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Analysis of innovative learning services in Web, interactive TV and mobile applications for non-formal settings

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1. Introduction

The emergence of knowledge society and knowledge-based economy signifies a new era for education and training i.e. ubiquitous learning. Ubiquitous learning aims at replacing old-fashioned time/place/content-predetermined learning with a just-in-time/at work-place/customized/on-demand process of learning. The new services related to providing personalized ubiquitous access to high quality learning courses will create new markets and provide means to increase productivity and hence growth and employment throughout the economy providing more convenient access to information and communication tools. New tendencies in eLearning put users at the centre with the goal of improving participation, opening up opportunities for everyone and enhancing skills containing measures regarding e-inclusion in all action lines.

An important strategy for achieving this is the multi-platform provision of eLearning services. If all citizens are to be included, it is crucial that eLearning services be available over different terminals such as PC, TV sets or mobile phones. In view of these objectives, the development of an integrated multi-platform eLearning service delivery environment that will allow the inclusion of European citizens into information society becomes a central research goal.

The CHIRON project "**Reffering Innovative Technologies and Solutions for Ubiquitous Learning"** aims to develop reference material which shows and analyses research outcomes, experiments and best practice solutions for new kinds of e-learning, based on the integration of broadband Web-, digital TV and mobile technologies for ubiquitous applications in the field of non-formal and informal life-long learning.

In task 7.1 "**Analysis of Innovative Learning Services in Web, Interactive TV and Mobile Applications for Non-formal Settings"** the task leader (Institute of Mathematics and Informatics, Bulgarian Academy of Sciences) with the co-operation of the other partners developed the final analytical survey of the project, which integrates, updates and generalises the developed analyses and conclusions inferred during the project, and identifies sample cases and best practices with evaluation of their effectiveness.

The survey presents the new challenges and benefits of ubiquitous Web, interactive TV and mobile applications, covering innovative learning services and new functionalities of the ubiquitous access to global knowledge repositories. It leads to formulation of short-term and long-term prognosis of the future of

ubiquitous learning applications in the form of possible scenarios and recommendations. In the following sections we summarize the main chapters of the analysis.

Generic issues for innovative learning services of Web, interactive TV and mobile applications for ubiquitous learning

The future trends in ubiquitous learning point to the investigation and development of specialized innovative services allowing wide range of learners to access and to follow courses by Web-based tools and Digital Video Broadcast tools at training institution and/or at workplace or at home, combined with the practically ubiquitous connectivity of the mobile devices.

Following this idea this chapter defines a set of innovative learning services that are suggested by several very important research projects (ELENA (http://www.elena-project.org/), LOGOS (http://www.logosproject.com/), SeLeNe (http://www.dcs.bbk.ac.uk/selene/), MOBILearn (http://www.mobilearn.org/), MUSIS (http://www.musis.se/), *etc.*) dated from the last few years. Short descriptions of these projects are included.

New models, technologies and applications for Just-in-Time Learning and Knowledge-on-Demand Applications

Incredible velocity and volatility of today's markets require just-in-time methods for supporting the need-to-know of employees, partners and distribution paths. It is also clear that this new style of learning will be driven by the requirements of the new economy: fast, just-in-time and relevant. The knowledge-on-demand (KoD) paradigm as it emerges from the current needs of the knowledge-based society points out the following basic requirements for learning: anyone, anytime, anywhere delivery of education and training, adapted to the specific requirements and preferences of each individual citizen within different eLearning and e-working settings. This requires work towards feasible technical solutions to support the KoD concept.

Our focus in this chapter lies on several technological decisions – Semantic Web, Interactive TV and wireless and mobile technologies – that enable fast, just-in-time, relevant and on-demand ubiquitous learning.

New organisational structures and relations between learning at home, in social venues, on the move, in school and workplace

This chapter first outlines the existing learner's needs and possibilities/choices for further learning. Then it presents the learning process in different situations and future trends for ubiquitous learning implementations. Finally, the chapter includes some guidelines for planning ubiquitous learning applications, from the aspect of different learning scenarios.

Methods for measuring of ubiquitous eLearning effectiveness and the relative educational values of different approaches, products, learning environments and processes

The evaluation process should be taken into account, especially for testing ubiquitous eLearning effectiveness and assessing the educational values of different approaches, products, learning environments and processes. This chapter presents evaluation methodology and techniques that could help companies and users to verify if ubiquitous eLearning products and services meet their objectives. The evaluation methodology is concerned with finding out how well users can use something (i.e. ubiquitous eLearning product and/or service), what they think about it, and what the major problems are, with the aim of improving design and re-design phases.

New standards and abstract architectural models for integrated Web, interactive TV and mobile applications

The ubiquitous learning and its services do not have to be considered isolated from the developed and new standards and specifications in the area because the goal is to maximize the reusability and portability of the learning process. In this chapter a set of standards and abstract models for integrated Web, interactive TV and mobile technologies are listed *i.e.* DVB–MHP (Digital Video Broadcasting – Multimedia Home Platform), GPRS (General Packet Radio Service), 3GPP (3rd Generation Partnership Project), Wi-Fi (802.11), IrDA (Infrared Data Association), Bluetooth, WAP (Wireless Application Protocol), UMTS (Universal Mobile Telecommunications System), HSDPA (High-Speed Downlink Packet Access), 3G LTE/SAE (Long Term Evolution).

Services for ubiquitous learning applications based on Semantic Web technologies and interoperable ontologies

This chapter traces the role of ontologies for integrating eLearning services. Based on this consideration a Semantic Integration Framework is presented. The aim of the framework is to provide an integration service platform that offers learner-centric support for Web-based learning and semantic relations between source learning resources.

Services for creation, storage and delivery of personalized, reusable, shareable content objects. Access-on-demand to digital libraries for ubiquitous learning

This chapter pays a specific attention to services for content delivery, creation (production), adaptation, personalization, storage, indexation, semantic searching, *etc.*, their main issues and future trends. It also explains how access-on-demand to the knowledge can be realized in digital libraries for providing ubiquitous learning.

Learner modelling, profiling and personalization. Learning customization

This chapter presents the learning modeling, profiling and personalization, standards and implementations. It also includes a web services-based methodology for learning customization by profile.

Services in personalized and adaptive learning environments tailoring to the individual learners' contexts, knowledge, needs, learning styles and preferences

Personalized and adaptive learning environments require semantic-based and context-aware services for tailoring to the individual learners' contexts, knowledge, needs, learning styles and preferences. These services make it possible to achieve semantic interoperability between heterogeneous information resources and services. The technological and conceptual differentiation between various systems can be bridged through the use of standards or by following approaches based on well accepted models. At first this chapter presents previous work related to studying issues in personalization and eLearning. It then addresses the issue of providing appropriate learner-oriented solutions based on integration of learning standards, established models and adaptive technologies. The chapter also includes issues related to the access of metadata stored in adaptive learning systems.

Grid technologies and services for learning environments. Learning grid

This chapter presents the new technology for flexible, secure and coordinated sharing of distributed heterogeneous resources and data, called Grid. The chapter describes its special features, services, functionalities and applications. The ubiquitous learning is one of these applications. Grid-based conceptual decision is the Learning grid, defined as an advanced learning environment built on Open Grid Services Architecture-compliant software, providing a variety of innovative services for transformation of information into knowledge, distributed services such as simulation environments, real-world input, 3D visualisation systems, in the framework of a virtual organization, *etc*.

Recommendations and scenarios

The analysis in task 7.1 leads to formulation of short-term and long-term prognosis of the future of ubiquitous learning applications in the form of possible scenarios and recommendations, included in this chapter.

In particular, these scenarios determine that:

- Learning will be realised in different learning contexts, modelling learning process and learning materials by considering different ways and phases of cross-media authoring, access, delivery, study and assessments through different modes and levels of integrated communication spaces.
- Personal environments will be populated by personal communication and computing devices, accessories, wearables, implants. eLearning services will be adapted to the user's individual situation, location and preferences.
- Mobility and ubiquitous access will be a key challenge for in-field job training needs.
- Learning demands high bandwidth broadband, it calls for new high quality graphical environments; it stimulates the introduction of new and innovative services in digital content and software.
- Business environments will benefit from eLearning solutions creating a competitive advantage for European business and will especially facilitate SME's exploring new markets, *etc*.

2. Generic issues for innovative learning services of Web, interactive TV and mobile applications for ubiquitous learning

The future trends in ubiquitous learning point to the investigation and development of specialized innovative services, methods and instruments allowing wide range of learners to access and to follow courses by Web-based tools and Digital Video Broadcast (DVB) tools at training institution and/or on workplace (typically with Internet protocol based information infrastructure), or at home (with much bigger presence of TV sets than of computer equipment), combined with the practically ubiquitous connectivity of the mobile devices.

Following this idea we can determine a set of innovative learning services that are suggested by several very important research projects (ELENA project, LOGOS project, SeLeNe project, MOBILearn Project, MUSIS project, *etc.*) dated from the last few years.

- Knowledge-on-demand learning services – They could provide semantic-led access to the virtual repositories, multilingual support and flexibility in order to produce personalised re-usable learning materials.
- Services (tools) for creation resources based on learning standards that are interoperable and can be deliver by different learning communication spaces (Web, iTV, mobile technologies)
- Personalisation service – The personalisation service can be recognized as a functionality, which customises access to learning services and learning resources (in the context of the delivery of a learning service) based on learner profiles (career development plans can even be part of such a profile). The result of the personalisation service is usually a customised view on a learning repository or a learning management network (connecting various educational nodes that facilitate the provision of additional educational services). The customisation can be performed in many ways using techniques such as collaborative filtering or rule-based personalization in order to modify a user's query or to reduce the results produced by the query. A special personal learning assistant (PLA) can support learners in searching for, selecting and contracting learning services. PLAs can also trigger the delivery of the following services.
    - *Query rewriting service* – The query rewriting service extends a user query by additional restrictions, joins, and variables based on various profiles. This extension is

performed based on heuristic rules/functions maintained by the query rewriting service. Query rewriting services can be asked for adding additional constraints to user queries-based on user preferences and language capabilities. They can also be asked to extend a user query based on previous learner performance maintained in learner profiles, if a query is constructed in the context of improving skills. Query rewriting services can also be asked to rewrite a user query based on information the connected services need.

- *Recommendation service* – The recommendation service provides annotations for learning resources in accordance with the information in a learner's profile. These annotations can refer to the educational state of a learning resource, the processing state of a learning resource, *etc*. The service holds heuristic rules for deriving recommendations based on learner profile information. Recommendation services can be asked to add recommendation information to existing instances based on learner profile information.
- *Link generation service* – A link generation service provides (personalized) semantic relations for a learning resource in accordance with the information in a learner's profile. These relations can show the context of a resource (*e.g.* a course in which this learning resource is included), or they can show other learning resources related to this resource (*e.g.*, examples for this learning resource, alternative explanations, exercises). The link generation service holds heuristic rules for creating semantic hypertext links. Some of the rules refer to information from the learner profile, in absence of learner profile information the service can at least provide some, not optimized, hypertext links. Link generation services can be asked for adding links and link type annotations to a given learning resource. They can be asked to generate a context for a given learning resource, or to generate a context for several learning resources by adding hyperlinks between them. They can be asked also to generate a learning path.

- Advanced (semantic-based) services for the discovery and sharing of suitable learning resources, facilitating a syndicated and personalised access to the resources.
- Syndication learning services, event and change notification learning services, learning content update services, presentation services.
- Services for accessing knowledge and realising context aware and

location based learning in a mobile environment for example via collaborative spaces. These services can provide mobile users by enhancing learning management system (LMS) functionality in the following aspects: context discovery, mobile content management and presentation adaptation and packaging and synchronization of the learning materials.

- Repository services – They provide access to any kind of knowledge repository which is connected to a learning network. Repositories can contain simple files, single learning objects, learning object packages, single databases, federated databases, P2P network infrastructure, *etc.*
- Educational service mediators – They allow the consumption of heterogeneous learning services via assessment tools, learning management systems, educational (meta) repositories and live delivery systems such as video conferencing systems or iTV.

Best practices

ELENA project – The objective of the ELENA project is to demonstrate the feasibility of smart spaces for learning. Smart learning spaces are defined as educational service mediators, which allow the consumption of heterogeneous learning services via assessment tools, learning management systems, educational (meta) repositories and live delivery systems such as video conferencing systems or iTV. Central design element of the ELENA smart learning space is a dynamic learner profile, which includes learning history, learner specific information and learning goals (ELENA).

Interconnecting learning services in a smart learning space leads to an empowerment of learners since they become capable of choosing among a variety of knowledge sources in order to achieve their personal learning goals. ELENA prepares the grounds for the rise of educational service markets and new service value chains, which will allow institutions to treat the performance of educational services as a make-or-buy decision.

Project aims and objectives

The aim of the ELENA project is to demonstrate the feasibility of Smart Spaces for learning allowing personalized access to heterogeneous learning services. This aim is achieved by the following objectives:

- To analyse existing standards for modelling learning-relevant data

beyond learning objects and to provide recommendations for their further development.

- To develop schemas describing educational services such as educational activities, learning material delivery, teaching assessment and learner assessment.
- To design and implement a smart space for learning that integrates heterogeneous services such as assessment services, content brokerage, learning management and human resources management.
- To test the applicability of smart spaces to the field of education and training from a business and organizational perspective and draw conclusions for the design of intelligent environments in this field.
- Develop best practice guidelines for deploying smart learning spaces from an organizational, technological and pedagogical perspective (ELENA).

Definition of ubiquitous learning in the ELENA project

A Smart Space for Learning aims at managing the distribution and consumption of learning services via a personal learning assistant. Smart spaces for learning are built upon learning management networks, which connect various educational nodes that facilitate the provision of educational services. In ELENA project educational nodes are realized as peers of a peer-to-peer (P2P) network or network nodes of a learning management network. This P2P network is based on Edutella, a peer-to-peer infrastructure that aims at connecting heterogeneous peers with different types of repositories, query languages and different kinds of metadata schemata. On top of the learning management network personal learning assistants (PLA) interact with the connected peers to query for suitable learning services. A PLA supports learners in searching for, selecting and contracting learning services. PLAs can also trigger the delivery of services.

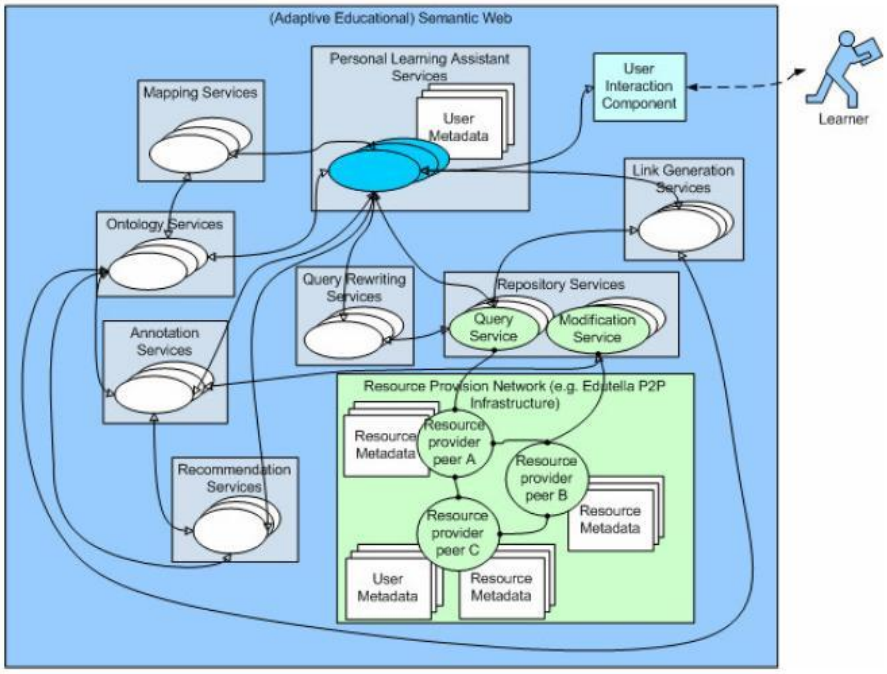

Figure 1: ELENA architecture for personalization services

"Knowledge-on-Demand for Ubiquitous Learning" project (LOGOS) – The project contributes to the openness for ubiquitous learning of the large-scale repositories of digitised text, graphics, audio, video objects and to the process of their transformation into learning content, adequately enhancing and facilitating the knowledge building. The project addresses innovative development of the main components of the learning processes – resources, services, communication spaces. New functionality of the learning communication spaces will be achieved by integrated Web, digital television and mobile technologies, supporting cross-media learning content. New eLearning management systems based on this integration will improve and extend the learning services within new consistent pedagogical scenarios. The use of annotated and adequately structured knowledge from digital archives will enable lecturers/authors to participate in 'open source' content development from massive, dynamically growing learning resources.

The project is targeted at the following results:

- Development of learning scenarios for ubiquitous learning in different learning contexts, modelling learning process and learning materials by considering different ways and phases of cross-media authoring, access, delivery, study and assessments through different modes and levels of integrated Web-based, DVB and mobile technologies;
- Development of authoring studio for generation of learning resources from existing digital archives;
- Development and implementation of knowledge-on-demand ubiquitous learning platform, integrating learning resources and communication spaces through knowledge-on-demand learning services;
- Extended experimentation of the functionality and usability of the platform implementation by authors/lecturers and learners in multiple national contexts.

The project meets the challenges of Europe enlargement by its research and development to provide highly customizable knowledge-on-demand learning services for the broad public in ubiquitous manner.

MOBILearn Project – The MOBILearn Project (MOBILearn) offers Open Mobile Access Abstract Framework (OMAF), based on the layers of infrastructure and implementation profiles. The OMAF is based of the intensive study of the existing best practices among the Open Knowledge Initiative and IMS Abstract Framework. OMAF addresses conceptual layout of services for accessing knowledge and realising context aware and location based learning in a mobile environment for example via collaborative spaces. Multi-layer model of OMAF, on Figure 2, is composed by the following layers:

The Mobile Meta Applications Layer (MmAL): the set of systems, tools and applications obtained as a combination/integration of two or more mobile applications, to provide extended and more complex functionalities to users.

The Mobile Applications Layer (MAL): the set of systems, tools and applications specifically designed and implemented to provide a particular mobile functionality. They are built starting from the suite of mobile services and common services.

The Mobile Services Layer (MSL): the set of components able to provide mobile specific services, which are used by the mobile applications.

The Generic Services Layer (GSL): the set of components that provide

generic services to be used by the application services.

The Infrastructure Services Layer (ISL): the underlying services that enable to exchange data in terms of communications, messaging and transactions.

The Service Access Points (SAP): interface to the corresponding service. Each SAP provides access to one service capability. SAPs is implemented through APIs (Application Programming Interfaces)

The Components Store (CS): a set of components that has to be specified to support the Generic and Mobile services. For instance, it will be possible to find in the BSC the data models for images (BMP, GIF, *etc*.), user profile and location, geographical coordinates of objects, *etc*.

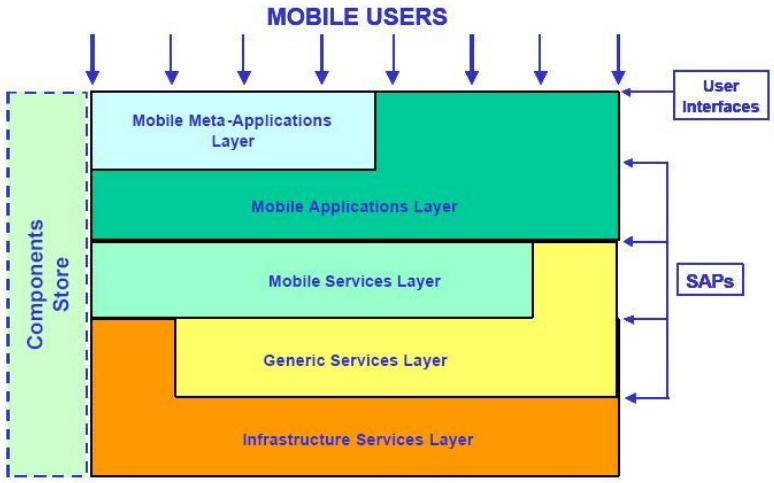

Figure 2: MOBILearn multi-layer model of Open Mobile Access Abstract Framework

The architecture provides all possible eLearning services and additional services to mobile users by enhancing LMS functionality in three aspects: "Context Discovery"; "Mobile Content Management and Presentation Adaptation" and "Packaging and Synchronization".

The "Context Discovery" automatically detects the devices' capabilities and limitations (software and hardware) and check what services can be provided. "Context Detection" adds additional abstraction that can hide the details about the different physical methods of context discovery. For example for finding location

different positioning systems can be used – in one case the user will be outside and can use a GPS system and in other will be inside the building and will use the local network signal for that.

The “Mobile Content Management and presentation adaptation” is responsible for selecting the proper services for the device capability and adapt them. The presentation adaptation can include adaptation of the structure, adaptation of the media format, quality or even type, *etc*. This subsystem is also used to adapt the presentation for auxiliary services, not only presentation of content.

The “Packaging and Synchronization” subsystem is responsible for supporting disconnected scenario. During offline operations the subsystem continues tracking of the user activities and feeds back the statistics to the LMS.

SeLeNe project – The SeLeNe project aims to elaborate new educational metaphors and tools in order to facilitate the formation of learning communities that require world-wide discovery and assimilation of knowledge. To realize this vision, SeLeNe is relying on semantic metadata describing educational material. SeLeNe offers advanced services for the discovery and sharing of learning resources, facilitating a syndicated and personalised access to such resources. These resources may be seen as the modern equivalent of textbooks, comprising rich composition structures, "how to read" prerequisite paths, subject indices, and detailed learning objectives.

The SeLeNe project was funded as an EU FP5 Accompanying Measure (IST-2001-39045) running from 1st November 2002 to 31st January 2004. This project was part of action line V.1.9 CPA9 of the IST 2002 Work Programme, contributing to the objectives of Information and Knowledge Grids by allowing access to widespread information and knowledge, with eLearning as the test-bed application. We conducted a feasibility study into using Semantic Web technology for syndicating knowledge-intensive resources (such as learning objects) and for creating personalized views over such a Knowledge Grid.

The project had three main objectives:

- To conduct a study of on-line educational resources and metadata, and of learners' and instructors' expectations of eLearning systems.
- To identify technologies for syndication and personalization of educational resources, including: semantic reconciliation and integration of heterogeneous educational metadata, structured and unstructured querying of learning object descriptions, language

primitives for defining user views, and automatic notification of changes in the descriptions of learning objects.

- To identify technologies for managing evolving RDF description bases, and design the high-level system architecture of a Self e-Learning Network.

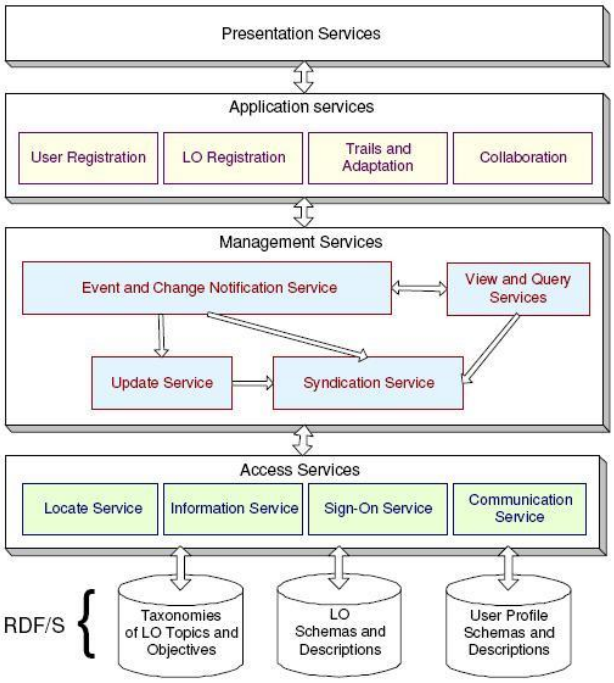

Figure 3: SeLeNe Service Architecture

Definition of ubiquitous learning in the SeLeNe project

Learners in the 21st century are diverse in their educational backgrounds, learning goals and learning needs. Semantic Web technology has the potential to help address these varied needs by using semantic metadata describing educational material in order to aid learners and instructors to locate suitable learning resources, and also to share learning resources they have discovered or authored with other people with similar needs.

A Self e-Learning Network offers multiple learning services for the discovery and sharing of learning resources, facilitating a syndicated and personalised access

to such resources, *etc*. Using Self e-Learning Network will contribute the development of ubiquitous learning paradigm based in Web space.

MUSIS project – the main goal of the MUSIS (**MU**lticast **S**ervices and **I**nformation in **S**weden) project are to explore, identify and develop a number of innovative multicast services with multimedia information to be distributed over wireless networks using multicasting solutions at university campuses. Other objectives are:

- to create an innovative model for content creation and distribution consisting of end users, telecom operator and technology provider;
- to integrate a carrier-grade multicasting platform that enables economic real-time broadcasting of rich media content on 2.5G cellular networks, to an unlimited number of cellular, using a minimal and limited amount of shared bandwidth.

The project aims to go beyond the basics of media delivery and to look at second order service models which involve interactivity and location-specific content.

Services developed in MUSIS are organized as a range of channels to which users can subscribe. Each user can build a personal portfolio of services that interest them. Multimedia content is sent, according to a predefined time schedule, to subscribers over the cellular network using multicast technology. Content is downloaded in the background. This eliminates complex user interactions, which are a major barrier to market acceptance.

The initial service trial conducted during the fall 2004 at KTH in Stockholm offered news, music, and lifestyle services to university students – a major target market for mobile multimedia. In addition, the Bamboo solution's channel-based structure allowed tightly targeted services such as lecture notes and course materials. The second round of testing (Spring 2005) underway at Växjö University (VXU) includes even more sophisticated services such as interactive multimedia and location-based services.

