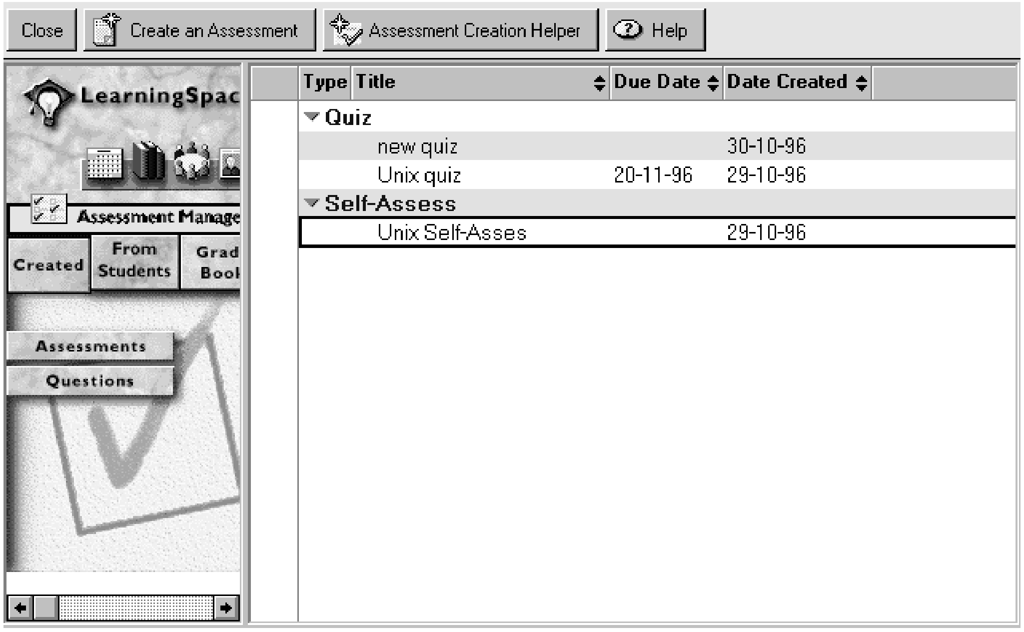

Figure 4.12: Assessment module

change it.

4.6.4 Learner

Learners will start at the Schedule module, and can see the outline according to the division chosen by the content author. All assignments are listed here, and will take learners to the appropriate module. For example, there may be a MediaCenter assignment, to write a design deliverable document. Also, any assessments will be listed here. So the Schedule module is the central area for learners.

Learners or learner teams may also setup their own discussion forum in the CourseRoom module. Depending on the setup of the course, these learner-created forums may be made private to the individual learner or team.

4.7 Evaluation of Lotus LearningSpace

The process of implementing the course as described in section 4.6 forms the basis of this evaluation. This means it is rather limited, because issues such as managing learners, scalability, and learner participation could not be evaluated. The evaluation will also be limited to the usage of Lotus LearningSpace, not the installation of LearningSpace software itself. It is assumed that LearningSpace is already installed, and ready to accessed and configured.

Evaluation was done on a PC running Microsoft Windows 3.1, equipped with an Intel 486DX-100 processor, 8 MB of RAM, and about 25 MB of hard disk space left after installation of Lotus Notes Client software. Access to the Lotus Notes server where LearningSpace is installed is done via the Internet, using Trumpet Winsock TCP/IP stack through a 33.6 kbps modem.