In order to test and evaluate the different services, 50 students from 3 different courses at VXU participated in a pilot project during the spring term 2005. They were each equipped with a NOKIA 6600 smart phone, running on a Symbian operative system, with 128MB memory. The Nokia 6600 includes an Internet browser, a bright 65,536-color TFT display, a camera equipped with digital zoom, a video recorder with audio, and a RealOne player for playback and streaming of

3GPP-compatible and RealMedia video clips. Educational material delivered for this project include small “micro lectures” in video format, voice based course information and assignments, and specific information related to the logistics (calendar information, cancellation of lectures and so on) of the different courses. In the case of the “micro lectures” the audio based and text information, the contents were developed for (and sometimes tailored to) the phone. This particular material sent to the phones was produced by the course instructor. In order to send this material to the phones, the teacher was using a special Web interface offering advanced learning services. The team also developed a number of services that allow Internet-based educational resources used in the course to be sent automatically to the phones (MUSIS, 2005).

ALFANET project provides an eLearning adaptive platform that allows individuals to have an interactive, adaptive and personalised learning through the Internet, and thus brings them the opportunity to learn on those matters that are relevant to perform and to improve their work. This core objective has been afforded through:

- ALFANET focus on learner-centred pedagogical methods highlighting activity, collaboration and the importance of the instructional design.
- ALFANET focus on adaptation through a set of components that make use and benefit from both technological and eLearning standards, and can be easily integrated in other eLearning platforms. The usage of eLearning standards, as IMS Learning Design (IMS LD), IMS Question and Test Interoperability (IMS QTI) among others, is of special relevance for the project and the global eLearning community, as the project provides a probe of concept of how to provide adaptation through standards interoperability.

ALFANET has delivered an eLearning system providing adaptive eLearning capabilities to Learners. The platform supports adaptation through the eLearning life-cycle (i.e. Design, Administration, Use and Auditing) and is made of four main subsystems: Authoring (Design phase), Publication (Administration phase), eLearning Instruction subsystem (Use phase), and Audit subsystem (Auditing phase) (ALFANET).

Authoring Tools

For the Design phase, ALFANET provides authoring tools that allow designing the course, making use of key eLearning standards, namely:

- The Learning Design Authoring Tool allows the course authors to generate eLearning courses based on IMS Learning Design (IMS LD) including metadata IMS MD/IEEE Learning Object Metadata (IEEE LOM) and generated the whole package as IMS Content Package (IMS CP).
- The QTI Authoring Tool supports the introduction of Metadata in the IMS QTI items and the generation of dynamic and adaptive questionnaires based on the Selection & Ordering specification provided by IMS QTI. It receives as input QTI items packaged with IMS CP.

eLearning Instruction Subsystem

For the phases of administration, use and audit, ALFANET provides an integrated platform designed as a service based architecture that provides the platform with flexibility, modularity and extensibility capabilities. The architecture is structured in three layers (ALFANET):

- The Server Layer acts as an integration platform for all the services providing core functionality for the eLearning Adaptive Services and for its integration to achieve adaptation. It has been designed based on J2EE architecture, and can be run into any J2EE server, being easily integrable in any existing system.
- The Service Layer provides the core eLearning functionality. It is composed of several independent services that have been integrated in the system. The majority of these services have been defined as components that based both on technology (EJB, JAXM, XML, etc) and eLearning standards (IMS CP, IMS LD, IMS QTI, IEEE LOM, IMS Learner Information Package) providing core functionality for ALFANET platform, at the same time offer open interfaces for possible integration with other platforms.
- The Data Layer is the core for all the data shared by the ALFANET server and the different services. This data is also stored in a XML database which allows storing directly the information in the corresponding standard format.

Service Layer Components

Following, a brief description of the **adaptive and interactive components** belonging to the Service layer:

- The **Instructional Design** (CopperCore) component provides the eLearning Platform with courses supporting different eLearning paths corresponding to concrete learner characteristics. It supports both the course administration (prepares the course to be used by different learners) and the interpretation of the defined course Instructional Design at the view of the User Model (IMS Learner Information Package – IMS LIP).
- The **Evaluation and Assessment component** provide support for the interpretation and presentation of dynamic adaptive questionnaires defined in IMS QTI and their evaluation at run-time. It supports adaptive questionnaires that are generated dynamically at run-time according to different properties of the User Model (IMS LIP) as the evolution of the learner in the course, the learner preferences, etc, and based on metadata associated to the items (IMS MD) as Learning Objective, Knowledge Level, *etc*.
- The **Adaptation component** provides recommendations and advises to learners while interacting with a course based on the experience derived from previous users' interactions, on the user model (IMS LIP), the course structure (IMS LD), the contents characterization (IMS MD/LOM) and the questionnaires results (IMS QTI). In addition it supports the adaptive functionality of the Instructional Design interpreter, the Interaction Services and the Presentation layer. User Modeling, Machine Learning and Multi-Agent Architecture are the technological bases of this innovative package.
- The **Presentation components** provide a personalised, adaptive interface (*e.g.*: according to learner preferences), integrated and homogeneous presentation for the different services that configure an eLearning platform, and also other kind of applications that integrate one or more services. The adaptive presentation uses the User Model, based on IMS LIP.
- The **Interaction Services** component supports individual and collaborative users' tasks in terms of interactive services (forums, file storage area, agenda, *etc*.) that are also included in the course definition at design time (IMS LD). On the other hand, it provides an explicit representation of components to support their adaptive presentation. Moreover, it supports the administrative tasks to manage services and their use by learners and tutors (ALFANET).

3. New models, technologies and applications for just-in-time learning and knowledge-on-demand applications

It is clear that new styles of learning are some of the next challenges for every industry. Incredible velocity and volatility of today's markets require just-in-time methods for supporting the need-to-know of employees, partners and distribution paths. It is also clear that this new style of learning will be driven by the requirements of the new economy: fast, just-in-time, relevant and on-demand.

Time, or the lack of it, is the reason given by most businesses for failing to invest in learning. Therefore, learning processes need to be fast and just-in-time. Speed requires not only a suitable content of the learning material (highly specified, not too general), but also a powerful mechanism for organizing such material. Also, learning must be a customized on-line service, initiated by user profiles and business demands. In addition, it must be integrated into day-to-day work patterns and needs to represent a clear competitive edge for the business. Learning needs to be relevant to the (semantic) context of the business (Adelsberger et al., 2001).

eLearning aims at replacing old-fashioned time/place/content predetermined learning with a just-in-time/at work-place/customized/on-demand process of learning. It builds on several pillars, *viz*. management, culture and IT (Maurer at al., 2001). eLearning needs management support (vision and plan for learning, integrating learning into daily work). It requires changes in organizational behaviour establishing a culture of "learn in the morning, do in the afternoon". An IT platform, which enables efficient implementation of learning infrastructure, is also needed. Our focus here lies on Semantic Web, Interactive TV (iTV) and wireless and mobile technologies that enable fast, just-in-time, relevant and on demand learning. Current technological solutions do not meet the above mentioned requirements. Some pitfalls are *e.g*. information overload, lack of accurate information, content that is not machine-understandable, undeveloped infrastructure, *etc*.

The knowledge-on-demand (KoD) paradigm as it emerges from the current needs of the knowledge-based society points out the following basic requirements for learning: anyone, anytime, anywhere delivery of education and training, adapted to the specific requirements and preferences of each individual citizen within different eLearning and e-working settings. This requires work towards feasible technical solutions to support the KoD concept.

Such technological solution is iTV. It combines the appeal and mass audience

of traditional TV with the interactive features such as those currently available on the Web and offers new possibilities for the viewer, who can directly access relevant information and other services being just 'one-click' away. Interactive Television provides a range of new services that combine video and data and give viewers greater control over what they see, in comparison with other traditional services. iTV is considered as the convergence of two different technologies: television and computer technology. iTV technologies have the potential to facilitate new methods of providing learning experience to the home and the workplace with a just-in-time/at work-place/customized/on-demand process of learning.

The new generation of the Web, the so-called Semantic Web, appears as a promising technology for implementing modern eLearning, too. The Semantic Web constitutes an environment in which human and machine agents will communicate on a semantic basis (Berners-Lee, 2000). One of its primary characteristics *viz*. shared understanding based on the ontology backbone. Ontology enables the organization of learning materials around small pieces of semantically annotated (enriched) learning objects (Neidl, 2001). Items can be easily organized into customized learning courses (fast and just-in-time) and delivered on-demand to the user, according to her/his profile and business needs (relevant). In fact, the Semantic Web could be treated as a very suitable platform for implementing an eLearning system, because it provides all means for (eLearning) ontology development, ontology-based annotation of learning materials, their composition in learning courses and (pro)active delivery of the learning materials through eLearning portals.

Requirements	**eLearning**	**Semantic Web**
Delivery	Pull – Student determines agenda	Knowledge items (learning materials are distributed on the web, but they are linked to commonly agreed ontology(s). This enables construction of a user-specific course, by semantic quirying for topics of interest.
Responsiveness	Reactionary – Respons to problem at hand	Software agents on the Semantic Web may use commonly agreed service language, which enables co-ordination between agents and proactive delivery of learning materials in the context of actual problems. The vision is that each user has his own personalised agent

		that communicates with other agents.
Access	Non-linear – Allows direct access to knowledge in whatever sequence makes sense to the situation at hand	User can describe situation at hand (goal of learning, previous knowledge,…) and perform semantic quirying for the suitable learning material. The user profile is also accounted for. Access to knowledge can be expanded by semantically defined navigation.
Symmetry	Symmetric – Learning occurs as an integrated activity	The Semantic Web (semantic intranet) offers the potential to become an integration platform for all business processes in the organisation, including learning activities.
Modality	Continuous – Learning runs in parallel and never stops	Active delivery of information (based on personalised agent) creates a dynamic learning environment.
Authority	Distributed – Content comes from interaction of the participants and the educators	The Semantic Web will be as decentralised as possible. This enables an effective co-operative content management.
Personalization	Personalized – Content is determined by the individual user's needs and aims to satisfy the needs of every user	A use (using personalised agent) searches for learning material customised for her/his needs. The ontology is the link between user needs and characteristics of the learning material.
Adaptivity	Dynamic – Content changes constantly through user input, experiences, new practices, business rules and heuristics	The Semantic Web enables the use of knowledge provided in various forms, by semantical annotation of content. Distributed nature of the Semantic Web enables continuous improvement of learning materials.

Mobile learning suited the flexible learning paradigm of anywhere, anytime and supported the learning fraternity's need to shift focus from a traditional didactic approach to learning delivery to that of supporting learning however, whenever and wherever the learner may choose. Contemporary mobile devices can also be useful in learning for several reasons: they can provide modular content, wireless access, automated delivery, convenience, performance, and information on-demand; they are personal and responsive. The high portability, user centred

design, acceptable durability and potential network capability of the mobile equipment of the new millennium, meant that it had potential to fulfil the needs of emerging learning trends and in many cases could do this in a far more cost effective way then had ever been possible before.

Case studies

The following three projects explore and present just-in-time methods for supporting the knowledge-on-demand to different groups of potential learners. They present new styles of learning driven by the requirements of the new economy: fast, just-in-time, relevant and on-demand ubiquitous learning process.

The **project "Enhanced Learning Unlimited" (ELU)** intends to develop and validate the use of interactive digital TV (iDTV) systems for learning. Despite the popularity of the PC, it is expected that TV will remain the leading device in each home and that delivery of t-learning will be part of iDTV deployment in the future. The advantages of iDTV include ease of use, low additional cost, and the small footprint. The ELU team will research, develop and implement pedagogical scenarios for the use of iDTV at home, universities and schools. It will exploit the potential of iDTV to support a personalised, just-in-time, flexible and learner-centred pedagogical approach. On the pedagogical side, ELU will examine how to bridge the gap between 'edutainment' and 'engaged learning' and how to turn a passive viewer into an active learner. ELU will also provide solutions to integrate learning support systems (human and electronic). To test the effectiveness of iDTV, several types of content will be developed. On the technological side, ELU will provide content creation tools that combine:

- educational content authoring (thematic info, tutorial, demos,…);
- entertainment content authoring (user-immersion, educational games,...);
- examination content authoring (multiple-choice questions, tests,...).

The content will be SCORM-compatible and will be delivered on the MHP open platform. The ELU system will include supporting facilities, such as knowledge retrieval and delivery tools. In order to validate its technology, ELU will develop tools to simulate iDTV for areas in which real deployment is not feasible at this stage.

ELU will promote the use of immersion technologies and media convergence. User immersion enables 'natural learning' while media convergence enables

common-core content to be broadcasted to all viewers and personalised knowledge to be transferred and exchanged individually on-demand.

The new project **"Learning Content Management System Using Innovative Semantic Web Services Architecture" (LUISA)** (starting March 2006) addresses the development of a reference semantic architecture for the major challenges in the search, interchange and delivery of learning objects in a service-oriented context. This entails the technical description of the solution in terms of current Semantic Web Services technology, and also the provision of the ontologies, facilities and components required to extend and enhance existing learning technology systems with the advanced capabilities provided by computational semantics. The technology development objective of LUISA is put in a context of relevant learning scenarios – both academic and industrial for evaluation and also to serve as a blueprint for technology adoption. The outcomes of LUISA are expected to make a significant contribution to the automation of learning technology systems beyond current standards, fostering the advancement of Web-based learning with an increase in the capacity to locate, search and negotiate learning resources mediated by semantic tools (LUISA).

The last example for a best practice is the mobile **Game-Based Learning** project **(mGBL).** Within this project ten partner organisations from Austria, Croatia, Italy, Slovenia and the UK have joined forces to work on the development of a platform for the presentation of educational content in a playful and emotional way on mobile devices. The largest challenge within this project is the idea of communicating content from the fields of career guidance, e-health and e-commerce in an involving and emotional way to different target audiences. Based on innovative methods from the fields of m-learning (mobile learning) and the latest research results from the field of didactics, new forms of game-based learning on mobile phones will be developed. The development of a game based m-learning platform shall provide an easy-to-use and cost effective method for embedding different types of content into mobile games in order to convey this content at an emotional level. Besides the modules for the development, administration and distribution of the games on different mobile devices (provisioning) the platform will contain a software-based tool for the selection of appropriate mobile games from existing game templates as well as a module for evaluation of the users' acceptance and for measuring the individual learning success. The results of this project will both enable new forms of learning and support traditional learning processes by involving the mobile channel for presentation and training of learning content. The research work carried out by mGBL will also present impulses for the field emotion-based marketing.

4. New organisational structures and relations between learning at home, at social venues, on the move, at school and at workplace

4.1. "Life situations" – existing learning needs and possibilities/choices for further learning

Successful u-learning applications are the bricks of our construction of knowledge society. On the other hand, we cannot create the best product (in this case, a good application), if users don't use it (or not use it often enough to make the desired effect) and we do not receive comments and remarks as feedback, which would help us improve the product's functionality. This is the same problem as of eLearning. People often tend to "stick" to what they are already familiar with, and, although they have a natural interest in new things, this comes increasingly difficult with age – not just biological, but practical reason. Social context is determinative in this sense too: if someone is (or, to be precise, would be) open in general, but he spends 10 – 12 hours with routine work or otherwise tiring work (for instance a lot of stress, lot of responsibility, underpayment, etc), then, no matter how great mind he/she is, he will have no energy left for discovering new things. This is why, parallel with the development of applications, we must **communicate the benefits of u-learning**. In other words, we must make it evident for them, why this is good for them, what they can gain through it. This communication, certainly, will be different, depending on target group. When planning/publishing an application for children of ages 4 – 8 for instance, we would want to communicate differently when speaking to the children themselves, or to their parents, or to their teachers. When publishing an application addressed to SME's, we would wish to communicate differently to the company leader, and the employees. It is a question of crucial importance, whether we can attract users at the first instance, and whether we can keep their interest on the long term. Different strategies should be worked out for these two purposes, and, again, it is a good idea to start from the commonly known and accepted, but at the same time visualising the future, and make the benefits evident.

Previous consultation with possible users and testing through real-life challenges and solutions is a good way to prepare the path. A company, who discovers the benefits of u-learning, will become stronger and faster growing. Competitors will notice this. Also, companies that realize the importance of u-learning sooner will have a greater amount of experience on this field, when others will only start "having a look". Consultation is very important for effectiveness of the introduction of u-learning. When talking to a user (whether an employee, or a decision-maker, an author, *etc.*), let's find out what his problems/difficulties are.

Where there is a problem, there is also a challenge and therefore an opportunity to improve. If we can successfully catch and describe these opportunities, we are catching the success of u-learning too (together with the success of the user of course). For instance, if someone has to travel one hour going to work, and one our going home, this must be tiring. Is he going with public transport or car? Is he more receptive in the morning (when he is "fresh"), or that time he prefers to plan his day and "prepare" for the problems to solve? Maybe this is the time to refresh something that he can use well in his work. Or, he can get help by a short "mobile training" concerning teamwork, collective problem solving and stress handling. In the evening, is he tired, wanting to relax? He/she may want to play (and relax) a little bit on his mobile device, and in the meantime learn something that he can use well the next day. Or, he may want to reflect on a problem he encountered that day, and by solving it he can begin the next day with new energy. Apart from workplace, is he facing difficulties at home, concerning for instance communication with the spouse or the children? If the answer is "sometimes...", we already have a possibility to help the user in making his life better. Where there are problems, there are possible solutions too. There are literally dozens, hundreds and thousands of life-situations, where the quality of life, comfort, effectiveness, image of future of a certain individual can be ameliorated. Catching these situations, and providing an interesting solution that takes the user a step forward, is the basis of the development of u-learning.

The future of u-learning, similarly to any learning, is a process, and as such, cannot be forecasted precisely. What we can do is constantly build our conception (regarding u-learning in this case). In this process, practical and scientific approach, general and specific problems together with their solutions, "real life" applications and theories must go hand in hand, in order to become better and better students of this field.

4.2. Learning process in different situations

The future trends in ubiquitous learning point to the investigation and development of methods, instruments and specialized services, allowing wide range of learners to access and to follow courses by Web-based tools and Digital Video Broadcast /DVB/ tools at training institution and/or on workplace (typically with Internet protocol based information infrastructure), or at home (with much bigger presence of TV sets than of computer equipment), combined with the practically ubiquitous connectivity of the mobile devices.

Undoubtedly, there has always been learning in the workplace. Practical work in enterprises repeatedly challenges the employees to widen their knowledge and

skills. Individuals and their employers will share a responsibility for increasing the quality and quantity of learning at work. Equipping people with the right knowledge and skills will be crucial to maintaining high and sustainable levels of employment and price stability. It will also improve productivity. Vocational learners or workers have a strong motivation to improve their career development opportunities within a highly competitive environment, mainly interested in accessing knowledge and real-time assistance from their workplace, at the time and place that it is needed to complete certain tasks. Workplace learning is defined as learning or training undertaken in the workplace, usually on the job, including on-the-job training under normal operational conditions, and on-site training, which is conducted away from the work process (*e.g.* in a training room) (ANTA, 2002). Workplace learning should provide the skills leading to the capacity to innovate. Innovation has become a key concept in the ability of firms to be competitive. In the optimal workplace learning situation, a systemic approach involving networks and partnerships is critical. This situation makes learning-on-demand not just practical, but necessary, or often inevitable. Moreover, the "skill mix" that is required for the job, is always changing. Workers need up-to-date knowledge on a daily basis; therefore the importance of ability to learn alone becomes high. They must be able to learn with our own "direction", from realizing and analyzing the problem, through searching for adequate information, resources and help, till actively solve the problem (often in teamwork).

This is why a good, modern and effective workplace must support learning at work. This increases productivity, and therefore stability of the company. There are generic skills like communication, problem solving skills, IT skills, customer service skills, and more specific skills (professional, technical, *etc*.). These skills help the individual and therefore the enterprise, to respond to change (through capacity to innovate), and therefore the competitiveness of the company becomes better.

Big enterprises and SME's have different characteristics, though. Small firms have to face several difficulties: they cannot release people from work hours. They lack the time and expertise to find/organize the right trainings. They may not have the financial strength to purchase cost-effective learning methods; they may even struggle for simple short-term survival. This is why it is of crucial importance of changing the learning culture in SME's – while the task might be more challenging, because of the mentioned difficulties, and the special (individual, therefore less generalizable) characteristics of the SME's. We should pay even more attention to finding the best method of learning, from the long list of available choices: action learning situated learning, incidental learning, just to name a few.

New skills also improve the personality – therefore not just the employer and employee will benefit from learning at work, rather, many more people inside and outside the enterprise.

On the other hand, one UK-based survey (2000) found that the home was the third most important location for learning after the workplace and college or university. Learning at home allows the students to learn when they want and at their own pace. They can study a wide range of subjects through distance learning at any level including degree courses and beyond. Learning at home, or distance learning, can be ideal if the subject students are interested in isn't available near where they live, or they prefers the flexibility and freedom of learning in their own time. The students learn by reading course material, working on course activities, writing assignments and perhaps working with other students. Learning can be supported by a tutor and the student services. Learning from home makes use of a variety of media to help with teaching, studying and communication between students and tutors.

Moreover, many employees is pursuing eLearning programmes in their own time, using their own home based computers or TV. If this model is to spread it will effectively shift the burden of payment for eLearning from the SME to the individual. This in itself raises further issues. However, in any case if employability requires lifelong learning and a major component of that learning is through home based eLearning the effect is to lengthen the working week and increase pressure and responsibilities of employers at the very time when a number of European Member Sates are attempting to reduce stress and working hours.

Learning on the move or mobile learning (m-learning) uses mobile technologies to enhance the learning process. With a background of more than 4 years of trialling, research and development, m-learning has helped thousands of learners from all walks of life to develop their skills, confidence and motivation to learn. Inspirational m-learning projects have taken place across the world in a variety of learning contexts, demonstrating the flexibility of this learning medium. The feedback received from the learners and tutors involved have shown that m-learning is a success.

Nomadic learning is a form of learning in which a learner has continuity of service across different sessions and, possibly, different locations. A nomadic learning technology system provides continuity of service to a learner across separate sessions, and is sometimes disconnected from the networks it uses for communication among its subsystems and with other systems.

4.3. Guidelines for planning of u-learning applications, from the aspect of learning scenarios

Effectiveness and benefits

Effectiveness is of key importance in any development. Certainly, we want to see that every penny, every minute that we invested in the given work, will make its effect. As we could see from the previous work packages of this project, the task is challenging, given its complexity in its nature, and the fact that u-learning is an innovative approach and as such, always reserves some surprises.

Generally speaking, it is probably a good idea to **start with something that can be defined thoroughly**, and where the results are easy to measure. For instance, an application for a precisely defined age-group, in an environment where we are thoroughly familiar with the social context, IT background, learning styles and preferences and existing knowledge of the users, and there is a specific learning goal we want to reach. Probably real life situations are, and will be the best tutors in this exploration. When there is a concrete learning goal (a problem to be solved, a skill to be developed, *etc.*), it is quite easy to measure the effectiveness of the course – simply by looking at the learner's progress, and through surveys of satisfaction/acceptance.

Both from a practical and theoretical point of view, it is probably a good idea to **start from something that already exists**. When there is a successful (effective) application for instance, we should try to widen it, according to the demands of u-learning in general. For instance, when an eLearning application employs a combination of certain pedagogical methods (*e.g.* a presentation+video+excercise+test), we could try to think, what other methods we could add and what this could add to the pedagogical value/effectiveness of the application. For instance, by adding some elements that employ a different pedagogical method (*e.g.* discussion); we can measure whether the application is more effective in building cooperation and teamwork skills. Or, if the application is targeted on a group of known age-group and IT background, we could have a look, what should be added to or changed within the application, to make it understandable for people with lower IT skills, or for people of a different age-group (*e.g.* children). Next, if the application runs well in average eLearning environment (acceptably good computer, access to high speed internet), we could have a look, how the application should be changed so that it becomes applicable in a mobile environment, using for instance a mobile phone connected to a PDA. Probably some functions will be perfectly usable. Other functions will be more difficult to adapt, others again will have to be changed completely. Then we can

draw conclusions: what aspects of the application remained common in both applications? (eLearning and m-learning). What are the facets that are specific to the media? (in this case, the PDA). What were the restrictions we had to apply? On the other hand, limitations can also become an advantage in some cases. (For instance, a simplified graphic interface will run faster on a narrower bandwidth.)

In general, we should **draw conclusions** from real life situations, and, similarly to the learning process itself, create new understandings (knowledge), then discuss it (forums, discussion groups, cooperation between the actors of u-learning industry), then reflect on it and subsequently publish new studies/results, new theories and new questions.

In this process, **coherency and consistency** is of key importance too. Even though "random experiments" can also bring fruitful results, these results can be mined better if a "scientific" approach is also present in our experiment. (In short, when we know what we try to do, why we do it that way, and what results we expect from it – and we take this way of thinking through the whole process of our experiment and/or development.) The more "parameters" (aspects/methods) we change in our application, the more difficult it becomes to precisely measure the change in the results. Professional experience of a company and its employees is determinative. Certainly, if the goal is to build a big house, we must be able to build a wall first. So, it might be more effective to make smaller steps first – and always measure the result in a well thought way.

5. Methods for measuring of ubiquitous eLearning effectiveness and the relative educational values of different approaches, products, learning environments and processes

Evaluation refers to a process of gathering data and then analyzing or ordering it in such a way that the resulting information can be used to determine whether the product or the software is effectively achieving its stated objectives.

The evaluation process should be taken into account, especially for testing ubiquitous eLearning effectiveness and assessing the educational values of different approaches, products, learning environments and processes.

Companies and users that do not know how to evaluate effectively e-learning tools and services (how to evaluate the efficacy, the efficiency, the user friendliness, *etc*…) could follow some of the techniques described in this chapter in order to verify if ubiquitous e-learning products and services match their objectives.

In fact the adoption of the effective ubiquitous e-learning products or services is really difficult as the selection of cell-phones or PDAs: similar products can be found on the market and only an effective use of evaluation procedures could help the user to select the proper products or services.

The evaluation process is mainly used to address specific aspects of the product such as:

1. the efficiency
2. the effectiveness
3. the usability
4. the quality of educational materials
5. the quality of the system/platform services

Specific goals can be determined from the above concerns. These goals allow for the creation of evaluation scenarios and tasks that will let us know if our concerns are valid and what measures can help us determine if in fact the participants are having trouble completing the scenario or the test.

5.1. Evaluation methodology

The evaluation methodology is concerned with finding out how well users can use something, what they think about it, and what the major problems are, with the aim of improving design and re-design phases.

The process of the evaluation is essential for assuring quality of use:

- how effectively and efficiently intended users can achieve particular goals using a product or prototype
- how satisfied they are with it
- how well it meets specific requirements (*e.g.* learnability, appeal, engagement, error avoidance, *etc.*)

There are different methods for evaluating a product, an environment or a process. It is important to select a set of methods that are practical and valuable for use in product assessment:

- **inspection methods,** based on having evaluators only examine a software product without involving end users.
- **user testing**, based observation of the use of systems or prototypes by a sample of users (in lab or field), to assess quality of use and identify problems
- **user satisfaction methods**, which employ interviews or questionnaires to gain insights into what users think of a product, identify areas of difficulty and assess satisfaction.

5.2. Inspection methods

The focus of usability inspection methods is on the usability related aspects of the user-interface of interactive products and services.

They usually are very efficient with a high benefit-cost ratio. Evaluators are given evaluation patterns, to be guided in the evaluation process. Tasks precisely describe which hypermedia "objects" (*i.e.* functionality, information structures, or interface elements) to focus upon and which actions to perform on them in order to analyse their usability.

Evaluation patterns are a set of very detailed usability criteria associated to the various tasks. These criteria are obtained by refining general usability principles

with respect to the specific context of hypermedia applications. Tasks provide a precise guide about which actions to undertake on which application constituents during evaluations. Usability attributes provide detailed reference criteria against which to judge the inspection findings. As a consequence, inexperienced evaluators, with lack of expertise in usability and/or hypermedia, are able to provide good results.

5.3. User testing

Usability testing is a highly efficient method for measuring:

- the quality of use of a software/product/service
- the acceptance of a software/product/service
- detecting issues

Observing typical present or future users working through a set of tasks identifies weaknesses as well as positive aspects of any device or software application. Valuable insights are collected for a focused and cost effective optimisation of the product under scrutiny.

Generally, a Usability test is divided into three phases: **Planning, Testing, Reporting.** In the following meaningful steps are listed for each of the three phases.

Planning: identification of the panel

The selection of participants whose background and abilities that are representative of the products intended end user is a crucial element of a successful usability evaluation. The evaluation will be valid only if the people evaluated are typical end users of the product, or as close to a selected set of characteristics as possible.

You must find a representative sample of users, with sufficient sample size and diversity to cover significant minorities.

The following is a list of the key characteristics of the end users that are considered as critical differentiators for successful adoption and use. These characteristics are the basis for participant selection for the evaluation:

- Age, Sex
- School level or kind of work
- Use of PC, Internet, LMS
- Preferred device (Tv, mobile, PC,…)
- Preferred learning style
- Media preference (audio, text, video)

Others criteria may be identified based on the nature of the system/products to be tested.

Planning: logistics

It is necessary to set up a specific environment for the evaluation. For example, if the application is a networked one, the evaluation must take place in a location where a network connection is available. In any case the selected location should be large enough to comfortably accommodate a desk for the participant to sit at while completing the evaluation.

Testing remotely (*e.g.* over the internet) is a newer possibility to collect user reaction. It is best suited for projects which involve an international user population, or when feedback from many sources (*e.g.* in a wide spread project team) is required. For remote testing, the application has to be developed as capable to run on the internet very early, and put on a server for access by the users. Then either the Internet address is posted to selected users, which are specifically asked for feedback (preferred), or is open to public and feedback is by monitoring activity and by persons who answer the attached questionnaire on their own accord.

This method differs in many points from standard lab testing:

- There is no control over users. How, when and with which support task are solved is unclear, even if the target user is actually at the system or even near the system.
- Equally, the environment is not determined, so the test could be run at the intended site or in a completely different location.
- There is no opportunity to observe what users are doing and how they are reacting.
- There may be no opportunity to interview the users about their experience.
- Significantly more users must be tested than in the lab, to compensate

for the lack of control and defined task solution.
- Overall, validity and reliability may be questionable because of the lack of control.

Planning: design of scenario and questionnaires

A realistic scenario (list of tasks/pilots to be performed in a well identified context) has to be carefully designed keeping in mind the desired goals of the evaluation. Pre-test and post-test questionnaires are very efficient tools to measure respectively background information on the user and satisfaction rates related to the performed experiments. Sometime additional tests (*e.g.* learning style questionnaire) are used to identify specific characteristics of the user.

Planning: definition of the material to be used in the experiment

In order to complete the evaluation process specific material should be designed and developed. The following is a list of materials that should be created:

- Initial information and instructions
- Participant profile analysis (Learning style questionnaire)
- Task scenario packages
- Evaluation participant debriefing materials (questionnaire)

Content should be prepared and localized in different languages in order to avoid the introduction of side effects due to linguistic problems.

Planning: people involved in the test and related responsibilities

Supervisor: Typically at least one person is needed during the testing. She/He is the main observer and takes notes, and also interacts with the subject if needed (assistance, guidance).

*Subjects: i*t is essential to select subjects who fit the user profile defined in the project. A minimal number of five users per clearly distinguishable user group is highly recommended. If there is the need to group users by different characteristics, a "merged" group to be used as "control group" should be foreseen.

Additional observers: it is strongly suggested that all key areas of a project participate at least partly in the observation. Even if some observation training is needed to accomplish meaningful results, it has been shown to be helpful if many

team members know the user reaction to the system from own experience.

Planning: definition of data collection methodology (Objective and Subjective Measures)

Collection of performances (objective measures)

The performance evaluation can consist on a series of lesson/pilot that should be used separately and sequentially:

- a performance evaluation in which each participant is asked to perform the first pilot and then a first final test
- a performance evaluation in which each participant is asked to perform the second pilot and then a second final test.

The individual participants complete the pilots while being measured by a timekeeper and are observed by the specialists/administrator.

Collection of assessments (subjective measures)

After all pilots are completed or the time expires, each participant has been debriefed by the evaluation administrator. The debriefing included the following:

- a questionnaire (User Satisfaction Questionnaire) after the first pilot and an interview to gather additional insights from the participants
- a questionnaire (Usability Questionnaire) to verify the usability of the interface and of the scenarios
- completion of a brief post evaluation questionnaire in which the participants share their opinions on the service's usage, appearance of application screens, and general impressions of the service
- participant's responses to probes from the evaluation monitor about specific errors or problems encountered during the use.

Testing: participant greeting, background/screening questionnaire and orientation

Each participant should feel comfortable and relaxed. The participants will be given name tags and asked to fill out a short background questionnaire.

The participants will receive a short introduction and orientation to the

evaluation, in the form of a script, or sequence, of verbal instructions. This material will explain the purpose and objective of the evaluation, and additional information about what is expected of them. They will be assured that the system is the center of the evaluation and not themselves, and that they should perform in whatever manner is typical and comfortable for them.

Testing: performance evaluation

The performance evaluation consists of a series of scenarios that are used separately and sequentially. The individual participants complete the scenario while being measured by a timekeeper and observed by the specialists/administrator. The scenario could be identified as follows:

- after the orientation, the participants will be asked to sit down at the computer. The evaluation administrator will give the participants the task scenario booklet and instruct them
- after the participants begin exposed through the evaluation scenario, they will be encouraged to work without guidance except for the provided material and the service itself and a measure of time of exposure will be collected
- after the completion of the scenario and a defined interval of time, a specific test will be proposed to complete.

Testing: participant debriefing

After the evaluation scenario is complete or the time expires, each participant will be debriefed by the evaluation administrator. The debriefing will include the following:

- completion of a brief post evaluation questionnaire in which the participants share their opinions on the service's usage, appearance of application screens, and general impressions of the service
- participant's overall comments about his or her experience
- participant's responses to probes from the evaluation monitor about specific errors or problems encountered during the use

The debriefing session serves several functions. It allows the participants to say whatever they like, which is important if tasks are frustrating. It provides important information about each participant's rationale for performing specific actions, and it allows the collection of subjective preference data about the

application and its content.

After the debriefing session, the participants will be thanked for their efforts, and released.

Reporting: analysis of results

The results collected during the testing phases should then be organized and analyzed. Different statistical methods can be used in order to correctly analyze data. Some of the most common techniques used to analyze collected data are:

- T-Test: it measures the significance of a difference of means. It is used to compare the means of two groups or the means of one group with a constant
- Multivariate Analisys of Variance model will be performed on collected data to see main and interaction effects of selected independent variables (*i.e.* LS, content type, background, *etc.*) on dependent variables (performances measures).

The data analysis and results will allow to:

- identify inherent problems and inconsistencies
- prepare suggestions for optimizations/improvements
- discussion of the results with the client / within the expert group

5.4. User satisfaction methods

Evaluation of user satisfaction aims to discover what people think and feel about using a product and to assess the perceived quality of use. It is based on asking people to share their experiences and opinions, usually in a structured way by responding to specific spoken or written questions. It may involve drawing out insights by facilitating commentary or discussion on the experience of using something.

There are well established techniques for eliciting user views, identifying issues, and measuring user satisfaction.

Focus groups

Focus group techniques are powerful for developing concepts and assessing

first impressions. Group discussion is facilitated around predefined topics. Focus groups can be used to discover 'gut reactions' to concepts, elicit expected user requirements, uncover prejudices and to draw out insights into what people think of a existing product. Their disadvantage in evaluating new designs is that they typically involve speculation about the use of future designs, rather than the real experience of trying out prototypes.

User interviews

User interviews can explore people's opinions of products, their preferences, experiences, areas of difficulty, patterns of use, reasons for not using, and suggestions for improvement. Hence interviewing is a key technique at all stages of development. Interview data can be quantitative (counts of responses), or qualitative (insights into issues and motivations). Interviews are highly effective in evaluating usability when used to debrief users after user testing, to explore the experiences that lay behind what was observed.

Interview protocols

It is advisable to work with other stakeholders when designing questions. Create a brief, well-structured list. Use closed questions for quantifiable data, and open questions (to be asked flexibly) to elicit deeper views where required. It is important to ask the right things at the right moment, and to avoid leading questions. It is essential to pilot the interview questions, and revise them as required.

Questionnaires

Questionnaires can ask much the same things as interviews, but have to get good valid answers without the benefit of an interviewer's skills. Hence the question order, wording and administration instructions are critically important. Many questionnaires fail to get good responses simply because they look too long and seem confusing. Keep them short and well structured, and give simple clear instructions.

To make it possible to analyse responses from multiple users, questionnaires should have sufficient simple closed questions, where users can

- state if they agree / are undecided / disagree
- state a degree of agreement or preference

- choose one or more items from a list.

It is important to well define the scale of ratings depending on the expected goals: for example a pair number of rates will avoid the user to indicate an average rate.

Subjective, free text answers can give good insights, but are more difficult to analyse and tend to draw fewer responses. Again, it is essential to pilot the questionnaire, and revise as necessary.

Feedback forms

Questionnaire principles apply to the design of feedback forms, and the forms must visibly be very short and simple. Product feedback forms typically draw very few responses, and these are from a self-selecting minority, so careful interpretation is required, recognising these limitations.

6. New standards and abstract architectural models for integrated Web, interactive TV and mobile applications

The ubiquitous learning and its services do not have to be considered isolated from the developed and new standards and specifications in the area because the goal is to maximize the reusability and portability of the learning process. In the following section a set of standards and abstract models for integrated Web, interactive TV and mobile technologies are listed:

DVB–MHP (Digital Video Broadcasting – Multimedia Home Platform)

The MHP (Multimedia Home Platform) is simply a common API (Application Programme Interface) that is completely independent of the hardware platform it is running on. MHP (Multimedia home Platform) is an open standard platform, which will alter proprietary or vertical markets of existing software platforms into one that will enable content to be authored once and 'run' anywhere. Enhanced Broadcasts, Interactive Broadcasts and Internet Content from different providers can be accessed through a single device *e.g.* set top box or iDTV that uses this Common DVB-MHP API. It will enable a truly horizontal market in the content, applications and services environment over multiple delivery mechanisms (Cable, Satellite, Terrestrial, *etc*.)

MHP defines a generic interface between interactive digital applications and the terminals on which those applications execute. This interface decouples different provider's applications from the specific hardware and software details of different MHP terminal implementations. It enables digital content providers to address all types of terminals ranging from low-end to high-end set top boxes, integrated digital TV sets and multimedia PCs. The MHP extends the existing, successful DVB open standards for broadcast and interactive services in all transmission networks including satellite, cable, terrestrial, and microwave systems.

The core of the MHP is based around a platform known as DVB-J. This includes a virtual machine as defined in the Java Virtual Machine specification from Sun Microsystems. A number of software packages provide generic application program interfaces (APIs) to a wide range of features of the platform. MHP applications access the platform only via these specified APIs. MHP implementations are required to perform a mapping between these specified APIs and the underlying resources and system software.

The main elements of the first release of the MHP specification are:

- MHP architecture (as introduced above),
- Detailed definition of enhanced broadcasting and interactive broadcasting profiles,
- Content formats including PNG, JPEG, MPEG-2 Video/Audio, subtitles and resident and downloadable fonts,
- Mandatory transport protocols including DSM-CC object carousel (broadcast) and IP (return channel),
- DVB-J application model and signalling,
- Hooks for HTML content formats (DVB-HTML application model and signalling),
- DVB-J platform with DVB defined APIs and selected parts from existing Java APIs, JavaTV, HAVi (user interface) and DAVIC APIs,
- Security framework for broadcast application or data authentication (signatures, certificates) and return channel encryption (TLS),
- Graphics reference model,
- Annexes with DSM-CC object carousel profile, text presentation, minimum platform capabilities, various APIs.

The MHP specification provides a consistent set of features and functions required for the enhanced broadcasting and interactive broadcasting profiles. The enhanced broadcasting profile is intended for broadcast (one way) services, while the interactive broadcasting profile supports in addition interactive services and allows MHPs to use the world-wide communication network provided by the Internet (PJB, 2003).

GPRS (General Packed Radio Service)

General Packet Radio Service (GPRS) is a mobile data service available to users of GSM mobile phones. It is often described as "2.5G", that is, a technology between the second (2G) and third (3G) generations of mobile telephony. It provides moderate speed data transfer, by using unused TDMA channels in the GSM network. Originally there was some thought to extend GPRS to cover other standards, but instead those networks are being converted to use the GSM standard, so that is the only kind of network where GPRS is in use. GPRS is integrated into GSM standards releases starting with Release 97 and onwards. First it was standardized by ETSI but now that effort has been handed onto the 3GPP.

GPRS upgrades GSM data services providing:

- Point-to-point (PTP) service: internetworking with the Internet (IP

protocols) and X.25 networks.

- Point-to-multipoint (PT2MP) service: point-to-multipoint multicast and point-to-multipoint group calls.
- Short Message Service (SMS): bearer for SMS.
- Anonymous service: anonymous access to predefined services.
- Future enhancements: flexible to add new functions, such as more capacity, more users, new accesses, new protocols, new radio networks (Wagner, 2005).

3GPP (3rd Generation Partnership Project)

The 3GPP was originally created to produce globally applicable Technical Specifications and Technical Reports for 3rd Generation Mobile Systems based on evolved GSM core networks and the radio access technologies that they support. The scope was subsequently amended to include the maintenance and development of the Global System for Mobile communication (GSM). To insure interoperability, standard codecs will be utilized in transmission of multimedia information. These standards are recommended by the 3GPP SA WG4, which deals with the specifications for speech, audio, video, and multimedia codecs (3GPP).

Wi-Fi (802.11)

Wi-Fi is composed of several standards operating on different radio frequencies: 802.11b is a standard for wireless LANs operating in the 2.4 GHz spectrum with a bandwidth of 11 Mbps; 802.11a is a different standard for wireless LANs, and pertains to systems operating in the 5 GHz frequency range with a bandwidth of 54 Mbps. Another standard, 802.11g, is for WLANS operating in the 2.4 GHz frequency. A draft version 1.0 of the proposed Wi-Fi 802.11n standard was formally adopted for consideration on 19 January 2006 at the IEEE's bimonthly meeting. In addition, it discusses market opportunities for MIMO and 802.11n, which is expected to provide over 100 Mbps of throughput and roughly four times the range of 802.11b/g (Wikipedia).

Infrared Data Association (IrDA)

The Infrared Data Association (IrDA) defines physical specifications communications protocol standards for the short range exchange of data over infrared light, for uses such as personal area networks (PANs). IrDA devices typically have throughput of up to 115.2Kbps or 4Mbps. Smart phones, many

PDAs, printers and laptop computers use IrDA protocols, primary for synchronization with data on the desktop based computers (Wikipedia).

Bluetooth

Bluetooth is an industrial specification for wireless personal area networks (PANs), also known as IEEE 802.15.1. Bluetooth provides a way to connect and exchange information between devices like personal digital assistants (PDAs), mobile phones, laptops, PCs, printers, digital cameras and video game consoles such as the Nintendo Wii and Sony PlayStation 3 via a secure, globally unlicensed short range radio frequency (Wagner, 2005).

WAP (Wireless Application Protocol)

WAP is an open international standard for applications that use wireless communication (for example, Internet access from a mobile phone). WAP was designed to provide services equivalent to a Web browser with some mobile-specific additions, being specifically designed to address the limitations of very small portable devices. It is now the protocol used for the majority of the world's mobile Internet sites, otherwise known as WAP-sites. The Japanese i-mode system is the other major competing wireless data protocol.

WAP 2.0

The new version of WAP, is a re-engineering of WAP using a cut-down version of XHTML with end-to-end HTTP (*i.e.*, dropping the gateway and custom protocol suite used to communicate with it).

Some observers predict that this next-generation WAP will converge with, and be replaced by, true Web access to pocket devices. Whether this next generation (Wireless Internet Protocol to mobile) will still be referred to as WAP is yet to be decided. XHTML MP (XHTML Mobile Profile), the mark-up language defined in WAP 2.0, is made to work in mobile devices. It is a subset of XHTML and a superset of XHTML Basic. A version of cascading style sheets (CSS) called WAP CSS is supported by XHTML MP.

WAP Push

WAP Push has been incorporated into the specification to allow WAP content to be pushed to the mobile handset with minimum user intervention. A WAP Push

is basically a specially encoded message which includes a link to a WAP address. WAP Push is specified on top of WDP; as such, it can be delivered over any WDP-supported bearer, such as GPRS or SMS.

In most GSM networks, however, GPRS activation from the network is not generally supported, so WAP Push messages have to be delivered on top of the SMS bearer. On receiving a WAP Push, a WAP 1.2 or later enabled handset will automatically give the user the option to access the WAP content.

In this way, the WAP Push directs the end user to a WAP address where particular content may be stored ready for viewing or downloading to the handset. The address could be a simple page or multimedia content (*e.g.* polyphonic ring tone) or a Java application. Using WAP Push, one can make it easier for end users to discover and access new mobile services (Wikipedia).

Universal Mobile Telecommunications System (UMTS)

Universal Mobile Telecommunications System (UMTS) is one of the **third-generation (3G)** mobile phone technologies. It uses Wideband Code Division Multiple Access (W-CDMA) as the underlying standard, is standardized by the 3GPP, and is the European/Japanese answer to the ITU IMT-2000 requirements for 3G Cellular radio systems.

To differentiate UMTS from competing network technologies, UMTS is sometimes marketed as 3GSM, emphasizing the combination of the 3G nature of the technology and the GSM standard which it was designed to succeed.

UMTS supports up to 1920 kbit/s data transfer rates (and not 2 Mbit/s as frequently seen), although at the moment users in the real networks can expect performance up to 384 kbit/s – in Japan upgrades to 3 Mbit/s are in preparation. However, this is still much greater than the 14.4 kbit/s of a single GSM error-corrected circuit switched data channel or multiple 14.4 kbit/s channels in HSCSD, and – in competition to other network technologies such as CDMA-2000, PHS or WLAN – offers access to the World Wide Web and other data services on mobile devices (Wikipedia).

High-Speed Downlink Packet Access (HSDPA)

High-Speed Downlink Packet Access (HSDPA) is a new mobile telephony protocol and is sometimes referred to as a 3.5G technology. In this respect it

extends WCDMA in the same way that EV-DO extends CDMA2000. HSDPA provides a smooth evolutionary path for Universal Mobile Telecommunications System (UMTS) networks allowing for higher data capacity (up to 14.4 Mbit/s in the downlink). It is an evolution of the W-CDMA standard, designed to increase the available data rate by a factor of 5 or more. HSDPA defines a new W-CDMA channel, the high-speed downlink shared channel (HS-DSCH) that operates in a different way from existing W-CDMA channels, but is only used for downlink communication to the mobile (Wikipedia).

Conclusion

As it can be seen from the list above, the current standards define wireless and high capacity wired networks as good perspectives for ubiquitous learning. The new standards of the wireless world are promising, however we should keep in mind that the location of the user, and the traffic of other users have great impact on the connection speed. In the near future, as mid-2007 a new standard, called Long Term Evolution (3G LTE/SAE) is expected. Products offering 100 Mbit/s downlink and 50 Mbit/s uplink wireless connections are expected in 2009. 3G LTE/SAE is the next step in terms of user-service experience, improving latency, capacity, throughput and services. 3G LTE improves spectral efficiency, allowing for a large increase in system capacity and reduced cost per gigabyte. 3G LTE can utilize existing 2G and 3G spectra as well as new spectra. 3G SAE addresses cost-efficient deployment and operations for mass-market usage of IP services as well as improvements in integration of non-3GPP access technologies (3G LTE/SAE).

7. Services for ubiquitous learning applications based on Semantic Web technologies and interoperable ontologies

7.1. The role of ontology for integrating eLearning services

eLearning systems are made possible by the ubiquity of Internet standards such as TCP/IP, HTTP, HTML and eXtentensible Markup Language (XML) – an evolved representation format for interoperability. Additionally, emerging schema and semantic standards – such as XML-schema, Resource Description Framework (RDF) and its extensions, and the DARPA Agent Markup Language and Ontology Inference layer (DAML+OIL) together provide tools for describing Web resources in terms of machine-readable metadata. While, some these technologies are matured and already in use, ontology representation languages promise to play an important role in the development of the Semantic Web.

The adoption of XML Standard with open Internet protocols has further defined a way of integrating distributed resources at the software service level. There is a rapid evolution and adoption of Service Oriented Computing (SOC) paradigm (Papazoglou & Georgakopoulos, 2003) that utilises services as fundamental elements for developing applications. This provides a foundation in achieving interoperability and heterogeneous access to learning resources. SOC involves service layers, functionality and roles as described by the Services Oriented Architecture within which, services are self-describing, open components that support rapid, low-cost components of distributed applications.

Alongside evolutionary representation formats for interoperability, many metadata standards have also emerged for describing eLearning resources. Amongst others are: Learning Object Metadata (LOM), Sharable Content Object Reference Model (SCORM), Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE), Instructional Management System (IMS). While, most of these approaches provide a means for describing, sharing and reusing resources, the concept of interoperability and heterogeneous access to content chunks is yet to be fully achieved.

Using service-oriented architectures with existing metadata standards may provide a unified way for enabling interoperable eLearning services. This requires a formal way of representing these services.

Ontology has been term adopted from philosophy used in computing to describe formal, shared conceptualisations of a particular domain (Fensel, 2001)

(Gruber, 1995). Tom Gruber defines ontology as "*an explicit representation of a conceptualisation. The term is borrowed from philosophy, where ontology is a systematic account of existence. For AI systems, what 'exists' is that which can be represented*." Ontology represents information entities such as persons, artefacts and events in an abstract way. Ontologies are designed so that knowledge can be shared with and among people and possibly intelligent agents.

Ontologies are therefore advanced knowledge representation, which consists of several components including: concepts, relations and attributes, instances and axioms. Hierarchical concepts are linked with an "is-a" relation. It is clearly due to the unambiguous nature of ontologies that it has probably become the most rapidly evolving with diverse areas of applications. It has been envisaged that ontological engineering could assist in dealing with interoperability challenges in eLearning systems.

Ontologies enable semantic interoperability between information systems thereby serving a central role for the Semantic Web and in particular a means for integrating eLearning services. They can be used to specify user-oriented or domain-oriented learning services. Intelligent mediators can also use them – a central notion in teaching and learning. Therefore the development of ontologies has been useful for object or service modelling for eLearning domain (Ishaya, 2005). While it is clear that ontology engineering enables interoperability, most ontological structures and protocols are fixed and implicitly assumed. Thus, the agent that engages in integrating different ontologies is assumed to know and agree with both structures and protocols in priori. This is suitable in closed environments. But advances in technologies are increasingly pushing eLearning towards open, flexible and dynamic environment. It should also be noted that ontologies do not overcome any interoperability problems, since it is hardly conceivable that a single ontology could be applied in all kinds of domains and applications. In order to explore an open and flexible way of integrating ontologies, the next section describes a conceptual framework proposed by (Ishaya, 2005).