4.7.1 Hardware and software requirements

The main software requirement to access LearningSpace is the installation of Lotus Notes Client, which in the 16-bit Microsoft Windows version needed at least 40 MB of hard disk

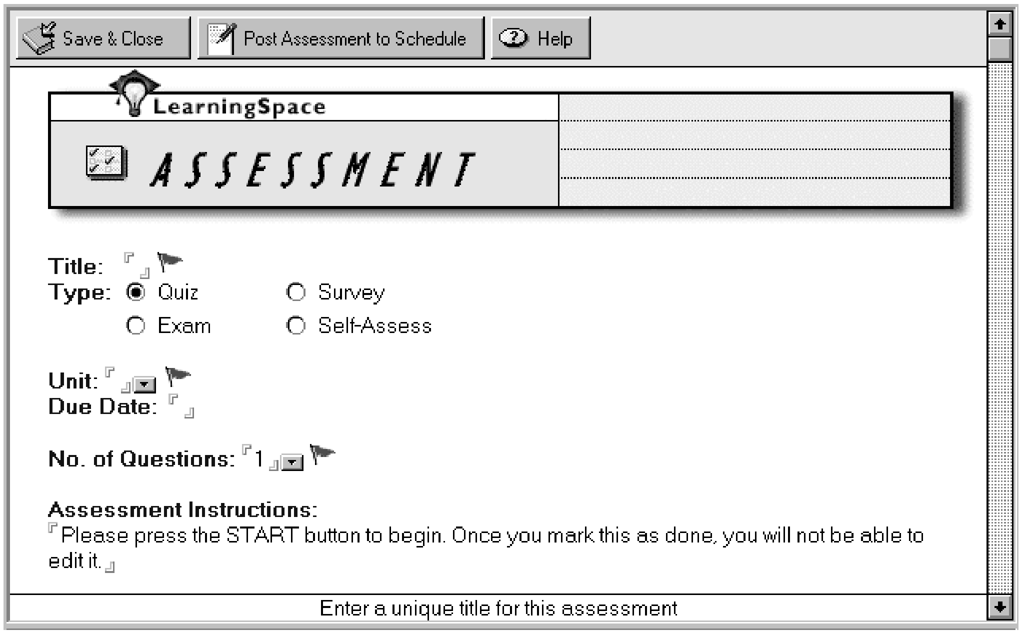

Figure 4.13: New Assessment entry

space for a typical installation. A full installation would need about 70 MB of hard disk space. The minimum memory requirement for this client software is about 8 MB of RAM. Even then, during the implementation of the networks design course, there are occasions when the client software complained of lack of memory. So a comfortable working environment would need at least 16 MB of RAM.

The Lotus Notes Client software is a proprietary product, and is intended to be a generic and powerful interface to Lotus Notes, the underlying groupware system. Although users of LearningSpace are helped by its own buttons (as shown in the screenshots), if the Client software is not set correctly, they may be faced with a bewildering workspace and array of menus.

Connection to a network is also essential, either directly on a LAN connected to the Lotus LearningSpace server or remotely through remote networks such as the Internet. The case study was implemented using the latter method. As connection was done through an ordinary telephone line, achieving at most 33.6 kbps (more often less than that), interaction with LearningSpace was a slow process. A click on a button can take as much as 10 seconds for LearningSpace to react. This can be minimised by replicating the LearningSpace modules to the local hard disk, which is explained in section 4.7.2.

4.7.2 Groupware facilities

Since Lotus LearningSpace uses Lotus Notes (an established groupware platform), it has excellent support for replication and asynchronous collaboration.

Replication

Replication is the differentiating feature with other model of DOLE, especially WWW-based ones. Nomadic learner can connect once to replicate the modules. After that the replication facility will only synchronise the changes. This greatly minimises connection time, and in turn minimises cost to learners. However, it should be noted that the five LearningSpace modules are large, averaging 2 MB each. Accessing LearningSpace through the Internet, using standard dial-up facilities, it took almost an hour to complete the initial replication.

Asynchronous collaborative activities

Facilities for managing and participating in discussion forums are excellent. Together with the replication facility, nomadic learners can participate in discussion forums off-line and synchronise when connected.

4.7.3 WWW facilities

For better access, it is desirable to combine WWW with groupware (as discussed in section 2.2.4). This is not available in the version used in this project. However, the current release allows learners to access Lotus LearningSpace using an ordinary WWW browsers. Course instructors and contetn authors still have to use the proprietary Lotus Notes client software.