7.2. Semantic integration framework

Based on the background provided in the previous section, it can be seen that the main challenge of eLearning systems developers is towards moving beyond simple extension of learning resource access to providing mutual understanding that may exist between the diverse learning contents. To meet this challenge, this section presents "Semantic Integration Framework" shown in Figure 4. It defines three main layers- interface, service integration and management with service composition running across all the three main layers (Ishaya, 2005).

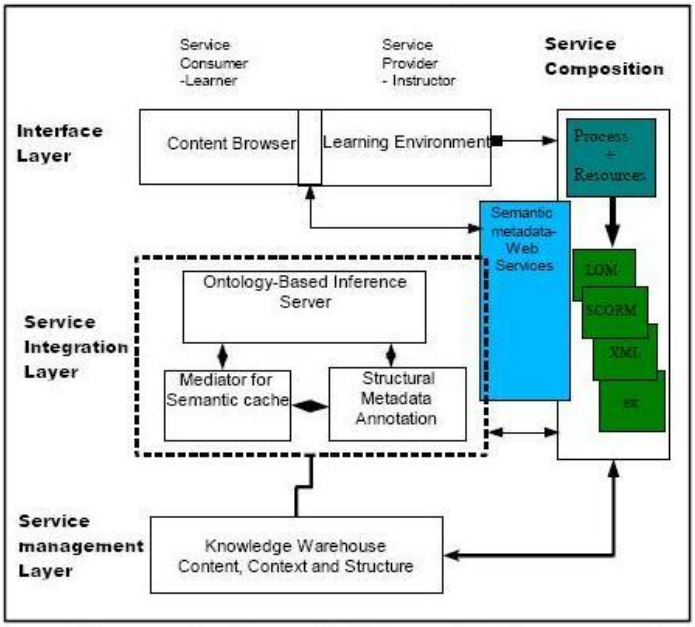

Figure 4: Semantic Integration Framework

The aim of the framework is to provide an integration service platform that offers learner-centric support for Web-based learning and semantic relations between source learning resources. This has been developed using web services, an ontology and agent components. The heart of the framework is the service Integration layer – a semantic bridge that defines semantic relations between source and target ontology instances. Here, source ontology instances are different standards used in describing learning objects (LOM, SCORM, XML, *etc*.) (Ishaya, 2005).

Within the framework several learning objects providers can submit their learning objects based on existing metadata standards and be verified for a service-based on a well-defined ontology. The service composition layer provides tools that help with the composition of re-usable learning services. This is done through a defined task/process flow engine. The framework supports a contextual representation for flexible operation and integration of learning services. This will enable description of low level basic features of a learning object (*e.g*. content), an intermediate (metadata level) describing the characteristics, functions and associated objects (*e.g*. title, author) and the high-level description of contexts and meaning associated to each learning object and then services. At the service

integration layer, an ontology-based inference server will define target ontology instances. It specifies the domain knowledge ontology that would better understand the domain information coming from different instances. This is achieved by providing a binding code between the domain ontology inference and source ontology instances using web services. The agents will then interact with the content parser to provide the user with relevant and customised learning needs. Within the service integration layer is also the mediator for semantic cache, this has been introduced to increase semantic comprehension among difference services and models.

Knowledge relating to the relationships between learning objects, which will be gained from the description logic, will be useful in comparing the objects within a learning object repository. When mappings are identified between objects and ontologies, the appropriate mark-up will then be generated for the appropriate learning service. The interface layer is to provide an integrated user Interface for both the content provider and the consumer. This provides a content parser that would deal with different functions and presentation formats. Thus a learner using Blackboard for example would have their semantic and related information transformed into Blackboard style presentation, which those using standard Web browsers would see theirs transformed in XML format. XML standard is used in order to facilitate content parsing for different presentation styles (Ishaya, 2005).

8. Services for creation, storage and delivery of personalized, reusable, shareable content objects. Access-on-demand to digital libraries for ubiquitous learning

Services for creation, storage and delivery of personalized, reusable, shareable content objects

A very important trend of the future is that any learning content from any source (digital libraries and repositories with digital objects, knowledge grids, *etc*.) will be available anywhere at any time – via natural interaction – on any interactive learning platform, in any format desired by the user, which implies that a specific attention should be paid to services to content delivery, creation (production), adaptation, personalization, storage, indexation, semantic searching, *etc*. This section will discuss the main issues and future trends of these services (NEM, 2006).

Services for learning content discovery

In a near future world where content on demand is available everywhere from any providers, finding appropriate learning content for the user needs (discovery) becomes of the most importance. Discovery can be both of specific pieces of content and also packages of related content. The discovery engine should have some intelligence, remembering previous choice selected and that information to steer new searches. The normal, current use of discovery is for a search to be conducted, followed by the subsequent download of the information being sought. This is the way most people expect discovery to be used. An alternative view is that the search service could be based on an example or based on searches one has made previously (based on a profile that could be stored in the network or in the learning platform) or on some consensus view.

Services for learning content production

The mission of the future ubiquitous learning platform, as far as content is concerned, should be to facilitate the production of new audiovisual learning content that take maximum advantage of the new capabilities of networked electronic media in order to integrate all citizens into the Information and Knowledge Society.

The production of interactive learning content will become the most important

element of content production. Learning content will ask for contributions from individuals, and individuals will wish to personalize and adapt content to their needs.

The main requirement is the realization of more economical and more easily usable tools for content production. It is therefore crucial that content developers have better access to technology that enable them to create content and implicitly opens the way to distribution channels.

Domestic tools offering content capture services are already almost indistinguishable from professional tools; the focus should be on tools for content manipulation and editing that run on domestic IT equipment. Above all, such tools must be intuitively usable – this will require trials with large user groups.

The main issues will be concerned with usability and rights management rather than with the technology itself.

Services for learning content adaptation

Learning content adaptation is the ability to tailor content to the current circumstances of the user. Content adaptation is related to content personalization, which is concerned with tailoring content semantically to the user's requirement.

Today, very little content adaptation is performed by the learning platforms. Some features are supplied in the field of media adaptation, but this adaptation is very light. Some broadcasters make low-resolution versions for the content available on Web. Video content may have components to make it more accessible to some users – subtitles for the hard-to-hearing, sign language interpretation, and audio description for the blind or partially sighted – and these components sometimes can be selected optionally by learner.

Several international research efforts are focused on the design and implementation of middleware infrastructures for content adaptation. Most of those proposals tend to adopt an adaptation approach based on static content selection, some research activities have already addressed real-time content production, and only a few research efforts consider dynamic binding to resources and service components.

The broadcasters' promise is to supply services that are easy to use and better adapted to what the user needs by providing learning information in the right

format. The vision is to achieve autonomous on-the-fly adaptation, with no human intervention, adapters should be capable of self-description, and a pervasive support infrastructure should take the appropriate context-based adaptation decisions, without affecting the design and implementation of multimedia servers and client applications.

Learning content personalization and context awareness

Learning content personalization is the ability to tailor the content to the learner's preferences as well as the learner's context. Personalization is a means of meeting the user's needs more effectively and efficiently by making interactions faster and easier. Furthermore, content personalization is closely related to knowledge management, data mining, and learning objects annotation and indexing.

User experience personalization will be effective when they are receive highly relevant learning content available exactly when they want – any type of media available at anytime and in the most efficient way. Advanced learning content delivery systems need to exploit information about the environment in which they are working.

This 'context awareness' is much more than location awareness alone, or merely the immediate situation. The vision is to have a middleware infrastructure capable of collecting all context metadata from clients, servers, involved resources and the environment in general and of transparently deciding the most appropriate content customization operations, with no impact at all on the design and implementation of multimedia clients/servers.

A very important objective in the field of personalization is the development of a system that is aware of the user's situation. Such a system will interpret the contextual information in the light of preferences previously declared by the user or choices previously made to supply appropriate 'tagged and targeted content'.

A support service infrastructure should be able to properly aggregate data about the context, in order to distil a context view at the proper level of abstraction depending on who/what is in charge of taking decisions on the basis of that view. Sometimes, those context data should be migrated, possibly proactively, with the learner they apply to, depending on learner movements during the service session.

Services for content indexation (automatic generation of metadata)

Indexation means generating search keys enabling efficient retrieval of content in both relevance and speed respects. The lack of proper indexing and retrieval system is rendering useless most of the huge collections of digital multimedia content that are available. Only a few indexing techniques can be considered as mature and effectively deployed audio and video segmentation, image and music identification, speech-to-text transcription in very favourable conditions, *etc*.

The main aim is to develop advanced automatic analysis and recognition tools and systems for audio visual learning content capable of generating highly semantic metadata in a very fast and reliable way. Target services include audiovisual delivery over fixed and mobile networks (TV, VoD) and all associated functionalities, personal content management, professional content management, *etc*.

Semantic searching for content

Discovering content can be defined as the act of which a user or an agent finds a description that fulfils certain user criteria. The primary goal in content discovery is always to find the most suitable content among all the possible ones. The search engines, nowadays, accept key words as input and generate as output a list of objects that contain these words. The quality of the results depends on the classification of the list.

A semantic search has two main advantages compared with the traditional search: it accepts questions formulated in natural language and the result of these questions is a fragment of information that is sought. Semantic searching attacks the overload of information. It may have the potential of revolutionize the way in which we search digital information. It changes the paradigm of "search" to "content selection".

Digital libraries for ubiquitous learning

A promising direction in the current eLearning strategies and activities points to contemporary ubiquitous learning through the involvement of digital libraries in the learning processes. Digital libraries are a contemporary conceptual solution for access to information archives. According to an informal definition of digital libraries, they are managed collections of information, with associated services, where the information is stored in digital formats and accessible over a network.

Digital libraries contain diverse hypertext-organized collections of information (digital objects such as text, images, and media objects) for use by many different users. The collected information is organized thematically and uses hyperlinks that allow the connection between any piece of data and additional data on the same topic. As an addition to the digital objects collection, there are many levels of metadata, indexes, hierarchical links, *etc*. (Krastev, 2005).

The main characteristics of digital libraries are the following:

- Ability to share information;
- New forms and formats for information presentation;
- Easy information update;
- Accessibility from anywhere, at any time;
- Services available for searching, selecting, grouping and presenting digital information, extracted from a number of locations. Using these services depends on the user preferences, needs and wishes of the users, *i.e.* there is personalization available;
- Contemporary methods and tools for digital information protection and preservation;
- Ability to use different types of computer equipment and software;
- No limitations related to the size of content to be presented.

In the past digital libraries were isolated and monolithic systems limited to access to content of a single provider. The development of the technologies during the last years provides new functionalities and advanced services to contemporary digital libraries such as specialized services for

- Multi-layer and personalized search, context-based search, relevance feedback, *etc*.
- Resource and collection management;
- Metadata management
- Learning content personalization and context awareness;
- Content indexation;
- Semantic annotation of digital resources and collection, *etc*.

The new digital libraries will provide and manage complex services, processes and workflows on the basis of existing services. It is expected that these services be heterogeneous, autonomous and distributed. The flexibility, the automatic adaptation, the access anywhere and anytime, the decentralization, the wide variety of digital objects and collections, the information security, *etc*. will be of the some requirements (Kiernan at al. 2003).

Digital library architectures

A **hypermedia digital library** (HDL) can be considered as a database, storing data of different type (text, raster, vector, static and moving images, animation, audio or other media), which is structured in a way to allow easy manipulation and use. Data is stored in the database in the form of objects, usually annotated to facilitate running search queries. To make these procedures automatic, the HDL includes techniques for descriptive presentation of the data semantics as well as services for its management (Pavlov&Paneva, 2005).

Web technologies help organizing hypermedia digital libraries by providing a means to structure and present them in a hypermedia manner. Hypermedia represents hypertext media; therefore it adheres to the hypertext information organization rules. Users are allowed to quickly move across subject-related topics in a non-linear way. These topics may include sets of objects, such as text, images, audio and other media, which relate to one another via hyperlinks. The HDL is a simplified conceptual solution for presenting complex multimedia content in the Web space (Pavlov&Paneva, 2005).

Grid-based infrastructure – The digital library is currently undergoing a transition from a statically integrated system to a dynamic federation of services. This transition is inspired by new trends in technology which include developments in technologies like web services and grid infrastructures as well as by the success of new paradigms like peer-to-peer networking and service-oriented architectures. The transition is driven by digital library "market" needs. This includes a requirement for a better and adaptive tailoring of the content and service offer of a digital library to the needs of the relevant community as well as to the current service and content offer, and a more systematic exploitation of existing resources like information collections, metadata collections, services, and computational resources.

Such new decentralized and service-oriented architectures for digital libraries make the library functionality available in a more cost-effective and tailored way and thus open up new application areas for digital libraries. Future digital libraries should enable any citizen to access human knowledge any time and anywhere, in a friendly, multi-modal, efficient, and effective way. A core requirement for such digital libraries is a common infrastructure which is highly scalable, customizable and adaptive.

A grid is a network or collection of distributed computer resources, which are accessible through local or global networks and are presented to the end user via an

enormous virtual computer system, *i.e.* it is a virtual, dynamically changing organization of structured resources, which are shared among individuals, institutions and systems. Some of the main advantages of the grid technology are: optimized and personalized access and enhanced management of digital resources; virtual resource organization; ability to be used worldwide, *etc*. The grid technology introduces essential improvements in the current distributed information systems, which are the proper basis for building contemporary digital libraries.

In essence, the creation of virtual digital libraries on the basis of grid-based infrastructures, support for the integration of metadata, personalization services, semantic annotation and the on-demand availability of information collections and extraction services will make digital libraries more useful and attractive to a wider clientele. Such a test-bed digital library infrastructure has been created for the DILIGENT project (integrated project funded in part by the European Commission FP6 IST Programme), based on the grid technology (DILIGENT). Figure 5 depicts DILIGENT infrastructure.

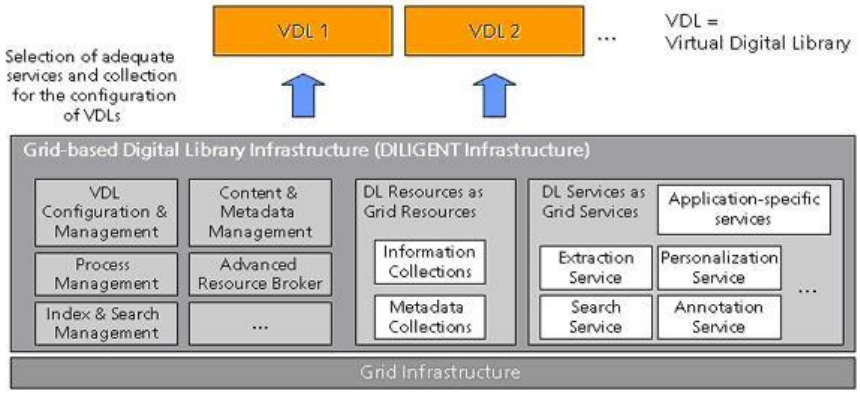

Figure 5: Grid-based digital library Infrastructure

Hyperdatabase infrastructure – Future digital libraries should enable any citizen to access human knowledge any time and anywhere, in a friendly, multi-modal, efficient, and effective way. A core requirement for such digital libraries is a common infrastructure which is highly scalable, customizable and adaptive. Ideally, the infrastructure combines concepts and techniques from peer-to-peer data management, grid computing middleware, and service-oriented architectures. That infrastructure is offered in the project DELOS „A Network of Excellence on Digital Libraries" (DELOS) funded by the EU's Sixth Framework Programme

(6FP). Peer-to-peer networks allow for loosely coupled integration of digital library services and the sharing of information such as recommendations and annotations. Grid computing middleware supports the dynamic allocation and deployment of complex and computationally intensive digital library services such as the extraction of features from multimedia documents to support content-based similarity search. A service-oriented architecture provides common mechanisms to describe the semantics and usage of digital library services. Furthermore, it supports mechanisms to combine services into workflow processes for sophisticated search and maintenance of dependencies. As depicted in Figure 6, the digital library architecture envisaged consists of a grid of peers which provide various kinds of digital library services such as storage, extraction or retrieval services. These digital library services can be combined with processes. High scalability is achieved by executing the processes in a completely distributed, peer-to-peer fashion. For that, metadata about processes, services, and load of the peers is distributed and replicated over the grid. This is performed by a small hyperdatabase layer atop each peer. This layer also takes care of peer-to-peer navigation and execution of processes.

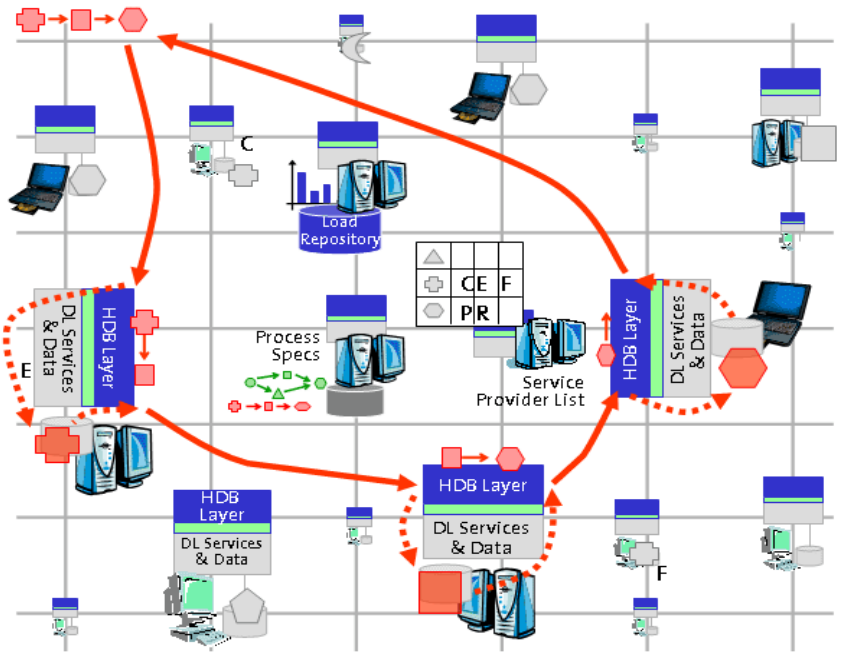

Figure 6: Digital library architecture based on a hyperdatabase infrastructure

Digital libraries and eLearning systems vis-à-vis

The involvement of digital libraries in the eLearning processes requires the formulation of special features and principles that are to be met by the digital libraries so that the latter can be used efficiently by the eLearning systems. The last-years' trends of eLearning for optimising and advancement put additional requirements to the learning process and construction of work scenarios. In that sense, the following special features and principles can be laid down:

Resources-on-demand – Digital libraries have to provide resources and materials on-demand to the end-user. Tools and technologies to support indexing, cataloguing, retrieving, aggregating, and creatively exploiting of different textual, non-textual and complex objects /resources have to be developed in them. New eLearning trends dictate the implementation of tools for personalised preference-based access to digital libraries in which the user's preferences will be used for filtering, extraction and aggregation of digital objects in order to reduce the volume of data presented to the user.

Resource description – The objects in digital libraries have to be segmented (*i.e.* partitioned into logical units), annotated and semantically indexed so that metadata are attached to them and describe their content including semantic descriptions based on appropriate domain ontologies. The metadata are written with standard description languages and are stored in an appropriate metadata repository that provides management services including efficient retrieval based on Boolean and similarity queries so that it is possible to search for content satisfying various search parameters.

Interoperability – Establish protocols, standards and formats to facilitate the use and assembly of distributed digital libraries and their resources.

Intellectual property rights – A key element for digital libraries is appropriate recognition and protection of legal rights such as copyright, publicity, privacy, matters of obscenity, defamation, intellectual property protection. The vision for digital libraries includes fluid, easy access to a wide variety of materials. This is often in conflict with the duties of libraries and archives entrusted with care and management of materials that may be subject to privacy rights or other needs for security. Efforts to formulate digital libraries will be delayed or frustrated in the absence of a common, responsible framework of rights, permissions, and restrictions that acknowledges the mutual needs of rights-holders and users of materials in digital libraries. The challenge here is, in part, to develop mechanisms, perhaps social expectations independently or in combination with technical means,

regarding acceptable levels of access (for example where privacy rights are at issue) and use (such as the extent or permissible copying and dissemination).

Heterogeneous resources in a coherent way – A digital library that provides diverse content will be characterized by heterogeneity in original format, in digital format and resolution, and in the level of detail and format of descriptive information that is available to support access. In the face of great diversity of content and description, special problems attend to the development of a coherent approach to indexing and presenting retrieval results. It is important that any approach allows all the information available to be used to aid the retrieval rather than force the user who wants to search across the entire resource to rely on some lowest common denominator of descriptive information.

Sustaining the resource – The creation and maintenance of digital libraries is very expensive. Costs are incurred for production, for ongoing provision of access, and for preservation of the digital information. The cost to develop and operate a distributed architecture for long-term archiving, migration, and backup of digital materials are high, too. Libraries would benefit from better estimate of costs and trends in cost for production and maintenance of a corpus of digital information *i.e.* it is important to develop economic models for the support of digital libraries.

Provide more efficient and more flexible tools for transforming digital content to suit the needs of end-users – Today, each content item in most digital libraries is represented in multiple forms or versions. The multiple forms exist to serve varieties of users, function as archival masters, and reduce download time and transmission loads on networks. A content provider may produce large and small versions of images; compressed and uncompressed versions of images, texts, audio, and video; texts formatted for browser software and also formatted for preservation or publication; and materials both in proprietary formats and in public or "open" formats. This burden of plural production and maintenance results from the fact that today many digital objects are hard to transform on the fly. Similar capabilities are also needed to ensure the preserving of digital content for posterity.

The objects in digital libraries and repositories are usually stored in raw format and the content often in not structured to be used for learning purposes. For that reason, it is important to provide clear-defined processes of transformation of library's resources into learning objects. One decision is offered in the project "Knowledge-on-Demand for Ubiquitous Learning" (LOGOS) through the development of authoring studio for generation of learning resources from existing digital archives (figure 7). The authoring studio will include a working environment with tools for pre-processing of digital audio and video objects from

existing archives. The pre-processing tasks may include format transformation, segmentation, indexing, annotation, semantic description, *etc*. The authoring studio will permit building-up of reusable and compound learning objects. The versatile pre-processing of the available audio and video materials will allow the users – authors of learning materials, lecturers and/or advanced learners – to achieve a good personalisation level of the produced courseware, considering the learning context, learners aims, stimuli, and interests, educational and cultural background, learning places, learning styles, course organisation, course duration, *etc*. The creation of the courseware will be based on sound educational model of the learning process, considering the specifics of combined (Web-based, DVB-based, mobile) delivery mode. The Web-based versions of courseware, produced by means of the authoring studio, will be formed according to international learning standards (*e.g*. SCORM) in order to be applicable for different Learning Management Systems.

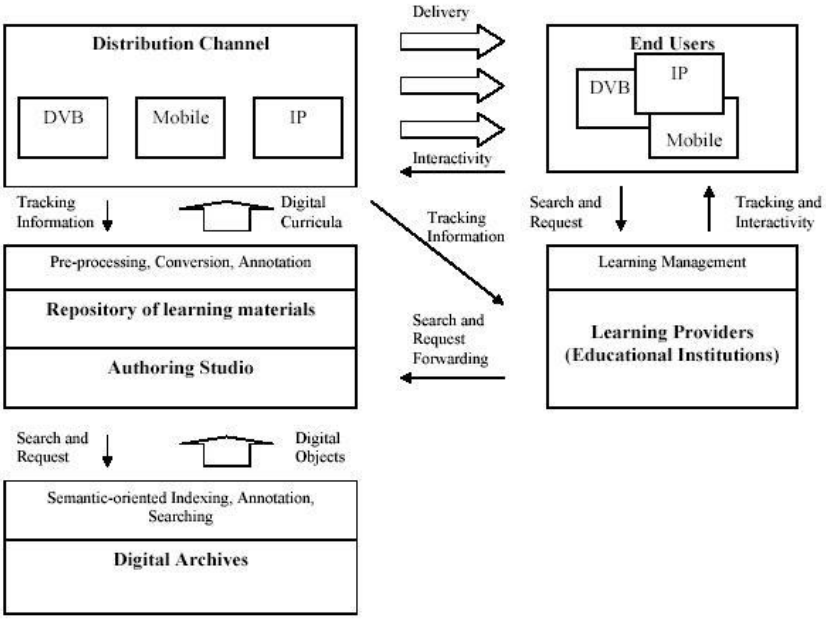

Figure 7: Conceptual Scheme of LOGOS platform

Some applications of digital libraries in eLearning systems

During the last few years a lot of eLearning projects have been developed

using the digital libraries with multimedia content as a source of multiple digital objects and services. This section presents some of them.

The **project "DialogPlus – Digital Libraries in Support of Innovative Approaches to Teaching and Learning in Geography"** aims to embed a wealth of existing digital resources developed in the US and the UK into the curricula of four US and UK higher education institutions, in four different sub-areas of geography. The electronic resources are made available through interoperable digital library technology and integrated directly into course units in undergraduate programs supported by virtual learning environments within each institution (DialogPlus).

The project **"Digital Libraries for Global Distributed Innovative Design, Education and Teamwork" (DIDET)** proposes the development, implementation and use of a test-bed to improve the teaching and learning of students partaking in global team-based design projects and combines the use of digital libraries with virtual design studios.

The Arts and Humanities Data Service (AHDS) Visual Arts through its association with the Arts and Humanities Research Board serves the research initiatives by:

- Providing Internet access to collections of visual arts digital resources created by and of use to the research community;
- Preserving visual arts digital resources to ensure its long term use;
- Promoting good practice and advice for the creation and use of visual arts digital resources for research purposes.

Moreover, AHDS Visual Arts has completed "Promoting the use of on-line image collections in learning and teaching in the visual arts" (PICTIVA), a two-year project whose aim is to promote the use of online image collections in learning and teaching in the visual arts.