4.7.4 Conformance to standards

Strictly speaking, as there are no standards yet, we could not say precisely whether Lotus LearningSpace conforms to any DOLE standards. However, as discussed in chapter 2 and 3, emerging trends, requirements, and a high-level specification of DOLE can already be identified. For instance, a missing feature from Lotus LearningSpace is synchronous communication facilities, such as video conferencing or application sharing. Although successful distributed open learning can be done using only asynchronous communication facilities, this feature is desirable for a comprehensive DOLE, particularly for supporting online learners. To its credit, Lotus LearningSpace supports many features that are identified as necessary for DOLE, such as multimedia, asynchronous communication, and learner information. These features will contribute towards conformance to future standards.

Chapter 5

Conclusions

From the discussion in the preceding chapters, we can draw several conclusions:

- Proprietary distributed open learning environments (DOLE) limits their usage and may results in duplication of efforts. This is because education providers are tied to a specific environment and cannot directly use learning materials created on another environment. Likewise, course content authors must develop several versions of their courses if they want it to be widely available to learners. Learners also have to face new environments each time they enrolled on a new course.
- Various activities are emerging to propose standardisation of DOLE, with varying impact. The activities range from standardising file formats (small impact) to defining every aspect of a complete networked intelligent tutoring systems (large impact).
- There are two directions for standardisation of DOLE, from the bottom-up and from the top-down. The bottom-up direction came from the computer networking field and is largely driven by commercial interests. The top-down direction came from the academic community and is largely driven by research interests.
- Using the RM-ODP standard can help in producing a high-level specification of DOLE reference architecture. However, the genericity and complexity of the RM-ODP standard can hinder the process. It remains to be seen whether the RM-ODP standard is suitable for further refinement to the high-level specification.
- Lotus LearningSpace evaluation results:
  - Offers excellent support for nomadic learners, with its replication.
  - Lacks synchronous communications facilities for online learners.
  - May conform to future DOLE standards, because it has many features that are currently identified as required.

In conclusion, the contributions of this project are:

- An examination of various standardisation activities for DOLE.
- A high-level specification for DOLE based on the RM-ODP standard.
- An evaluation of Lotus LearningSpace as one example of DOLE.

Further work should be done to refine the high-level specification to make a complete standardised reference architecture. This can be done by defining the remaining RM-ODP viewpoints of the specification. Also, a more thorough evaluation of delivering courses using DOLE should be conducted, using real learners and a course fully developed by qualified content authors.

Chapter 6

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6.1 Papers and Books

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6.2 Internet resources

6.2.1 Online papers

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6.2.2 Online journals and magazines

Journal of Asynchronous Learning Networks `<http://www.aln.org/>`

Asynchronous Learning Networks Magazine `<http://www.aln.org/>`

6.2.3 Project home page

There is a *Project Homepage* `<http://www.dcs.shef.ac.uk/ m6bpi/project/>` on the Internet.

Appendix A

Project Diary

15 May 1997	Interim report draft submitted
23 May 1997	Interim report submitted
11 June 1997	Discussion on interim report and progress
1 June 1997	Progress review
24 July 1997	LearningSpace orientation
13 August 1997	Progress review
1 September 1997	Draft dissertation submitted
5 September 1997	Final dissertation submitted

Appendix B

List of Abbreviations

AICC	Aviation Industry CBT Committee
CBT	Computer-based Training
CEdMA	Computer Education Management Association
DOLE	Distributed Open Learning Environments
EP	Education Provider
IEEE	Institute for Electrical and Electronics Engineers
IMS	Instructional Management System
ISO	International Standards Organization, also InternationalOrganization for Standardization
ITU-T	International Telecommunication Union - Telecommunications Sector
LAN	Local Area Network
MB	Megabyte
OILS	Open Integrated Learning System
OOTD	Object-oriented Text Decomposition
RAM	Random Access Memory
RM-ODP	Reference Model of Open Distributed Processing
WWW	World Wide Web