The **project "Knowledge-on-Demand for Ubiquitous Learning" (LOGOS)** contributes to the openness for ubiquitous learning of the large-scale repositories of digitised text, graphics, audio, video objects and to the process of their transformation into learning content, adequately enhancing and facilitating the knowledge building.

The LOGOS project involves the multimedia digital library, named "Virtual

Encyclopaedia of the Bulgarian Iconography", for the implementation of the learning scenario "Access-on-Demand for studying of East-Christian culture and art" for ubiquitous learning in different learning contexts, through different modes and levels of integrated Web-based and mobile technologies (Pavlov et al., 2007). This Internet-based environment becomes a place where iconographical objects of different kinds and origins were documented, classified, and „exhibited" in order to be widely accessible to both professional researchers and the wide audience. Rare specimens, private collections, icons from difficult-to-access storages, distant churches, chapels, and monasteries, objects in a risk environment or unstable conditions, *etc*. are appearing for new e-exposition. The library provides services for registration, documentation, access and exploration of a practically unlimited number of East-Christian iconographical artefacts and knowledge (Pavlova-Draganova et al., 2007) (Pavlov et al., 2006a) (Pavlov et al., 2006b) (Paneva et al., 2007) and the end users could use this rich knowledge base through its interactive preview, objects complex search, selection, and group, personalization. The first release of the BIDL was developed five years ago during the national project "Digital Libraries with Multimedia Content and its Application in Bulgarian Cultural Heritage" (contract 8/21.07.2005 between the Institute of Mathematics and Informatics, BAS, and the State Agency for Information Technologies and Communications).

The LOGOS project main objective was to create a platform for ubiquitous (any place, any time, personalized) learning which combines:

- a subsystem, called "Authoring studio" for creation of learning materials from existing digital repositories by semantic annotation and access.
- facilities for cross-media courseware delivery through digital video broadcasting, mobile and IP-based communication channels.

The architecture of the LOGOS authoring studio (Arapi et al., 2007d) is based on the following hierarchy of data models for the information objects:

- *Media objects* – 'raw' multimedia (MM) objects, catalogued in the repositories with some technical characteristics orientated to multiple channel delivery;
- *Digital objects* – media objects, annotated with technical and administrative, as well as with content describing semantic metadata, based on domain ontologies;
- *Learning objects* (presentational and assessment objects) – digital objects, enriched with educational metadata (LOM);

- *Courseware objects* – graphs of learning activities associated with learning objects.

The LOGOS platform takes in consideration the following user roles:

- *Knowledge Engineers* – their involvement in the development of learning resources is to create and maintain domain-specific ontologies, necessary for the semantic description of MM content.
- *Annotators* – they are involved in the development of learning resources by annotating, segmenting and semantically indexing the raw MM material in order to create and maintain digital objects.
- *Educationalists* – they create reusable learning objects by sets of digital objects, enriched with educational metadata.
- *Learning Designers* – they create abstract learning scenarios for dynamic development of personalized courseware.
- *Courseware Developers* – they create, maintain and publish courseware for learners.

The Architecture of the LOGOS platform includes the following main blocks:

- *Ontology Management Tool* for creation and management of multilingual domain ontologies with graphical, intuitive and user friendly interfaces that could be efficiently used by domain experts (knowledge managers). The tool can create and manage knowledge inference rules, constraints and templates in order to reduce the indexation effort. Uses Conceptual Graphs formalism.
- *Content Description Tool* – produces LOGOS Digital Objects by segmentation and indexing of the MM objects, their annotation, semantic description and necessary format transformations. Uses semantic indexing templates created by the OMT to guide the annotation process.
- *Description Tool for Learning Objects* – produces reusable LOGOS Learning Objects by pre-selection and organization into a hierarchy of relevant Digital Objects for a given pedagogical use. Provides means to create educational (LOM) metadata.
- *Courseware Objects Editor* – produces Courseware Objects, including quizzes (learner assessments), by combining appropriate Learning Objects.
- *Publishing Tool*: Publishes indexed, annotated, translated and enhanced audiovisual segments in appropriate formats to be used by

Learners using different devices such as PCs (SCORM objects), mobile phones and ITV.

- *Dynamic Courseware Creation Middleware*: for automatic creation of personalized courseware (eventual further editing by Courseware Objects Editor) according to specific learning needs expressed in Learner Profiles and using a set of Learning Designs.
- *Learning Management System components*: for delivery of courseware to Learners encapsulating functionality to adapt the learning material to user needs/delivery devices (not part of the Authoring studio).

The LOGOS platform includes also the following repositories:

- *Media Server* – manages Media Objects coming from external content archives;
- *Digital Objects Repository* – manages Digital Objects created on top of Media Objects or parts of them annotated and indexed with administrative and semantic metadata;
- *Learning Objects Repository* – manages Learning Objects built on top of Digital Objects and enriched with educational metadata;
- *Assessment Objects Repository* – manages Assessment Objects (Assessment Items or Tests) enriched with educational metadata.
- *Courseware Objects Repository* – manages Courseware Objects utilizing the underlying Learning Objects and Assessment Objects and corresponding to learning experiences that can be delivered using different delivery devices.

Topic Maps-based digital course library

Digital course libraries are educational Web applications that contain instructional materials to assist students' learning in a specific discipline. They play a vital role in out-of-class learning, especially in project-based and problem-based learning, as well as in lifelong learning. Digital course libraries are expected, on one side, to provide learners with powerful and intuitive search services that allow them to efficiently access learning resources, and on another, to support instructors with powerful authoring services for efficient creation and updating of instructional materials. The latter is closely related to the issue of reusability and shareability of learning content, which in turn is related to both the existence of shared agreement on the content and the standards-based representation of the materials.

Dicheva&Dichev address the problems of findability, reusability, and shareability of learning materials in digital course libraries by suggesting the use of Semantic Web technologies in creating them (Dicheva). More specifically, they propose a framework for digital course libraries that incorporates a meta-layer - semantic layer, based on conceptualization of the course subject domain. The fundamental idea is to build those libraries as both concept-based and ontology-aware repositories of learning objects. Further on, they propose that the implementation of such libraries is based on the ISO XTM standard – XML Topic Maps. Topic Maps (TM) are an emerging Semantic Web technology, that can be used as a means to organize and retrieve information in eLearning repositories in a more efficient and meaningful way.

Topic Maps provide an external meta-structure (a knowledge navigation layer) in the form of a dynamic, semantically based hypertext. As a result, TM-based courseware can offer the following benefits:

- For learners: efficient context-based retrieval of learning resources; better awareness in subject-domain browsing; information visualization; customized views, adaptive guidance, and context-based feedback.
- For instructors: effective management and maintenance of knowledge and information; personalized courseware presentations; distributed courseware development; reuse and exchange of learning materials, collaborative authoring.

The project goals include:

- Development of a framework, which facilitates building of ontology-aware digital course libraries that provide trusted reference information for self-study coupled with support for resource location and domain comprehension.
- Design, implementation, and evaluation of a software tool, which enables services such as creating, maintaining, and integrating disparate learning objects into standards-based ontology-aware digital course libraries.
- Design, implementation, and evaluation of a software tool that supports efficient search service, browsing, and navigation of course libraries.

TM4L: Creating and browsing educational Topic Maps

TM4L is an eLearning environment, which enables the creation, maintenance, and use of ontology-aware learning repositories based on Topic Maps. It provides support in conceptual structure design and maintenance through its functionality for editing, browsing, and combining such structures, coupled with support for relating concepts, linking concepts to resources, merging ontologies, external searching for resources, defining perspectives, *etc*. The TM4L environment consists of a TM editor and a TM viewer.

The TM4L editor

The TM4L editor is an ontology editor allowing the user to build ontology-driven learning repositories using Topic Maps. It provides ontology and metadata engineering capabilities coupled with basic document management facilities. The TM4L editor benefits from the Topic Maps' fundamental feature to support easy and effective merge of existing information resources while maintaining their meaningful structure. This allows for flexibility and expediency in re-using and extending existing repositories. The learning content created by the editor is fully compliant with the XML Topic Maps (XTM) standard and thus interchangeable and interoperable with any standard XTM tools. The TM4L editor is Topic Maps-based, thus the main objects that it manipulates are topics (representing domain ontology concepts), relationships between them, resources, and contexts (represented by themes). It includes four different sections (views): *Topic Map*, *Topics*, *Relationships*, and *Themes*. The TM4L editor is implemented in Java and uses the TM4J Topic Map Engine (TM4J), which is an open source providing a comprehensive API that allows creating and modifying Topic Map structures stored either in-memory or persistently in a database. The editor has open modular architecture that allows an easy extension of its functionality.

The TM4L viewer

Authors consider the exploration practice as the process of finding information that is relevant to the learner's current tasks. There is a tendency towards browsing in terms of exploration, and the TM4L viewer should therefore be enhanced to better support both browsing and the combination of search and browse activities. The exploration practice differs from information querying in that no specific question needs to be answered. Instead, the user/learner wants to know about relevant information at a more global level, *e.g*. to see what information is available in terms of their current information needs. Exploration also differs from general analysis in that the issue is not to oversee the entire

collection in a holistic way but only inspect those parts relevant to the learner's current task. The exploration of large information spaces is a difficult task, especially if the user is not familiar with the terminology used to describe information. Conceptual models of a domain in terms of thesauri or ontologies can remedy this problem to some extent. Exploration on the level of concepts and relationships can be used as a navigation and query formulation mechanism fostering semantic exploration and discovery. In order such an ontological framework to be useful, there is a need for interactive tools for exploring large information sets based on conceptual knowledge.

9. Learner modelling, profiling and personalization. Learning customization

Learner modelling, profiling and personalization

The student model enables the system to provide individualised course contents and study guidance, to suggest optimal learning objectives, to determine students' profiles and the actual knowledge they have acquired, to dynamically assemble courses based on individual training needs and learning styles, and to join teachers able to provide support in terms of guidance and motivation and therefore to help the students with different backgrounds and knowledge levels to achieve their learning goals effectively on the Web.

The software developers face a number of challenges and difficulties when trying to model student profile and activities on real eLearning systems. The process of collecting student modelling data is time-consuming and requires the development of complex data structures to represent student's personal information, knowledge and behaviour in the learning domain. Once student data is collected, it must be converted into a format compatible with knowledge representation and reasoning systems to function as the input for the adaptive systems. Faced with these requirements, student modelling data is often stored in proprietary, hard-to-access formats that don't encourage reuse or distribution. In addition, in most cases the student models can only be used with the learning application, which it was developed for and when the application is changed or replaced they will be useless.

The student model needs to cover a certain amount of information that can be divided into two main groups:

- general student information such as learning goals, cognitive aptitudes, measures for motivation state, preferences about the presentation method, factual and historic data (personal information), *etc.*,
- information about student's behaviour in the learning domain such as overall competence level for the course, module competence level, concept competence level, module study time, test solving status, *etc*.

Naturally, student models "do not have to fully account for all aspects of student behaviour. In fact, we are interested in computational utility rather than in cognitive fidelity" (Self, 1990).

Learner model standards

The standards related to user model definition and representations are two:

- **IEEE Public And Private Information (PAPI).** It specifies both the syntax and semantics of a 'Learner Model,' which will characterize a learner and his or her knowledge/abilities

- **IMS Learner Information Package (LIP).** It can hold information about the learner, including his progress and received awards.

The above mentioned standards have already been described in a concise manner at CHIRON task T2.2 internal report. We give a more detailed description here.

IEEE Public And Private Information (PAPI)

The IEEE Public and Private Information Specification (PAPI) (PAPI, 2002) is a multi-part standard that specifies the syntax and semantics of a 'Learner Model', characterizing a learner (student or knowledge worker) and his or her knowledge/abilities. Learner information may be created, stored, retrieved, used, *etc.*, by learning technology systems, individuals (*e.g.*, teachers, learners, *etc.*), and other entities.

Parameters like knowledge, skills, abilities, learning styles, records and personal information are covered within PAPI. PAPI Learner allows parameters to be presented with an adjustable focus, starting with an overview down to the smallest units. PAPI Learner enables different points of view, which are for example learner, teacher, parent, school, employer and so on. As indicated by its name, PAPI Learner emphasizes the importance of privacy and security for a learner model.

The purpose of this standard is:

- To enable learners (students or knowledge workers) of any age, background, location, means, or school/work situation to create and build a personal learner information repository, based on standards, which they can utilize throughout their education, learning experiences, and work life.
- To promote data portability of learner information.

- To provide a framework for data security, data privacy, and data integrity.
- To enable learning content and learning management systems to provide more personalized and effective learning experiences.

PAPI is divided into three main areas: common features, information types and bindings. These areas are separated into smaller Parts where each Part represents a logical unit of the area. Various implementations of PAPI may include only some parts of the standard.

- The **Common Features** area contains the features such as the Core Features, the Data Element Registry and the Registration Authority. The Core Features include datatypes that are used by other parts of the standard. Information about data elements, such as enumerated value spaces, is covered by the Data Element Registry. Registration Authority Process gives a description of how to maintain the Data Element Registry.
- The **Information Types** area can be considered as learner information types.
- The **Bindings** area provides a mapping to various standards, specifications and technical reports.

The most interesting part of the standard is the six groups of learner information. These six Learner Information Groups cover, as its name already implies, the information about the learner in all details. The Learner Information Groups can be considered as the core and the purpose of the PAPI Learner standard. The Learner Information Groups divide the available information about the learner into six independent logical units, namely:

- **contact information:** is not directly related to the measurement and recording of learner performance and is primarily related to administration.
- **relations information:** is about the learner's relationship to other users of learning technology systems, such as teachers, proctors, and other learners.
- **security information:** is about the learner's security credentials, such as: passwords, challenge/responses, private keys, public keys, and biometrics.
- **preference information:** describes preferences that may improve human-computer interactions.

- **performance information:** relates to the learner's history, current work, or future objectives and is created and used by learning technology components to provide improved or optimized learning experiences.
- **portfolio information:** is a representative collection of a learner's works or references to them that is intended for illustration and justification of his/her abilities and achievements.

The PAPI Learner approach separates the learner information according to these six units. The utilizers of the PAPI Learner standard are not restricted to keep this structure. Thus, they are free to reassemble parts of the learner information to fit their needs.

The free combination of parts of the learner information may reveal privacy and security problems when sharing the information with other organizations. For example, combining the contact and the performance information might be useful for a specific application, but privacy violations occur when this information is shared. In this case there are conflicts between the privacy level of the contact information and the performance information. Such privacy issues were the main reasons why PAPI splits the learner information into six units. However, PAPI does not specify which unit of the learner information is private and which is public. It permits to handle the units of the learner information in different ways with respect to privacy. For example the learner contact information is private and secure while the learner preference information is marked as public. The level of security and privacy is selected by the administrator. An administrator can be the learner (for its own learner information), or the administrator of the organization.

IMS Learner Information Package (LIP)

The IMS Learner Information Package (IMS LIP, 2001) is a specification for a standard to record information about learners. Version 1.0 was released in March 2001 and the current version is 1.0.1 with some minor changes to the original version 1.0.

LIP is designed to hold information about the learner, including his progress and received awards. Further, LIP enables the transfer of this information between different software applications. More precise, LIP is a collection of information about a learner or a producer of learning content. The roles are not limited to one single learner; groups of learners can be handled as well. Producers of learning content may be organizations or individuals and are separated into three divisions, namely Creators, Providers and Vendors, with different tasks and rights. To

provide the ability of exchanging this information among different applications, the information is split into several packages.

The structure of IMS LIP consists of segments or categories and elements. The information about the learner is split into eleven segments, while the elements specify the data and the structure of a segment.

LIP divides the learner information into eleven segments, starting from the Identification to more administrative content like Securitykey. The reason for this separation is to meet the requirements of a large variety of use cases and to facilitate mapping among IMS and other relevant specifications.

The core structures of the IMS LIP are based upon:

Identification: The identification learner information contains all of the data for a specific individual or organization. This includes data such as: name, address, contact information, agent and demographics.

Accessibility: The accessibility learner information consists of the cognitive, technical and physical preferences for the learner, disability, eligibility and language capabilities. These describe the learner's capabilities to interact with the learning environment.

Qualifications, Certifications and Licenses (qcl): The qcl learner information consists of the qualifications, certifications and licenses awarded to the learner *i.e.* the formally recognized products of their learning and work history. This includes information on the awarding body and may also include electronic copies of the actual documents. A different 'qcl' structure will be used for each qualification, *etc*.

Activity: The activity learner information consists of the education/training, work and service (military, community, voluntary, *etc*.) record and products (excluding formal awards). This information may include the descriptions of the courses undertaken and the records of the corresponding assessment. A separate 'activity' structure will be used for each entry.

Goal: The goal learner information consists of the description of the personal objectives and aspirations. These descriptions may also include information for monitoring the progress in achieving the goals. A goal can be defined in terms of sub-goals. A different 'goal' structure will be used for each entry.

Competency: The competency learner information consists of the descriptions of the skills the learner has acquired. These skills may be associated with some formal or informal training or work history (described in the 'activity') and formal awards (described in the 'qcl'). A different 'competency' structure will be used for each competency through an external reference mechanism. The adopted competency definition follows the work of the IMS Competency Definition working-group.

Interest: The interest learner information consists of descriptions of hobbies and other recreational activities. These interests may have formal awards (as described in the associated 'qcl'). Electronic versions of the products of these interests may also be contained. Each interest will be described within its own 'interest' structure.

Transcript: The transcript learner information is used to store the summary records of the academic performance at an institution. This information may contain an arbitrary level of detail and so there is no proscribed structure for a transcript.

Affiliation: The affiliation learner information is used to store the descriptions of the organization affiliations associated with the learner. These affiliations may include education groups *e.g.* classes, cohorts, *etc.* but it is expected that these will be exchanged using the IMS Enterprise specification technique.

Securitykey: The securitykey learner information is used to store the passwords and security codes that are to be used when communicating with the learner. A different 'securitykey' structure will be used for each key and class of key.

Relationship: The relationship learner information is used to store the description of the relations between the other core data structures. All of the relationship information has been removed from the other structures to enable these to be collected at a single place. This structure may also be used to describe mapping relationships to be used by the communicating systems.

An **element** is considered as part of a segment. Specification of elements is based on certain data types (for example language strings) or on recursive hierarchical structures. An important issue regarding elements is the support referencing mechanisms, such as internal references, external references and references described by a Universal Resource Identifier (URI). IMS LIP

specification covers different kinds of data elements in order to support a wide range of requirements pertaining to adaptive learning systems. However, IMS LIP was designed to offer ways for supporting specific needs of the actual implementation. Thus, the implementation has the possibility to extend an element by its own needs.

XML Binding

IMS LIP uses an XML schema as the binding. It is possible to define element names within the document by using XML schemes, but the opportunity of using other bindings is not excluded. The XML schema defines elements, the content of these elements and their attributes. Further, it defines the vocabulary used within the IMS LIP standard.

IMS LIP produces a complete representation of learner information for eLearning systems. Considering the possible binding in form of an XML-schema, IMS LIP provides abilities to be used by applications in the context of personalization and where structured information is needed.

IMS-LIP and PAPI comparison

IMS-LIP improves on PAPI slightly by providing a string field for learning goals. Moreover, the IMS LIP work incorporated the IEEE PAPI specification. Figure 8 describes such the relationship (Wilson at al. 2002).

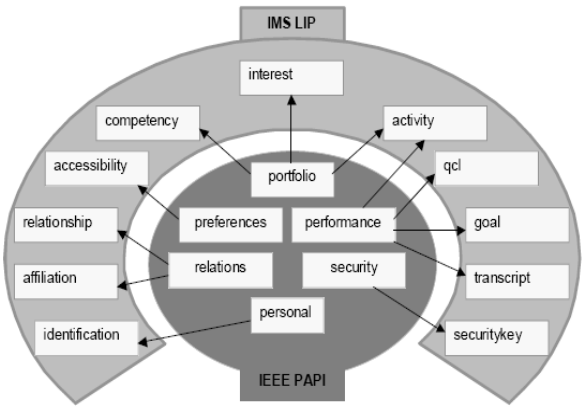

Figure 8: Incorporation between IMS LIP and IEEE PAPI

LIP and PAPI are competing specifications aimed in “learner information” description. PAPI Learner specifications use a registry-based approach for long-term maintenance of the “value domains” and their "permissible values" (often called "vocabularies"). Form the other hand, LIP uses XML while the PAPI Learner and its related standards use ISO/IEC 11179 and ISO/IEC 20944 for a complete suite of harmonized bindings. LIP organizes data according to “purposes” while PAPI Learner does not. This is a useful characteristic in those application contexts where data needs to be organized in customized ways. The previous considerations make LIP a better candidate than PAPI Learner.

Semantic Web modelling languages like the Resource Description Format (RDF) or RDF schema (RDFS) provide us with interesting possibilities. RDF models are used to describe learning resources but they can be used for learner description as well. The use of RDF to encode the profile data (so called learner data description) allows us to pick elements from multiple schemas, for instance, PAPI and IMS-LIP, and remain interoperable with other RDF-enabled systems. With the plethora of specifications available and the lack of even a de facto standard, we see the use of RDF to select from multiple existing schemas in order to create customised, application-specific data models as being the dominant trend in user modelling in the future.

Learner modelling implementations

Recently, student modelling researchers have begun to adopt technologies, applications and standards from the Semantic Web to solve the problems mentioned above. The first ideas of using ontologies for learner modelling have been reported by Chen&Mizoguchi (Chen at al., 1999). Kay also argues about the use of ontologies for reusable and “scrutable” student models (Kay, 1999). More recently the idea of using sharable data structures containing user’s features and preferences was proposed in order to enable personalized interactions with different devices for the benefit of the users. For this purpose, a user modelling mark-up language for ubiquitous computing built on XML technology has been proposed as a platform for communication (Heckmann at al. 2003). A complete ontology-based student model is presented in (Paneva, 2006).

In the **ELENA project (ELENA)** there is a very rich and detailed learner model developed. It is distributed and reflects features taken from several standards for a learner modelling and in particular, IEEE LTSC’s Personal and Private Information (PAPI) standard and IMS Learner Information Package (LIP). Its features can be combined according to the requirements of specific personalization techniques, which are provided as personalization services in a P2P learning

network RDF and RDFS as key tools of the Semantic Web, which are used to handle such situations (Dolog, 2003).

The user profile of the **SeLeNe project** is composed of two main parts: information explicitly supplied by the user and information collected transparently by observing the user's behaviour. SeLeNe's profile desciption is the following (Keenoy at al., 2004):

User-supplied information

When initially registering in the LMS the user will have the option to supply some information for their profile, and this can be expanded upon or modified at a later date. Of course, the user could choose not to supply any personal information, but the more data the system has the better it will be able to serve the user.

The user registration process should provide a series of forms to allow the entry of this data, with either text fields or a list of optional choices where appropriate.

The user-supplied information will include general demographic data and other personal data that can help in identifying useful LOs, and this will be stored using, for example, the following elements from PAPI and IMS-LIP:

- *PAPI elements:* Learner Personal Information as Personal Identifier (ID), Name, Postal Address, Age, Languages, *etc.*) and Learner Preference Information;
- *IMS-LIP elements:* Qualifications, Certifications and Licenses (Organisation, Level, Title, Date, Description); Interest (Type of interest, Description); Competency (Skills, knowledge, and abilities); Goals (Learning, career and other objectives and aspirations).

The final two IMS-LIP elements listed here, *i.e.* Competency and Goal, are probably the most important information needed by the system in order to provide effective personalization. Unfortunately they are also the most difficult to specify in a clear, concise and unambiguous way.

Existing specifications for learner profiles generally include space for a record of the learner's experience and current knowledge. The most sophisticated of these schemes appears to be that proposed in the IEEE PAPI standard. The PAPI profile contains a section of 'Performance Information' specifically "to provide improved

or optimized learning experiences" (PAPI, 2002):

- **Learner Performance Information**, which is a list of identifiers for learning experiences that the learner has taken part in, and their associated grades and awarding body.
- **Learner Portfolio Information** is a representative collection of a learner's works or references to them that is intended for illustration and justification of his/her abilities and achievements.

PAPI has been developed from the perspective of learner performance during his study. Personalization based on level of knowledge can be solved in PAPI by introducing extension and type of performance or by considering activity at the portfolio item is the result of some activity related to learning.

On the other hand there seems to be very little work specifically on how learners can express their learning needs; however, there is some advice on how teachers or authors of learning materials can specify the learning outcomes of their lessons, courses and LOs (OUNL-EML includes 'learning objective' as part of its information model for 'units of learning', but unfortunately gives no hint as to how these should be specified). If learners express their needs in the same terms as LO providers express the desired learning outcomes for their LOs, then accurate matching of LOs to users' profiles should be possible. It seems widely accepted that learning outcomes should be expressed as competencies – what a learner will be able to do as a result of following the learning materials. Most guidelines available are quite general and give a list of "the kinds of word you might want to use". A more formal taxonomy of educational objectives was specified by a committee of college and university examiners in 1956 (known as "Bloom's Taxonomy"), which identified six different types of educational objective, along with outcome-illustrating verbs which characterise each type (Bloom, 1956):

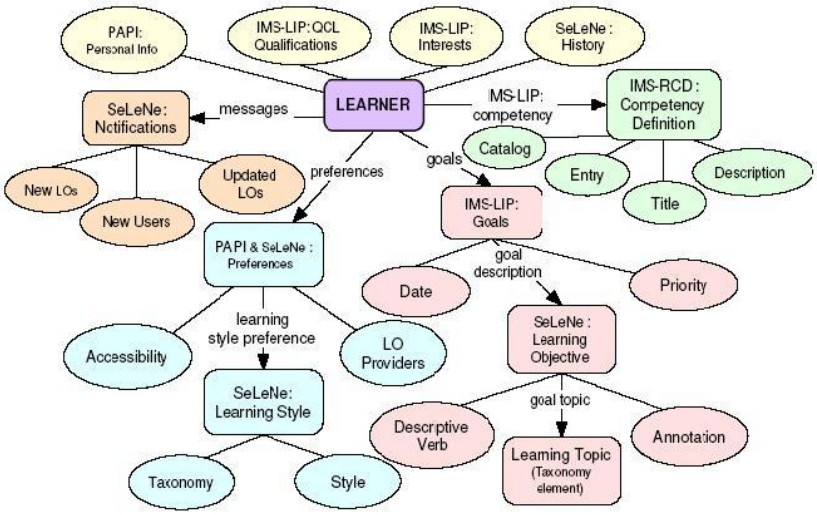

Figure 9: SeLeNe's Personal Profile Schema

Knowledge: of terminology, specific facts, universals and abstractions in a field. Knowledge here means the remembering (recalling) of appropriate, previously learned information.

- defines, describes, enumerates identifies, labels, lists, matches, names, reads, records, reproduces, selects, states, views.

Comprehension: Understanding the meaning of informational materials.

- classifies, cites, converts, describes, discusses, estimates, explains, generalises, gives examples, makes sense out of, paraphrases, restates (in own words), summarises, traces, understands.

Application: The use of previously learned information in new and concrete situations to solve problems that have single or best answers.

- acts, administers, articulates, assesses, charts, collects, computes, constructs, contributes, controls, determines, develops, discovers, establishes, extends, implements, includes, informs, instructs, operationalises, participates, predicts, prepares, preserves, produces, projects, provides, relates, reports, shows, solves, teaches, transfers, uses, utilises.

Analysis: The breaking down of informational materials into their component parts, examining (and trying to understand the organisational structure of) such information to develop divergent conclusions by identifying motives or causes, making inferences, and/or finding evidence to support generalisations.

- breaks down, correlates, diagrams, differentiates, discriminates, distinguishes, focuses, illustrates, infers, limits, outlines, points out, prioritises, recognises, separates, subdivides.

Synthesis: Creatively or divergently applying prior knowledge and skills to produce a new or original whole.

- adapts, anticipates, categorises, collaborates, combines, communicates, compares, compiles, composes, contrasts, creates, designs, devises, expresses, facilitates, formulates, generates, incorporates, individualises, initiates, integrates, intervenes, models, modifies, negotiates, plans, progresses, rearranges, reconstructs, reinforces, reorganises, revises, structures, substitutes, validates.

Evaluation: Judging the value of material based on personal values/opinions, resulting in an end product, with a given purpose, without real right or wrong answers.

- appraises, compares & contrasts, concludes, criticises, critiques, decides, defends, interprets, judges, justifies, reframes, supports.

This taxonomy can form the basis of a “recommended vocabulary" for the specification of learning objectives. Obviously, users of the system do not want (or need) to learn the intricacies of Bloom's taxonomy; the user interfaces for registration of users and of LOs should encourage the use of verbs from a representative subset (*i.e.* a few terms from each category) of the outcome-illustrating verbs given, by presenting them as options when describing learning goals/outcomes. The verbs chosen for this recommended vocabulary would make most sense as part of the specification of both a learner's goals and of a LO's learning outcomes. A user's learning objective (goal) can then be described by a combination of one of these verbs with a term from learning topics taxonomy. The combination of verbs with a topics taxonomy thus forms a structured vocabulary for describing user goals and LO outcomes.

Implicitly Gathered Information

The continuous collection of information implicit in user interactions with the system provides the adaptive part of the profile. As the user interacts with the system aspects of their behaviour can give clues as to their interests and preferences. If the system records certain user behaviour, these implicit indicators of interest can be used to aid the personalization functionality. A history of searches and LO access is recorded, including dates and details of the LOs browsed. The history information gathered can be stored in the profiles as a set of trails, capturing the history and other information in a standard format. This dynamic, growing history of LO interaction contains a wealth of information that can be mined, with the right techniques, to reveal information useful for personalization, for example, preferred authors and publishers, the user's learning styles, areas of interest within topics, *etc*. Thus the history part of the profile enables the provision of adaptive personalization functionality that takes account of the user's recent behaviour.

Learning customization

Customized learning, presenting just the right material to the learner on demand, can be described using data representations from learning technology standards. Wlliam Blackmon and Daniel Rehak (Blackmon at al. 2003) define the following ways for learning customization:

- ***At random*** – repeat random selection of learning objects;
- ***By profile*** – choose the course/content based on the learner's profile (role, skills, learning style, *etc*.);
- ***By discovery*** – for given learning objective, find a learning object that best meets the learning objective given the learning's current skill set, learning platform, learning style, language preference, *etc.*;
- ***By response*** – choose the next learning activity based on the learner's responses to questions.

William Blackmon and Daniel Rehak offer a web services-based methodology for customization by profile, specifically one of eliminating LOs from a course (Blackmon at al. 2003) because either:

- the learner's current role does not require the learning objective taught by the LO, or
- the learner's profile indicates the learner has already achieved the objective taught by a LO.

The learning content and data used in customization are represented in a set of standards-based data models. These are used in a content authoring and delivery process that customizes the activities delivered to the learner based on the learner's role and competencies.

Data: Content and learning activity customization uses six sets of data elements (with data representations taken from current learning technology standards):

- *Learning objects* – the collection of content and learning resources maintained in a content repository.
- *Content structure* – the organization of learning objects in a tree or hierarchical structure. (IMS Content Packaging Information Model, 2002)
- *Roles* – definitions of the job roles of a learner (no current learning technology standard).
- *Competency definitions* – definitions of the skills and knowledge acquired by a learner. (IMS Reusable Definition of Competency or Educational Objective Information Model, 2002)
- *Learner Information Package* – the collection of stored profile information about a learner. (IMS Learner Information Packaging Information Model Specification, 2002)
- *Sequencing* – rules used to select content and sequence the learner through a content structure. (IMS Simple Sequencing Information and Behaviour Model, 2002).

Process: There are four major steps to prepare and deliver a customized course (assuming there is a globally defined set of learner job roles and competency definitions):

- *Create course and content description* – describe the course and learning objectives. Starting with the overall content structure or hierarchy, the set of content objects, and the behaviour rules used to express the progression of the learner through the content:

    - Associate role and competency definitions with each learning object by mapping a sequencing objective id (used to label the objective) to a competency definition id or to a role id.
    - Specify the conditional rules used to customize the course by eliminating learning objects from the activity sequence. Sequencing rules are used to specify that if the learner has satisfied the *objective* associated with an element of instruction within the course, the learner

may skip that part of the instruction. Note: the definition of an objective in sequencing is not strictly limited to traditional skills-based objectives, and both competencies and roles can be represented as *objectives*. Thus you can write rules of the form: "*skip activity if learner has competency **x***", or "*skip activity if learner has role **x***". (Both can be expressed as "*skip if learner has sequencing objective **x***".) Sequencing rules can also express complex behaviours, including skipping activities, making activities optional, or making activities required. Objective-based customization rules exist in parallel with other sequencing behaviours, *e.g.*, remediation patterns, random selection, and limit conditions.

- *Establish learner profiles* – specify the learner's characteristics (preferences, roles, existing competencies with properties such as measure, expiration date) via a profile. The profile will specify the role of the learner (which in turn may yield a set of competencies required to perform the role), and will contain data on the learner's record relative to each of the specified competencies.
- *Register learners* – register the learner for the course. This will establish the actual learner role within the course (it may be useful to let the learner *play* a role different from his or her formal job role to support scenario-based learning).
- *Deliver course* – deliver the course, matching the course description to the learner's profile to select content. As the learner progresses through the course, the sequencing process examines the learner's record and uses the sequencing rules to skip those elements of instruction where the learner has satisfied the objective, *i.e.*, the learner has acquired the requisite competencies, or when the learner is in a specific role in the course. As the learner completes instruction, the profile may be updated to include mastery of subject matter. Delivery and customization continues until all required activities have been completed.

Web services implementation

The customization process has been implemented through a set of web services. The diagram (Figure 10) illustrates a general web services architecture for learning (left side), and a specific set of prototype web services used to provide content customization (right side).

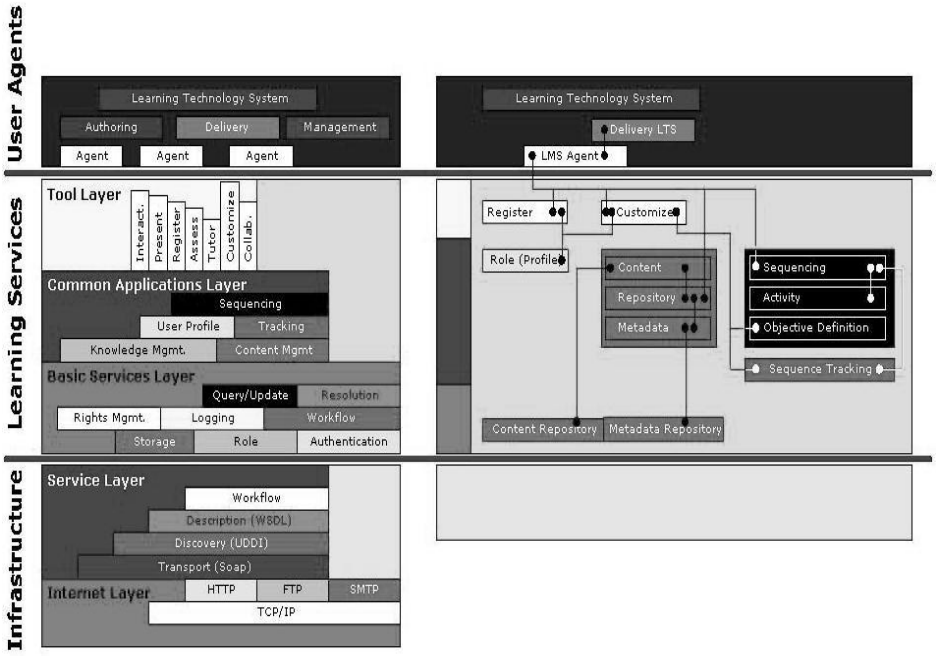

Figure 10: Web Services Architecture

Web services architecture: Rather than building large, closed systems, the focus is on flexible architectures that provide interoperability of components and learning content, and that rely on open standards for information exchange and component integration. The learning services architecture and the learning services stack provide a framework for developing service-based learning technology systems.

The left side of the diagram illustrates the general web services architecture for learning. The overall architecture is divided into layered services, *i.e.*, a services stack. From top to bottom, layers of the stack are:

- *User agents* – Components in the agents' layer provide interfaces between users (both end user applications and program agents) and the learning services. Agents provide the major elements of learning technology systems: authoring of content, management of learning, and actual delivery of instruction to learners.
- *Learning services* – The services layer consists of the individual

components of a learning technology system. Learning services are a collection of (many small, simple) data models and independent behaviours. Service components are characterized as providing a single function that implements a particular behaviour. Each service is identifiable, discoverable, (de)referenceable, and interoperable. They include built-in security and rights management, and assume an unreliable underlying network. Services are grouped into logical collections, where upper-level services rely on the support from the lower-level services:

  - *Tool layer* – Tools provide high-level, integrated server applications. Accessed via known, published interfaces, they provide the public interface to the learning tools, examples of which include tutors, simulators, assessment engines, collaboration tools, registration tools, *etc.* User agents and end user applications are built using collections of tool services.
  - *Common applications layer* – These are services that provide the commonly used learning functions and application support behaviours used by tools and agents. Common services include sequencing, managing learner profiles, learner tracking, content management, competency management, *etc.*
  - *Basic services layer* – Basic services provide core features and functionality that are not necessarily specific to learning, but which may need to be adapted for learning. Agents, tools or common services use the basic services. Some basic services include storage management, workflow, rights management, authentication, query/data interfaces, *etc.*

- *Infrastructure* – All services are built on and use a common infrastructure model. The infrastructure layer relies on basic Internet technologies (*e.g.*, HTTP, TCP/IP) to connect service components over the network. The services themselves are implemented using web services bindings. Messaging is done with SOAP; service descriptions are catalogued with UDDI, and described in WSDL – all are XML representations. Overall service coordination is expressed in a workflow or choreography language. These standard technologies permit the upper-level services to be implemented in a platform-neutral manner, and provide interoperability across different implementations of the actual learning services.

Content customization web services: A prototype implementation of content customization has been built using a set of web services, including:

Content repository web services:

- *Metadata service* – stores and retrieves metadata for content objects from the content repository
- *Content service* – stores and retrieves content objects from the content repository
- *Repository service* – acts as a broker between one or more learning management systems and multiple content and metadata services

Customized learning experience web services:

- *Role service* – updates a learner's tracking information in a course to customize the course based on the learner's role and competency information

Sequencing web services:

- *Sequencing objective definition service* – stores and retrieves the definitions of sequencing objectives
- *Sequencing activity service* – stores and retrieves information about sequencing activities and their relationships to sequencing objectives
- *Objective tracking service* – stores and returns progress information for a learner in a course

Management services:

- *Registration service* – registers a learner in a course

Utility services:

- *Role definition service* – stores and retrieves information about role definitions
- *Competency definition service* – stores and retrieves information about competency definitions
- *GUID service* – generates a Globally Unique Identifier (GUID) used to label other items

The services rely on a set of data stores (elements of a database). Content and metadata are managed by a content repository and content management system. Role descriptions and competency definitions are in private data stores managed as

services. Accessed via the shared services, the definitions are usable across multiple learning environments. The profile and tracking information are also stored in private data stores. With the addition of proper authentication and privacy controls, this information could be shared by exposing the services for external access.

Many of the prototype services provide data access, *e.g.*, typical CRUD (create/retrieve/update/delete) transactions against data stores, abstracting the storage model and representations from the upper-level services. Other behaviours are implemented as RPC-like call/response services.

Information flow through services: These services and the information flow between the services are illustrated on the right side of the diagram. The position of the services in the diagram corresponds to their function in the overall layered architecture.

The basic flow and interactions of the services to provide content customization invoke the agents, tools and services shown on the right side of the diagram:

- Access to learning and management (by learners and administrators) is through a Learning Management System (LMS) agent that includes both management functions and course delivery.
- Learner registration is through the LMS. The LMS agent uses the registration service (a tool-level service) to register the learner in the course. The learner selects a role for the course, retrieved from the role service (a common service) and the learner's role is updated in the learner's profile through the profile service (also a common service).
- During course delivery, the user logs into the LMS (login is handled via basic authentication services, not shown on the diagram). Once a learner is authenticated and logged in, the LMS uses the customization service (a tool-level service) to provide the customization process described above. The customization service uses the role and profile services to determine the actual role and competencies for the learner in the course. The course is initialized at first login – the sequencing objectives are set to initial values using the learner's roles and known competencies. This provides the information that the objective tracking service (a common service) needs to track the learner through the course.
- As the learner navigates through the course, the sequencing service (a common service that implements the sequencing process) determines what content to deliver to the learner. The content customization process

is as described above – it uses the specified rules to determine if a learning activity should be delivered to the learner. Customization uses the collection of sequencing services (all common services) to determine the next activity to deliver to the learner.

- Once an activity to deliver to the learner has been identified, the LMS agent uses the collection of content repository services to obtain the necessary learning objects and assets from the content repository and deliver these to the learner. The repository services include common services to manage the specifics of learning objects, *e.g.*, associate a set of metadata with a learning object, obtain the correct version of the content, and basic services to manage object storage in the content management system.
- As the learner interacts with the content, results are produced. The LMS agent uses the tracking services to record these. These tracking results are updated via the objective tracking service. This updated data is used in making subsequent sequencing and customization decisions.

In addition, a set of user authoring agents (not shown) provides interfaces to the role, competency and sequencing definition services to populate and maintain this information. Other services, not described, provide management of the content and metadata repositories, and provide user agents to load and manage content.

10. Services in personalized and adaptive learning environments tailoring to the individual learners' contexts, knowledge, needs, learning styles and preferences

10.1. Adaptive learning environments – standards, models and services

Ubiquitous learning research faces a great challenge the next years: to develop environments that effectively enable each learner to get *individual* support in filling ever-changing skills and competence gaps – i.e. to create environments for personalized adaptive learning (CRA, 2003). In particular, this challenge requires "developing semantic-based and context-aware systems to acquire, organize, personalize, share and use the knowledge embedded in web and multimedia content,… and to achieve *semantic interoperability* between heterogeneous information resources and services" (IST, 2004).

Personalized and adaptive learning environments require semantic-based and context-aware services for tailoring to the individual learners' contexts, knowledge, needs, learning styles and preferences. These services make it possible to achieve semantic interoperability between heterogeneous information resources and services. The technological and conceptual differentiation between various systems can be bridged through the use of standards or by following approaches based on well accepted models. In this section we first present previous work related to studying issues in personalization and eLearning. We then address the issue of providing appropriate learner-oriented solutions based on integration of learning standards, established models and adaptive technologies. We also present issues related to the access of metadata stored in adaptive learning systems.

Previous work in CHIRON

The provision of personalized eLearning services and the research efforts towards adaptive learning environments has been a key theme in other CHIRON tasks. The related findings have been documented in previous CHIRON deliverables and an internal report.

In particular the following issues have been investigated:

User modelling and personalization systems: Issues regarding user profile modelling and acquisition based on explicit and implicit interest indicators were

discussed revealing the relation between adaptive learning environments and other research areas such as information retrieval and adaptive hypermedia.

Inquiry learning for personalization of learning: Inquiry-based learning applications are based on a spiral process with five distinct steps that are taken repeatedly: *asking* questions, *investigating* solutions, *creating* new knowledge as one gathers information, *discussing* one's discoveries and experiences, and *reflecting* on one's new-found knowledge. Each step in this process naturally leads to the next: inspiring new questions, investigations, and opportunities for authentic "teachable moments." The inquiry process presents a very good model for building personalized eLearning applications because the learning activities are tailored to individual learning needs and learning styles. 55 inquiry-based learning applications have been described.

Experimental solutions for supporting adaptive content: Interesting solutions were identified and described. Various types of personalization were documented and a methodology for development of adaptive learning content was presented. A model for role- and competency-based customization that uses these standard representations was presented as well as issues regarding querying of learning objects for personalization. Implementation of personalisation techniques in Learning Grid-driven applications was also addressed.

The above mentioned findings make it clear that for the development of cost-effective eLearning solutions it is necessary to ensure sharing and reuse of learning resources, usually in a distributed environment and provide efficient retrieval mechanisms providing access to relevant and accurate information in a personalized manner. Personalization reduces the overload of retrieved resources and provides individualized learning experiences. To ensure this personalization it is necessary to provide personalization of learning activities and personalization of learning materials residing in learning repositories. In the most interesting cases, these learning repositories should be able to communicate with other repositories to exchange content. This raises the issue of their semantic and structural heterogeneity. Various interoperability issues arise that must be solved in open environments.

Actually the interoperability problem is relevant for adaptive learning systems in general and not only for learning repositories. Sharing of learning content, concepts, learner profiles, context models, learning design, adaptation and presentation specifications is needed. There are already solutions; *e.g.* for the exchange of learning objects and learner profiles, but this is just a part of the whole complex problem. The solution of the interoperability problem presumes the

specification of appropriate services for creation, storage and delivery of personalized, reusable, shareable learning objects as well as the provision of personalization services in an open distributed environment of interconnected eLearning environments.

Basic parts of adaptive eLearning systems

Various application areas have been moving towards integration of personalization services in order to meet the needs of individual users. To describe adaptive systems, one may distinguish between the following major concepts:

- The domain model: a model of the content of the system. The domain model defines the conceptual design of the system and essentially specifies what can be adapted.
- The user model: a model of the user's knowledge and preferences. The definition of the user model is based on the domain model so that the current state of the user could be described. This current state reflects the user's knowledge with respect to the concepts of the domain model. The term *user profile* is usually used to refer to the user related information that is exploited for adaptation of the content and the presentation mechanisms so that individualized services could be offered.
- The context model: a model of the current setting of the system with respect to a specific user. This model is used to adapt the system's behaviour depending on various parameters such as the devices used by a user or the place that the user is currently located.
- The adaptation model: a model of the adaptation semantics. It defines the status of adapted objects and their parts based on the related parameters and concepts of the user model and the context model. It may also specify adaptation techniques to be used.

In adaptive eLearning systems the above concepts need appropriate redefinition and extension:

- The domain model: a model of the learning content of the system. It is based on an appropriate modelling of learning objects (their structure and semantic information).
- The user model: a model of the user's knowledge and preferences. User's knowledge is usually given in terms of learning objectives/competencies that have been accomplished. The desired learning objectives/competencies may also be recorded to facilitate the delivery of

adequate learning material to the user. These learning objectives/competencies are linked to domain concepts. User preferences may include learning styles, preferred language, preferred presentation styles *etc*.

- The context model: a model of the learning context. Specific parameters about the place of the learning process and the groups of people that communicate with the user may also be included.
- The adaptation model: a model of the adaptation semantics. It defines the status of adapted learning objects and their parts based on the related parameters and concepts of the user model and the context model. It may also include adaptive learning activity selection, adaptive recommendation of learning material or adaptive learning service provision.
- The instruction model: it is needed in adaptive learning systems to specify a pedagogical approach (or a set of approaches) used for the navigation and the presentation of the learning content to meet individual needs and preferences.

In the following sections we present each one of the above models along with related standards and approaches for their specification. These standards and approaches are necessary to provide a robust framework for the development of adaptive learning systems able to communicate with one another.

Domain model

According to (Brusilovsky, 2003), the domain model of an adaptive learning system can be considered as two interconnected networks or 'spaces':

a) The knowledge space, which is a network of concepts that refer to actual content managed and adapted by the system and
b) The hyperspace, which is a network of hypermedia elements with educational material.

The design process of an adaptive learning system can be broken down in the following three activities:

a) Structuring the concepts that refer to the knowledge space and providing an adequate description and robust representation of them
b) Structuring the hyperspace of hypermedia elements (i.e. learning content) using appropriate representations

c) Connecting the knowledge space with the hyperspace in order to provide semantic information for learning objects.

The knowledge space of a system's domain model can be considered as a set of small domain knowledge elements along with their semantic links. Each such element represents an elementary fragment of knowledge for the given domain. These elements can be named as concepts, knowledge items, topics, knowledge elements, learning objectives, learning outcomes *etc*. Different kinds of links among these elements are possible including prerequisite links between learning concepts representing the fact that one concept has to be learned before another. Prerequisite links can support several adaptation and user modelling techniques. Other kinds of links are borrowed from semantic languages (like isA and partOf) facilitating the formation of domain ontologies representing an expert's knowledge about a particular domain used for learning. In that case, learning goals can be represented as graphs (simple cases such as sequences and trees are usually used) of particular domain concepts.

The *hyperspace* consists of learning objects. These objects consist of specific raw media elements (digital assets such as text, audio, video) that are combined to create learning resources. Learning objects combine raw media elements in order to provide reusable learning material that can be exploited to the creation of multiple individualized learning experiences. Learning objects can be structured in an adequate manner to form courseware objects. Learning objects may reside in distributed repositories with appropriate metadata. These objects can be searched and retrieved either by learners (possibly using Learning Management Systems) that want to use learning objects to build new competencies, or teachers (possibly using Learning Content Management Systems) searching for appropriate learning material to support their teaching activities in the classroom and/or engage their students in blended learning approaches.

The most important standards that can be used in order to provide a robust representation of a domain's model hyperspace and facilitating interoperability are the following:

- **IMS Content Packaging.** Describes the packaging of reusable learning objects and related raw media into courses.
- **IMS Question and Test Interoperability (QTI).** Describes assessment tests consisting of various types of questions.
- **Learning Object Metadata (LOM).** Defines the metadata that can be used for describing any kind of learning object (digital or non-digital) that may be used for learning, education or training.

In the following subsections we give an overview of the above standards.

IMS Content Packaging

IMS Content Packaging (IMS CP, 2004) is a specification for sending learning objects from one program to another, facilitating easier delivery, reuse and sharing of materials.

IMS Packages enable exporting of content from one learning environment or digital repository, and import it into another while retaining information describing the media in the IMS Package, and how it is structured, such as a table of contents or the HTML page to show first.

One of the key benefits of IMS Content Packaging is that all the various support materials for a piece of content (such as style-sheets, movies and images) can be bundled together, ensuring that HTML-based materials don't suffer from broken links. They can also be disaggregated and reused as individual learning objects.

Another key benefit is that content packages support rich metadata, enabling intelligent filtering and searching when stored in a repository of learning objects.

An IMS Package consists of an archive and a manifest. The archive can be a ZIP file or a CD-ROM; basically anything that can contain files. The manifest is an XML file that describes what the Package contains and how the content is organized.

The manifest XML file contains three main sections:

- A metadata section that describes the whole IMS Package.
- A resources section that lists the resources in the IMS Package (these can be hyperlinks to Web-based resources as well as actual files in the archive) and any metadata that describes them.
- An organizations section that describes the structure of the resources within the IMS Package.

The resources in the archive itself can be any type of media: for example, HTML files, GIF and JPEG images, Flash animations, PDF documents, PowerPoint slides, and Word documents. The only limitation is whether the recipient of the IMS Package has an application capable of viewing the files packaged up.

Any special requirements for viewing resources can be included in the metadata for either the IMS Package or the individual resources: for example, a particular browser version needed to view a Web page, or the need for speakers and a sound card to listen to audio content.

IMS Question and Test Interoperability (QTI)

IMS QTI (QTI, 2005) is designed to make it easier to transfer information such as questions, tests and results between different software applications.

The main things that IMS QTI allows are:

- Development of e-assessment resources with a range of question types and flexibility in assessment structure.
- Sharing assessment information among different software packages, enabling the editing and incorporation of questions designed by other IMS QTI users into own assessments.
- Facilitating the creation of question banks by subject experts.
- Transmission of results and learner information to central computing systems or learning management systems.

Results in QTI are specific to a single participant. They can, however, contain multiple instances such as the results of several assessments. There are four elements within the results reporting data model:

- The **summary** contains data such as the maximum score and how many attempts have been made.
- The **assessment** contains one or more questions, and may contain one or more sections.
- A **section** allows assessment designers to group a series of questions within an assessment, enabling them to produce a different section for each subtopic, and to calculate the score obtained for each section as well as over the assessment as a whole.
- A question and its associated data such as score, layout and feedback, together make up an **item**.

IMS QTI tries to be pedagogy-neutral, and makes available a number of commonly used item types such as multiple choice/response, true and false, image hot spot, fill the blank, select text, slide, drag object/target, order objects, match items, connect points. New item types can be added if required.

The two core structures within IMS QTI are ASI (Assessment, Section and Item), which is concerned with the content of the test, and Results Reporting. There are therefore two separate specifications which can be implemented independently from each other, or in harmony.

Version 1.2 of the IMS QTI specification consists of nine separate documents within the current QTI specification, containing many examples of how to use the specifications in a practical context.

A cut-down version, QTI Lite, was developed in response to concerns that the specifications were becoming increasingly complex. It deals with items only, and the only item type to be implemented is multiple choice single response. The response process for this is specified but simplified.

Version 2.0 of the specification was released in February 2005, and has already been adopted by a number of developers. Unlike v1.2, it provides guidance on the development of items only; however, IMS is actively working on the development of v2.1, which will specify how QTI items should be combined to create deliverable assessments.

IEEE LOM

The IEEE 1484.12.1 – 2002 Standard for Learning Object Metadata is an internationally recognized open standard (published by the Institute of Electrical and Electronics Engineers Standards Association) for the description of "learning objects". The IEEE working group that developed the standard defined learning objects as being "any entity, digital or non-digital, that may be used for learning, education or training", a definition which has struck many commentators as being rather broad in its scope. IEEE 1484.12.1 is the first part of a multipart standard, and describes the LOM data model. The LOM data model specifies which aspects of a learning object should be described and what vocabularies may be used for these descriptions; it also defines how this data model can be amended by additions or constraints. Other parts of the standard are being drafted to define bindings of the LOM data model, i.e. define how LOM records should be represented in XML and RDF (IEEE 1484.12.3 and IEEE 1484.12.4 respectively).

The IMS Global Learning Consortium contributed to the drafting of the IEEE Learning Object Metadata and endorsed early drafts of the data model as part of the IMS Learning Resource Meta-data specification (IMS LRM, versions 1.0 – 1.2.2). Feedback and suggestions from the implementers of IMS LRM fed into the further development of the LOM, resulting in some drift between version 1.2 of the IMS

LRM specification and what was finally published at the LOM standard. Version 1.3 of the IMS LRM specification realigns the IMS LRM data model with the IEEE LOM data model and specifies that the IEEE XML binding should be used. Thus we can now use the term "LOM" in referring to both the IEEE standard and version 1.3 of the IMS specification. The IMS LRM specification also provides an extensive Best Practice and Implementation Guide and an XSL transform that can be used to migrate metadata instances from the older versions of the IMS LRM XML binding to the IEEE LOM XML binding.

Some of the main things that the LOM is designed to help achieving are:

- Creation of well structured descriptions of learning resources. These descriptions should help facilitate the discovery, location, evaluation and acquisition of learning resources by students, teachers or automated software processes.
- Sharing of descriptions of learning resources between resource discovery systems. This should lead to a reduction in the cost of providing services based on high quality resource descriptions.
- Tailoring of the resource descriptions to suit the specialized needs of a community. This may include choosing suitable controlled vocabularies for classification, reducing the number of elements that are described or adding new ones from other resource description schemas.

Creators and publishers may use the LOM along with other specifications to "tag" learning resources with a description that can be associated with the resource. This will provide information in a standard format similar to that found on the cover and fly-page of a text book.

User model

The definition and representation of user's knowledge, learning objectives and tasks as well as preferences regarding the desirable content and appropriate learning styles is provided by the user model.

In terms of user's knowledge representation, in (Brusilovsky, 2003) it is noted that the majority of adaptive learning systems use an overlay model of user knowledge. The key idea of this approach is that for each domain model concept, the user model stores some appropriate estimation of the user's knowledge level of this concept. In the simplest form, this estimation is a binary value (known-unknown) that enables the user model to represent user's knowledge as an overlay

of the domain knowledge. Weighted schemes are becoming more and more popular because they are able to distinguish several levels of user's knowledge. In such schemes the knowledge of a user for domain concepts can be represented by (concept-value) pairs. The overlay model, although simple, is powerful and flexible as it can measure independently the knowledge of the user with respect to different domain concepts. Sophisticated systems user more involved kinds of overlay models storing multiple evidences about the level of user knowledge separately.

Apart from the overlay model, some systems keep a historic record of user actions. Such actions include user visits to individual pages, time spent during a visit *etc*. This historic record can be used as a secondary source of personalization. Some adaptive learning systems completely ignore the overlay model and use solely historic records for personalization.

An important aspect of the user model is the representation of learning goals. Learning goals refer to domain concepts that represent competencies that should be achieved by the user. The user model may also include user preferences in terms of preferred cognitive and learning styles, as well as the preferred language.

The interpretations of the student model do not have to be considered isolated from the developed standards and specifications in this area because the goal is to maximize the reusability and portability of the designed student model. Two of the most important and well-developed of these are the IEEE LTSC's Personal and Private Information (PAPI) Standard and the IMS Learner Information Package (LIP). Both standards deal with several categories for information about a learner.

The above mentioned standards have already been described in detail at previous section.

Context model

The context model is the organized representation of environment-specific parameters related to the provision of personalized learning experiences. The context model excludes all parameters pertaining to the user model, although sometimes the term context is used to describe also issues related to the user model, as presented here (*e.g.* information related to the user's domain knowledge). The user model together with the context model describes the parameters that an adaptive learning system should take into account in order to provide adequate adaptation to learning content and presentation. User and context model information should enrich queries into learning object repositories to maximize the efficiency of information retrieval.

The contextual information used in a context model may refer to both objective (*e.g.* technical characteristics of devices used for the delivery of the learning content to the user) and subjective elements (*e.g.* current mood of the user measured by emotional contextual aspects). Significant research is made in order to generate contextual metadata about objective and subjective aspects without the intervention of the user. This is facilitated by suitable physical or semantic sensors. Context-aware learning objects can access the available context information and adapt their behaviour to it.

Modern context-aware systems take advantage of generic and mobile user models to provide personalized and ubiquitous learning services. User competence profiles of users have to be considered in the case of situated learning in the context of work where learning is an integrated part of working. In such setting analyzing group modelling and pattern recognition in the user behaviour is also necessary.

It should be noted that the current exchange formats for contextualization of resources need to be extended for capturing and handling additional context information. No context model standards for adaptive learning systems are available. However, the development of context-aware learning systems can take advantage of existing context information standards for specific types of digital objects such as the MPEG21 Multimedia Framework – ISO/IEC 21000 (MPEG21, 2002) for multimedia applications.

As final note, it should be stressed that it is of crucial importance to include contextual aspects in the eLearning standardization activities.

Instruction model

Instruction model captures pedagogical aspects of the learning process including navigational design for an adaptive eLearning system. It is used to specify how the adaptation should be performed. It is an essential part for the description of the dynamics ("flow") of the system together with the adaptation model and the specification of system's presentation.

Specifications that are related to the design of pedagogical activities are:

- **IMS Simple Sequencing.** It specifies the representation of the desired behaviour of a learning experience.
- **IMS Learning Design.** It uses the metaphor of a theatrical play to define

the desired workflow in learning scenarios. It tries to achieve a separation between the pedagogical model employed and the actual learning content used.

We describe the above specifications next.

IMS Simple Sequencing

IMS Simple Sequencing (IMS SS, 2003) is a specification used to describe paths through a collection of learning activities. It declares the relative order in which electronic learning activities are to be presented to a learner and the conditions under which a resource is selected, delivered, or skipped during presentation. The specification considers only a limited number of common sequencing strategies.

IMS SS relies on the concept of learning *activities*, such as content or test questions. Activities are associated with other activities into a hierarchy, resulting in an *activity tree*. A *parent* activity and its *children* are referred to as a *cluster of activities*.

An activity has one or more objectives associated with it. Objectives are typically used to record the scores of test items. Objectives may also add objective maps, so that the result of an assessment item may be used to influence the sequencing behaviour in a widely separated branch of the activity tree.

An activity may additionally include auxiliary resources. Auxiliary resources provide the learner with help, glossaries or other context sensitive services.

Activity clusters have sequencing rules and limit conditions associated with them. Sequencing rules are used to influence the order of activities presented to the learner. Limit conditions, such as attempt limits, duration limits and date limits, are used by the sequencing rules to further influence when an activity is sequenced next to a learner.

Sequencing occurs within a conceptual runtime environment which translates navigation events into navigation requests to the sequencing engine. Results of sequencing are then used to modify or create the user interface which the learner sees.

IMS SS refers to single-user interaction. Multi-user interaction is addressed by LMS Learning Design, which is described next.

IMS Learning Design

The IMS Learning Design (IMS LD, 2003) specifies a language for describing learning activities, and gives a binding for this language to XML. An IMS Learning Design player is a software tool that interprets the XML notation of a learning design as participants work through it: at run time. This interpretation is analogous to a browser interpreting Web pages. The player may be a stand-alone tool, or it may be part of a learning environment.

IMS Learning Design describes how a learning design unfolds through the analogy of a theatrical play. Just as a play can be staged with different actors, in a different theatre with alternative props, so learning designs can be run again with different learners and tutors, on different systems, with alternative learning resources or tools:

- The play is presented in a series of acts, in which roles are played by those taking part, for example learner, tutor, mentor, and so on.
- People playing the roles undertake a series of activities within an act. For a learner these might include discussing with classmates the relative merit of a piece of source material. A tutor's activity may be to comment on their conclusions.
- Each role is presented with its own learning objects and services (*e.g.* communication tools) within an activity.
- An act is completed after all the activities of a specified role, or roles, are finished. Alternatively, a time limit may be set, after which an act completes.
- When one act completes, the next act is started. The play finishes when all the acts are completed; the learning design finishes when all the plays are completed.

Designing a scenario begins with the method element, which describes the play with acts and role-parts. The method element references the other elements in the learning design, which are located separately so that they can be reused and updated easily. For instance, within an act, each role-part element links a role to an activity. This is analogous to the script used by an actor during a play. The end of an act provides a point for synchronizing roles during the play, so that all participants start on a new set of activities at the same time. If this is not needed then the play can have just one act.

Activities are organized into activity structures, which can be assembled as either a sequence or a selection. Selection means that activities can be carried out in any order. Sequence means that activities are presented in a set order, with the next one being made available only after the previous one is completed. Activities reference an environment that contains the services and learning objects required for that activity. An activity can have its own learning objectives and/or prerequisites.

A role may have multiple players assigned to it, *e.g.* there may be many learners. Learning objects and activities are assigned to each role separately each time the learning design is run; they can also be shared between roles. Roles run simultaneously, and may do different things at the same time; there may also be interaction between them.

Services offer generic functions such as email, conferencing, searching and announcements. The locations of services are not specified during design, but are made available at run time, after people have been assigned to their roles. Both services and learning objects are referenced by activities. Again, this means that these elements are located separately so that they can be reused and updated easily.

There are three implementation levels within IMS Learning Design:

- **Level A** contains the core of IMS Learning Design: people, activities and resources, and their coordination through the method, play, act and role-parts elements. This simply provides for a series of time ordered learning activities to be performed by learners and teachers, using learning objects and/or services.
- **Level B** adds greater control and complexity through the use of properties and conditions. Properties may be internal (local) or external (global). They are used to store information about a person, such as test results or learner preferences; a role, such as whether the role is for a full-time or part-time learner; or a learning design itself. Internal properties persist only during a single run of a learning design, while external properties retain their values beyond the end of a run, and can be accessed from different runs and/or different learning designs. Currently the reuse of external properties is confined to the learning design author or to agreed usage within a community or institution. However, it is intended that external properties will include the use of those that are defined externally and widely agreed upon, such as the accessibility fields defined in the IMS Learner Information Package specification. Conditions allow the learning flow to be constrained according to specific circumstances,

preferences or learner characteristics. For instance, a particular learner may be presented with resources in random order, if their learning style or preference requires this.

- **Level C** offers the opportunity for more sophisticated learning designs through notifications (messaging), which allow for notification of new activities to be triggered automatically in response to events in the learning process. It enables the automation of learning flow activities, which are triggered by the completion of tasks, rather than the learning flows being pre-planned. For instance, a teacher may be notified by email that an assignment has been submitted and needs marking; once the score has been posted, the learner may be notified to undertake a new activity according to the result.

IMS Learning Design can be used to model and annotate adaptive learning design, but designing more complex adaptivity behaviour can cause problems. Currently, it is not possible to annotate learning content or define student roles considering their characteristics. We can say that a primary objective of this standard was interoperability between various systems, rather than reusability of learning design methods in various courses or learning units.

Adaptation model

The adaptation model contains the specific adaptation rules that define how other models are to be combined in order to provide the actual adaptation. These rules are used to elaborate what kind of adaptation is needed (and if needed) and then to specify the actual adaptation actions that should be taken.

As stated in (Paramythis and Loidl-Reisinger, 2004) existing approaches to the specification of adaptation rules include simple rule-based engines, case-based reasoners, *etc.*, all the way to powerful logic-based reasoning engines. The diversity of these approaches makes it very difficult to have a standardized specification that could accommodate all of them.

On the contrary, standardization of adaptation actions in adaptive learning systems is possible, mainly through the use of IMS Learning Design specification already presented here. In (Paramythis and Loidl-Reisinger, 2004) it is noted that Levels B and C of the specification introduce the concepts of properties, conditions and notifications, which can be used to specify arbitrarily complex dynamic behaviours for a system. However, adaptation actions in adaptive learning systems through IMS Learning Design may face difficulties due to the fact that the dynamic behaviour is achieved through the definition of programming flows (including

condition variables), enriched with event semantics. This approach is low-level and specifying complex adaptive actions is not facilitated. The adapting actions specification does not have semantic information and the behaviour specified cannot be reused as it is coupled with the related learning material.

10.2. Services for access to learning objects

An issue of paramount importance in adaptive learning systems is the access mechanisms they provide for their learning objects. These access mechanisms should be well defined in order to facilitate communication with other learning systems making it possible to share learning content and promote its reuse. In order to mutually understand their access mechanisms, these mechanisms should be built and described using accepted models and standards. Thus, interoperability among learning object repositories requires a common communication framework for querying and retrieving references to the stored objects.

Indicative services that should be provided include services to establish connection, retrieve and manipulate the desired metadata. The access service may cover to a specific domain, exploiting a specific metadata model or standard. As another option, they may provide a generic (domain-independent) access through an appropriate query language, using multiple underlying metadata models.

Some of the most interesting access services specifications and models are:

- **IMS Digital Repository Interoperability (DRI).** It is an IMS specification providing recommendation for the interoperation of the most common repository functions (search/expose, gather/expose, alert/expose, submit/store and request/deliver).
- **Learning Object Interoperability (LORI) Framework.** It is an abstract model for interoperability between independent learning objects repositories. It defines core services (authentication, session management) and application services (such as retrieval services and provision services).
- **Content Object Repository Discovery and Resolution Architecture (CORDRA).** Aims at an abstract, formal model for repository federations.
- **Open Knowledge Initiative (OKI).** It is a project that has issued specifications for a system architecture adapted to learning management functions.

In the following we present a description of the above mentioned metadata access services specifications and models.

IMS Digital Repository Interoperability (DRI)

The IMS Digital Repositories Interoperability (DRI) specification (IMS DRI, 2003) provides a recommendation for a specific set of functions and protocols enabling the intercommunication of diverse components. The DRI specification acknowledges a wide range of content formats, making it possible to apply it to both learning object repositories as well as to other traditional content sources, such as libraries.

The supported functions provide the capability to submit/store and request/deliver resources to/from an individual or system as well as to search/expose and gather/ expose learning objects stored in various repositories. The specification makes use of a variety of popular technologies including XML technologies, such as XQuery (XQUERY, 2006) and Simple Object Access Protocol (SOAP, 2003). It also recommends the use of established technologies such as Z39.50 (Z3950, 2000) and the Open Archive Initiative (OAI, 2006) protocols.

The specification tends to look more like a best practice guide which specifies how existing specifications are used to achieve interoperability. It specifies how core functions within the specification are supported.

The search/expose defines the searching of the meta-data associated with content exposed by repositories. It recommends the usage of either the Z39.50 protocol (popular within the library community), or XQuery, when searching learning object repositories developed using the IMS Metadata or Content Packaging data structures.

The gather/expose defines the soliciting of meta-data exposed by repositories and the aggregation of the meta-data for use in subsequent searches, and the aggregations of the meta-data to create a new meta-data repository. The aggregated repository becomes another repository available for Search/Expose and Alert/Expose functions. Open Archive Initiative (OAI) protocols are recommended. Query results from an OAI query can be aggregated into an entirely new metadata repository that can be queried by information seekers as an entirely new entity.

Submit/Store functionality refers to the way an object is moved to a repository

from a given network-accessible location, and how the object will then be represented in that repository for access. The location from which an object is moved can be another repository, a learning management system, a developer's hard-drive, or any other networked location. It is anticipated that existing repository systems may already have established means for achieving Submit/Store functions (typically FTP). This specification provides no particular recommendations for legacy repository systems, but wishes to draw attention to the following weaknesses of FTP as a transport mechanism for learning objects or other assets:

- Plain FTP provides no encryption capabilities, making it unsuitable for the transport of copyright controlled assets.
- Providing FTP server access to a networked location presents widely-recognized security risks.
- FTP does not provide means of confirming the successful delivery of assets from one networked location to another.

In the case of more recently developed repositories that deal specifically with learning objects, this specification makes significant reference to the IMS Content Packaging Specification.

The Request function allows a resource utilizer that has located a meta-data record via the Search (and possibly via the Alert) function to request access to the learning object or other resource described by the meta-data. Deliver refers to the response from the repository which provides access to the resource. There are two methods specified for this request/deliver function. First, if the object is contained in an IMS compliant system, then the IMS Metadata <location> element is used to store a pointer to the location of the resource. Second, if this is not the case, a location independent URL alternative, like OpenURL (OPENURL, 2003) is used. Objects are delivered using basics transportation protocols like http or ftp and resources are wrapped in an IMS Content Package.

An important issue regarding the services of IMS DRI is the passing of messages and other instruction between systems. The specification recommends the use of SOAP with attachments. SOAP with attachments is intended to provide a mechanism for exchanging structured and typed information between decentralized, distributed systems.

It should be noted that the functionality provided by IMS DRI specification provides the capability to build new kinds of learning object repositories that are created by automated processes. Harvesting resources from the network and

building new collections can provide a process for the creation of new repositories within a specific discipline or area of study.

Learning Object Interoperability (LORI) Framework

The *Learning Object Interoperability (LORI) Framework* (LORI, 2005) is an abstract interoperability model for learning technology. It is a layered integration architecture that defines services between independent learning object repositories.

The Learning Object Repository Interoperability Framework distinguishes between core services and application services. Core services cover the unique identification of learning objects, the authentication of users and repositories, the creation and management of interaction sessions, *etc*.

Application services make use of core services. For example, the core service session management might be required for the query service. Application services cover issues like indexing, harvesting, querying, contracting and delivery. In particular:

- Indexing is considered as a kind of replication service that allows one repository to "push" learning object metadata to another repository. It supports distributed maintenance of metadata through insert, delete or update operations.
- Harvesting is needed when one repository "pulls" metadata from another repository.
- Querying allows the searching of learning resources residing in a repository.
- A contracting service assigns access rights to a learning object stored at a remote repository.
- The delivery service interacts with the repository where the learning resource is stored and delivers an electronic learning resource to the end user.

XML-RPC (XMLRPC, 2003), Java RMI (JAVARMI, 2003), and SOAP (SOAP, 2003) are examples of messaging services that are mentioned in LORI to address the requirement of a common messaging infrastructure, which enables repositories to interact. The underlying lower level protocols could be TCP/IP, HTTP, *etc*.

A signification part of the LORI framework is the Simple Query Interface. It provides method support for asynchronous and synchronous queries. Since one major design objective is to keep the specification simple and easy to implement, the SQI has been built to meet the following requirements:

- SQI is neutral in terms of results format and query languages: The repositories connecting via SQI can be of highly heterogeneous nature: therefore, SQI makes no assumptions about the query language or results format.
- SQI supports Synchronous and Asynchronous Queries between a source (the entity issuing a query) and a target (a repository that receives and answers the query) in order to allow application of the SQI specification in heterogeneous use cases.
- SQI supports, both, a stateful and a stateless implementation.
- SQI is based on a session management concept in order to separate authentication issues from query management.

In order to make use of SQI to implement full query functionality, SQI needs to be complemented with agreements about:

- the set of attributes and vocabularies that can be used in the query,
- the query language and its representation,
- the representation of list of learning objects that satisfy the query, and
- the representation of individual metadata instances on learning objects.

SQI is agnostic on these issues: Any agreement between two or more repositories is valid for SQI. Such agreements can, for example, be expressed by XML schemas or RDF schemas.

SQI aims to become an independent specification for all open educational repositories. It can be deployed in two different scenarios.

- In the *synchronous* scenario, the target returns the query results to the source. Results retrieval is therefore initiated by the source through the submission of the query and through other methods allowing the source to access the query results.
- In the *asynchronous* scenario, results retrieval is target-initiated. Whenever a significant amount of matching results is found, these results are forwarded to the source by the target. To support this communication the source must implement a results listener. The source must be able to

uniquely identify a query sent to a particular target (even if the same query is sent to multiple targets). Otherwise the source is not able to distinguish the search results retrieved from various targets and/or queries previously submitted to a target.

A query interface operated in synchronous mode can perform multiple queries per session (even simultaneously). In case of an asynchronously operated query interface, the source provides a query ID that allows it to link incoming results to a submitted query (the source might query many targets and each target might answer to a query by returning more than one result to the source). Multiple queries can also be active within a session in asynchronous query mode.

SQI uses the stateful and stateless properties to describe whether repositories are designed to keep track of one or more preceding events in a given sequence of interactions. Stateful means that the target repository keeps track of the state of interaction, for example, by storing the results of a previously submitted query in a cache. Stateless means that there is no record of previous interactions and that each interaction request can only be handled on the basis of the information that comes with it. The SQI specification allows implementers to opt for a stateful or a stateless approach.

SQI design is based on the "Command-Query Separation Principle". This principle states that every method should either be a command that performs an action, or a query that returns data to the caller, but not both. More formally, methods should return a value only if they are referentially transparent and hence cause no side-effects. This leads to a style of design that produces clearer and more understandable interfaces.

SQI, as already mentioned, is not bound to a specific schema. It depends on a common metadata schema of the specific community where it shall be applied. However, several examples can be found that use application profiles to mix standardized concepts from IEEE LOM, Dublin Core, and other standards simultaneously in order to satisfy the needs of a specific community.

Content Object Repository Discovery and Resolution Architecture (CORDRA)

The *Content Object Repository Discovery and Resolution Architecture* (CORDRA) is an abstract, formal model for repository federations (Jerez et al. 2006). The basic CORDRA approach is to use a central registry containing the metadata for each content object from a set of independent repositories so that it is

possible to create federations of repositories. Each federation contains that set of repositories and the associated central registry. Multiple federations are possible and any given federation is assumed to represent a community of practice. Such a community could have its own set of metadata standards, access policies, collection policies, and so on, and the central of the federation should reflect those specific practices.

The community-based approach has significant advantages. The consistent and detailed description of learning objects presumes common practices and homogeneous content in order to facilitate optimal searching and organization of the learning object metadata. This situation is likely to exist in a set of relatively homogeneous learning object collections managed by a given community of practice. Then, detailed and internally consistent collections of metadata will allow for the efficient discovery and access to information.

The problem that arises is how to federate metadata collections from different communities of practices in order to provide search and retrieval services across heterogeneous collections. In order to address this problem, the CORDRA model provides another registration process. In this process, the first level registries, those collecting data directly from content repositories, provide data to a Registry of Registries (RofR).

The initial approach of CORDRA assumed a single RofR to which all federations would contribute. However, this approach changed and the current approach is to provide intermediate level RofRs, culminating in a Master RofR, which would serve as the CORDRA root. Starting from the Master Registry of Registries, an application should be able to discover and navigate to any individually identified content item anywhere within the complete set of repositories federated according to the CORDRA model. This new approach presents major challenges in both technical and organizational level that are currently investigated through prototype solutions. One of these challenges refers to the details of federation level metadata: What are the metadata that get pushed or pulled up from one level of registry to the next? The answer to that question will determine the methods that could be used to provide services across federations.

Open Knowledge Initiative (OKI)

The Open Knowledge Initiative (OKI) (OKI, 2006) develops and promotes specifications that describe how the components of a software environment communicate with each other and with other enterprise systems. OKI specifications enable sustainable interoperability and integration by defining standards for

Service Oriented Architecture. To this end, OKI has developed and published the *Open Service Interface Definitions* (OSIDs), whose design has been informed by a broad architectural view. The OSIDs define important components of a Service Oriented Architecture as they provide general software contracts between service consumers and service providers. This enables applications to be constructed independently of any particular service environment, and eases integration. The OSIDs enable choice of end-user tools by providing plugin interoperability.

OSIDs are software contracts only and therefore are compatible with most other technologies and specifications. They can be used with existing technology, open source or vended solutions.

The OKI V2.0 specs were expressed in terms of Java language bindings. As other language bindings become available, such as PHP and Objective C, it has become necessary to express the OSIDs in a more language-neutral way. The XOSIDs, consisting of a neutral XML description with XSLT for transformation into supported language bindings were released in June 2005 for OKI v2. Future specs will be expressed in terms of XOSIDs.

The OSIDs themselves are very generic and they use Types as a way of allowing implementation-specific behaviour. Developing a community consensus on Types is a crucial part of obtaining interoperability with OKI. The most popular OSID, Repository, has been so successful at interoperability because most of the implementations share at least one common Search Type.

The OSIDs released in OKI V2 are the following:

- **OSID Root:** Provides a mechanism for loading OSID managers
- **Agent:** OSID use Agents to represent individuals or processes that invoke specific Services. An example of an Agent is a specific Student, John Doe. This Agent might have the DisplayName "Doe, John ?, the Id 123-45-6789, and a Type indicating a Student. Agents can be organized into Groups. A Group also has a DisplayName, Id, and characterizing Type. In addition, Groups have a description. A Group can contain zero or more Agents. A Group can contain zero or more Groups (subgroups). An Agent can only be added as a member of a Group if it is not already in the Group, but the same Agent can be a member of a subgroup. Agents can have sets of Properties associated with them. Each set of Properties has a Type. The Agent OSID provides a variety of methods for managing these Agents and Groups.
- **Assessment:** Supports creating, organizing, administrating, evaluating,

storing and retrieving Assessments. Assessments are organized into Sections and within Sections into Items. Once composed, an Assessment can be Published in which case it is read to be Taken by an Agent1 (Student). Each Assessment, Section, or Item taken can have an Evaluation

- **Authentication:** Gathers required credentials from an agent, vouches for their authenticity and introduces the agent to the system. It permits an application to abstract the authentication process without having to manage the details of the underlying authentication service.
- **Authorization:** Allows an application to establish and query a user's privileges to view, create, or modify application data, or use application functionality.
- **Course Management:** Supports creating and managing a CourseCatalog. The catalogue is organized into:
    - CanonicalCourses, which are general and exist across terms;
    - CourseOfferings for CanonicalCourses, which occur in a specific term, have a CourseGradeType1, a Status, etc; and
    - CourseSections for CourseOfferings, which have a meeting location, schedule, student roster, *etc*.
- **Dictionary:** Provides a means to support multiple languages, domain-specific nomenclature and culture-specific conventions through interchangeable property files.
- **Filing:** Provides platform-independent means to handle files arranged in simple hierarchical containers.
- **Grading:** Supports characterizing, storing and retrieving Grades. A Grade is specified with four elements: a GradeValue, GradeType, GradeScale, and ScoringDefinition. These four elements provide a general and flexible way to characterize a Grade. The Service also provides for managing GradeRecords, which join information about the Grade, the Agent1 (Student) whose Grade it is, and the object that was Graded. This Service also includes methods for iterating through the GradeTypes, GradeScales, and ScoringDefinitions supported by a particular implementation. One can also iterate through the GradableObjects included among the GradeRecords; and through the GradeRecords themselves.
- **Hierarchy:** Manages parent-child relationships among elements. In addition to simple tree structures, the OSID supports hierarchy that is recursive and have nodes with multiple parents. User authorizations are usually stored as a hierarchy.
- **ID:** Supports managing and using Ids.
- **Logging:** Records and retrieves a variety of application activity history.
- **Repository:** Covers storing and retrieving digital content, referred to as

Assets, as well as information about the Assets. Assets, examples of which include: documents, course material, assessment item, images, video, audio, etc, reside in Repositories which have names and descriptions and which support a specific set of Asset Types. Repositories are themselves organized by the RepositoryManager that keeps track of repositories and supports certain operations such as searching for Assets across repositories. Associated with each Asset Type is a RecordStructure that defines the format of information comprising the Asset or information describing the Asset. An Asset can have content as well as Records, which are data in the format defined by the Asset's RecordStructure. Assets may contain other Assets.

- **Scheduling:** Manages events in shared calendars.
- **Shared:** Contains fundamental objects used in the other OSIDs to provide their functionality.
- **SQL:** Provides a means of storing, editing, and retrieving tabular data through the execution of SQL statements. The data store is presumed to be a relational database.
- **User Messaging:** Supports communication and notification among users.
- **Work Flow:** Provides a way to manage an interdependent succession of activities each of which has completion constraints.

10.3. Services tailoring learning materials to the individual learning styles

In the contemporary learning environments personalization techniques of learners' access to learning objects have to provide results tailored to the individual or group of learners and their learning styles as the response to search queries. When users search for LOs the results returned to them will depend on who they are as well as their query, since different LOs may be more appropriate for different learners. This section will track down one clear approach for personalization services implemented in Self e-Learning Networks (SeLeNes) project (Keenoy at al. 2004). Personalization will have an effect on search results returned from a keyword-based query at three different levels:

- *Filtering* of the returned LOs – excluding those LOs deemed unsuitable for the learner, even though they satisfied the original query;
- *Ranking* of the returned LOs – the 'best' LO for one user may be different from the 'best' LO for another, but personalized ranking means that they can both have the most suitable LO for them returned at the top of their search results;
- *Presentation* of results – users will have different preferences for the

display of their search results (*e.g.* display results as trails or as a simple list, display 10 results per page or 50 results per page).

Some aspects of personalization can also take place even before a query is submitted for evaluation: personalized queries can be constructed using information stored in the profile, by re-formulating or annotating the user's original query to reflect elements of their profile. The user profile has to contain information about preferences, aims, and educational history that can be used by the system. This is the first stage of filtering.

Keyword-based query service is not the only way that users can locate LOs – the schema of the LO descriptions can also be browsed to find relevant LOs, providing facilities such as 'browse by author' and 'browse by subject'. Personalization of the browsing process can occur at two levels:

- Allowing users to restrict the information they see to only those attributes of interest to them, organised in their preferred manner.
- LMS can use knowledge of a user's preferences (either those explicitly supplied by the user or those learned by the system itself) to recommend individual LOs or categories of LOs to the user as they are browsing.

Filtering and ranking search results

The query service will return a set of LO descriptions – all those LOs that satisfy the user's query. The user wants to be able to find exactly the right LO quickly, without having to browse too many of the results, so rather than present the results exactly as they are returned by the query service some processing is done first.

If a profile of the user is not available (or the user has personalization turned off) then all that can be done at this stage is some rudimentary ranking of the result set, possibly using standard ranking techniques from information retrieval and Web search.

However, we anticipate that usually some minimal profile will be available to the system, as users should supply at least some minimum information into their profile when first registering. In this case the ranking of LOs will involve personalization. This means that the system can attempt to show the user only those results likely to be most relevant to them personally, as well as relevant to the query in general.

The first step in this processing is to filter the results – remove all those LOs that we are certain will be of no use to the user. At this stage, for example, any LOs in languages that the user does not understand can be eliminated, as can those not meeting accessibility requirements, those at a far too high or low level of difficulty and possibly those covering only material that the learner is already completely familiar with.

Next, the remaining set of LO descriptions must be ranked in order of relevance to the user. Whereas filtering can be done with just the user profile, ranking a set of results should take the original query into consideration too (i.e. relevance must be judged against the combination of user profile and query, not just the profile).

The best algorithm to use for this ranking is still an open question, but it will take into consideration:

- Relevance of the LO to the query;
- How well the LO caters for the user's accessibility requirements;
- Whether the user has the prerequisite knowledge and experience;
- Matching between the user's goals and the learning objectives of the LO;
- If the user's learning styles are those catered for by the LO;
- If the user is likely to prefer it for other reasons (it is by a preferred author, say);
- The user's most recent activity.

The clear individual semantics of each section of the user profile allows focussed matching against relevant sections of the LO descriptions. For a LO to be a "good" LO for the user, the greatest possible number of different elements will match to some degree. Clearly, though, some factors are more important than others to the user and a good algorithm for combining them will reflect this. For example:

- If LO X caters for one of the user's learning styles but is not very relevant to the original query then other, more relevant LOs should be ranked higher even if their descriptions don't list one of the user's learning styles;
- If LO Y has a learning outcome that matches one of the user's goals but is far too difficult for the user to tackle (they have none of the prerequisite knowledge, say) then again other LOs (closer to the user's level) should be ranked higher.

With so many factors to take into consideration, discovery of which algorithms work better or worse for which groups of users requires much further work and testing, and is beyond the scope of this project. It may be that the ranking algorithm itself needs to adapt to the individual, and will differ from user to user (an additional section could be added to the user profile to store information about parameters used by the ranking algorithm).

Support for browsing as a trail

As the user is browsing LOs the trails and adaptation service can actively recommend the next LO to look at, effectively generating trails of length two (i.e. a trail consisting of the current LO and a suggestion for the next one) at every stage of the user's browsing, based on the user profile.

The recommendations can be derived in several ways:

- from the semantic relationships between the current LO and other LOs in the LMS repository;
- from the user's profile plus LO metadata – perhaps suggesting LOs that cover more advanced material on the same topic, and also suit the user's preferences (learning style, accessibility, *etc.*);

through a process of collaborative filtering, suggesting as the next step a LO that other similar users browsed after seeing the current LO (where similar users can be identified by having similar preferences or similar histories of LO access).

10.4. A pedagogy-driven personalization framework to support adaptive learning experiences

Different Learners have different learning styles, educational levels, previous knowledge, technical and other preferences and all these are needs and preferences that "one size fits all" solutions are not enough to satisfy them. Learners expect from systems that their personality and needs are known and taken into account in their learning activities. Moreover, the proliferation of the Internet and the wealth of content in Learning Object Repositories call for flexible solutions where content is not strictly bound with the learning plan but could be retrieved at run-time and ideally from many sources according to the Learner needs. Several research areas are related with the above challenges as Adaptive Hypermedia Systems, Intelligent Tutoring Systems, and Semantic Web (Brusilovsky, 1999). Although each area treats adaptivity of learning experiences from a different point of view, there is a convergence in the research community that pedagogy is important and should be

represented in a consistent way. Moreover, the pedagogical model should be reusable and separated from content allowing appropriate learning resources according to the Learner profile to be bound to the training scenario at run-time.

In order to effectively support pedagogically-sound adaptive learning experiences, several issues need to be addressed:

1. Appropriate formulation and description of learning objects giving special attention to elements related with educational context (*e.g.* Learning Objectives).
2. Consistent representation of pedagogy separated from content according to a model that allows for the binding of appropriate learning objects to the learning scenarios at run-time.
3. Appropriate representation of Learner Profiles giving special attention to elements representing the learning needs of Learners (*e.g.* learning goals, previous knowledge, learning style, educational level).
4. Specification of a personalization component that taking into account all the above constructs adaptive learning experiences that fit to the Learner's needs and preferences.

In this section, we present a framework that addresses the above issues. This framework allows for the dynamic creation of pedagogically-sound learning experiences taking into account the variety of the Learners and their individual needs. Among others this framework defines a model for the representation of abstract training scenarios (Learning Designs), where pedagogy is clearly separated from content. Appropriate Learning Designs are applied from the personalization processes performed by a personalization component to the construction of learning experiences where reusable learning objects are bound to the training scenario at run-time according to the Learner's individual needs and preferences (*e.g.* learning goals, previous knowledge, learning style, educational level, *etc.*). This way, the Learning Designs can be exploited and reused by the personalization processes for the construction of learning experiences for different instructional contexts. (This framework has been implemented in a service-oriented architecture built on an experimental digital library of audiovisual content. The work is partially funded in the scope of the LOGOS ("Knowledge-on-Demand for Ubiquitous Learning") STREP Project (IST-4-027451) and presented in (Arapi et al., 2006) (Arapi et al., 2007a) (Arapi et al., 2007b) (Arapi et al., 2007c) (Arapi et al., 2007e).

The main component of the personalization framework (Figure 11) is the Personalization Component. It takes into account the Learner Profile and finds an appropriate Learning Design that will is thereafter applied to the construction of

learning experience by binding specific learning objects to learning activities using information from the Learner's profile. Finally, the Transformation Component creates a SCORM package from the intermediate representation of the learning experience.

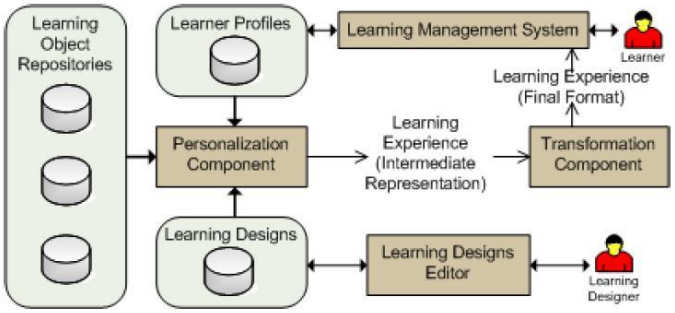

Figure 11. Architecture

LOM is used for the description of learning objects providing a consistent representation that facilitates their retrieval from repositories. If this framework is applied on top of digital libraries, the approach can be used in order to support multiple context views of digital objects. Information about the learning objectives of each object is important in order to apply this framework. We define a learning objective as a pair of a verb taken from a subset of Bloom's taxonomy (*e.g.* defines, *etc.*) and a topic referencing a concept or individual of a domain ontology. This can be expressed in LOM using its classification element. It is assumed that a SCORM compliant LMS is used to deliver the personalized learning experience to the Learner and keep the Learner profile up to date. A special tool, called Learning Designs Editor has been also implemented for the creation of Learning Designs.

Learning Designs

Learning Designs are abstract training scenarios that are constructed according to an instructional ontology (Figure 12). Training is composed of TrainingMethods that are different ways for teaching the same subject depending on the LearningStyle and EducationalLevel of the Learner. A TrainingMethod consists of reusable ActivityStructures built from Activities. Each Training, ActivityStructure and Activity has a LearningObjective structured as defined earlier. The LearningObjectType is used to describe the learning object properties without binding specific objects with Activities at design time. The related_with property can further restrict the preferred learning objects connecting them with

DomainConcepts or individuals in domain ontology.

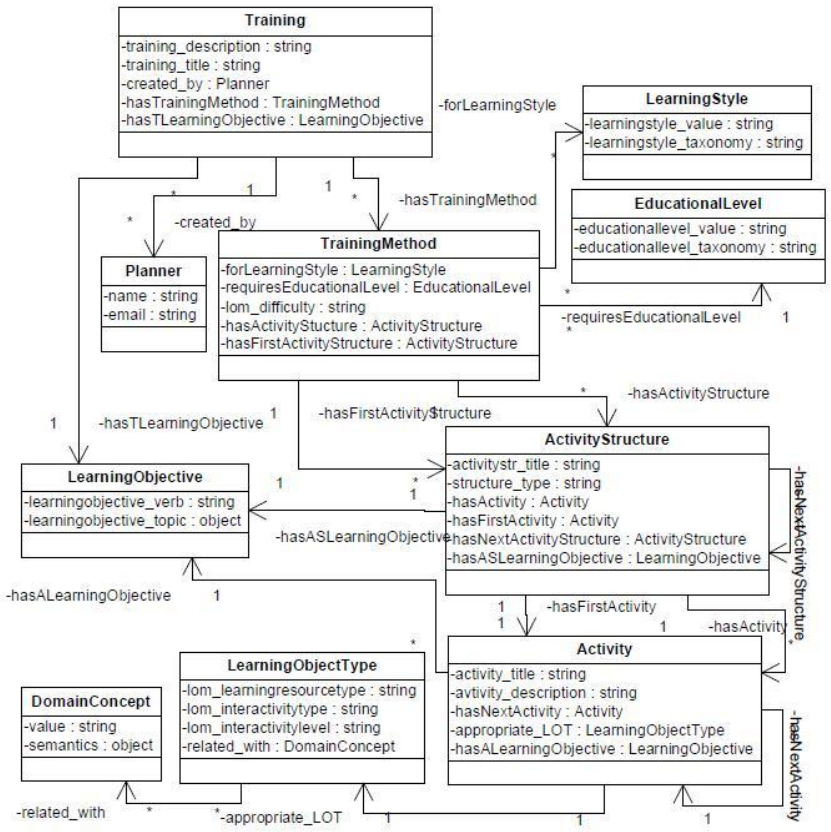

Figure 12. The instructional ontology

Learner Profiles

We focus on the elements that should be included in a Learner Model to support the framework presented here (Figure 13). A LearnerGoal is expressed in terms of LearningObjectives using the structure presented above. It has a status property (float in [0, 1]) indicating the satisfaction level of the goal so that one can also infer the previous knowledge of the Learner. The Learner can also define a priority for each Learner-Goal. Several types of Preferences are used: EducationalLevel and LearningStyle matching with the corresponding elements of the instructional ontology, Language, LearningProvider who makes available the

learning objects, LearningPlanner (the developer of learning designs) and Technical preferences.

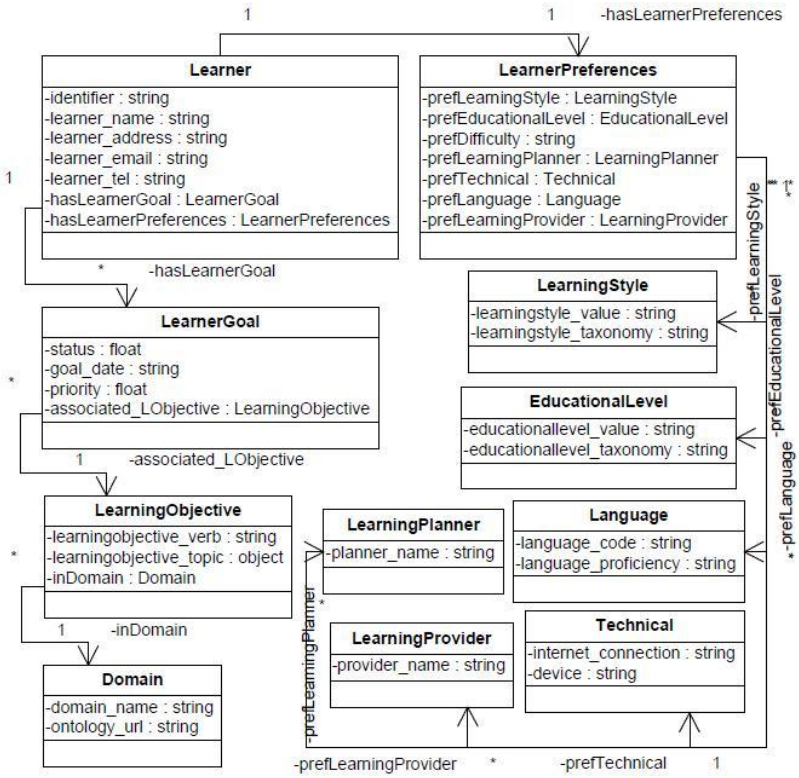

Figure 13. The learner ontology

The Personalization Component

The Personalization Component considers the Learning Designs and the Learner Profiles and constructs personalized learning experiences that are delivered to eLearning applications in SCORM format. The goal is to find an appropriate learning design that will be used thereafter to construct a learning experience adapted to the Learner's needs. Learning objects are bound to the learning scenario at run-time.

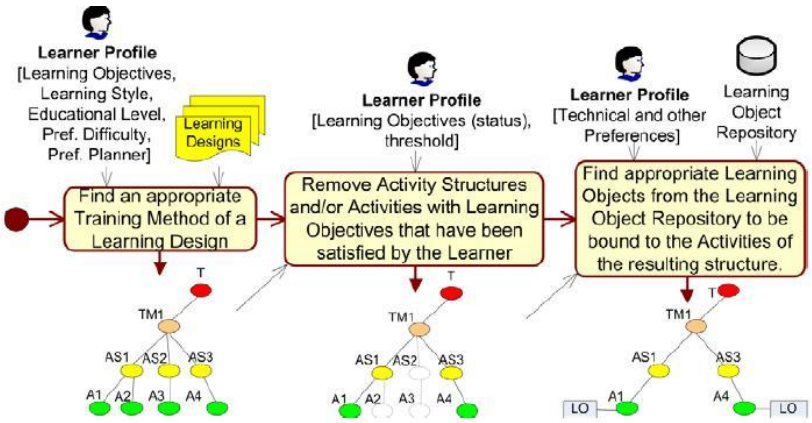

Figure 14. The personalization algorithm

11. Grid technologies and services for learning environments. Learning grid

The utilisation of currently available communication and information technologies has turned traditional location based education into location independent one. Nowadays, learning is equivalent to searching for sources and selecting the appropriate source to study from. The multitude of sources available on the Internet makes the selection of the appropriate source a rather difficult task. Learners need to access large volumes of data, most times distributed in many locations. Learners also need a variety of services available on demand that can be used and accessed from their environment to satisfy their learning needs. All of the above can be enabled by the utilisation of grid technologies.

Grid is a modern technology for the flexible, secure and coordinated sharing of distributed resources and data. Grid technologies define a new powerful computing paradigm where the customer of the grid will be able to use his or her private work place (Workstation, PC, UMTS phone,...) to invoke any application from a remote system, use the system best suited for executing that particular application, access data securely and consistently from remote sites, exploit multiple systems to complete complex tasks, or use multiple systems to solve large problems that exceed the capacity of a single one. Another interesting aspect of grid technologies is their support for resource sharing and problem solving in dynamic, multi-institutional virtual organizations. In this vision, the sharing does not mean simply exchange of data or files but rather a concrete access to resources. This "sharing capability" imposes the definition and implementation of well-defined resource management policies to specify what is accessible, from whom and under which conditions.

Traditionally, grid computing has addressed the needs of long-running scientific computations submitted as batch jobs. Long-running batch jobs can be distributed across several nodes in a grid and executed in parallel, resulting in shorter execution times. The benefits of grid computing extend to the provision of resource virtualization already supported by developing standards of the Open Grid Services Architecture (OGSA). Their use can shift the boundary of traditional networked models out to dynamically include and exclude elements of other organizations, thus increasing management and economical complexity.

In the case of networked business models, and thus from a virtual organization point of view, traditional technologies such as virtual private networks and Intranets/Extranets based on HTTP provide just an infrastructure for their basic functionality.

Conceptually, the grid can be thought of in terms of three layers: the computational/data grid, the information grid and the knowledge grid.

The bottom layer is the computational and data grid: the computer hardware and data networks upon which the work will be conducted. Above this lies the 'information grid': the databases of information to be accessed by the hardware, and systems for data manipulation. On top lies the 'knowledge grid', where high-level applications mine the data for the knowledge that can form the basis of semantic understanding and intelligent decision-making.

A data/computational grid forms the fabric of the grid to provide raw computing power, high-speed bandwidth and associated data storage in a secure and auditable way.

A knowledge grid uses knowledge based methodologies and technologies for responding to high-level questions and finding the appropriate processes to deliver answers in the required form. This last layer includes data mining, machine learning, simulations, ontologies, intelligent portals, workflow reasoning and Problem Solving Environments for supporting the way knowledge is acquired, used, retrieved, published and maintained. A knowledge grid should provide intelligent guidance for decision makers and hypothesis generation.

The Grid was originally designed for e-Science and was primarily concerned with supercomputing applications, but the framework it engendered to realise effective sharing of distributed heterogeneous resources (OGSA: the Open Grid Services Architecture) is now being applied to many other areas, especially enterprise computing, e-Commerce, eLearning, *etc*. The Open Grid Services Architecture (OGSA) represents an evolution towards a Grid system architecture based on Web services concepts and technologies. For eLearning this allows the creation of learning grids – learning environments built on OGSA-compliant software and services. Learning grids promise to introduce a new quality of eLearning by:

- enabling collaborative learning with peer-to-peer communication,
- making computing-intensive visualisations or simulations available for the learners,
- giving access to real-world data and resources like virtual laboratories.

We see the use of the Grid to support a paradigm shift in pedagogy to advance effective learning as a natural step in the recent historical progress of technology enhanced learning: Internet → Web → Grid.

New learning scenarios enter the picture: the user-centred, contextualised and experiential based approaches for ubiquitous learning imply the full exploitation of location-transparent access to distributed services such as simulation environments, real-world input, 3D visualisation systems and digital libraries, in the framework of a virtual organization. This allows a transition from current content-oriented eLearning solutions towards a user-centred, collaborative model.

The next generation of learning grid solutions will increasingly adopt the service-oriented model for exploiting technologies. Its goal is to enable as well as facilitate the transformation of *information* into *knowledge*, by humans as well as – progressively – by software agents, providing the electronic underpinning for a global society in education, research, science (semantic aspects), *etc*. These efforts are referred to the *Semantic grid (Knowledge grid)*.

Scenarios for utilisation of knowledge grid in the eLearning procedures

Numerous possible scenarios for utilisation of knowledge grid in the eLearning procedures are realisable. Most generally speaking they can be summarized by the following scenario:

Some users need to access certain digital objects to satisfy their learning needs. They connect to the learning provider portal to request the materials. The portal is connected to the knowledge grid that provides access to large volumes of digitised knowledge, most likely distributed at many locations. Special services find the relevant materials across the grid and deliver to the learning provider and by him to the users in suitable form.

One hypothetical scenario, assuming the use of knowledge grid, is the following: a learner on an early Sunday morning is watching a documentary on television. The topic of the documentary is the solar planet system and the learner finds this quite interesting, so she desires to learn some more. A little later, while travelling on the back seat of her parents' car during a typical Sunday journey, she uses her palmtop to connect to her school's portal to use the grid infrastructure and from there to NASA database to view some photos. These photos are actually located in a number of storage devises and in various physical locations, but the

student views them as a unified collection available on the grid. After viewing some photos of Mars (and perhaps after viewing Mars through a telescope connected to the grid), she decides to create a simulation of the relative positions of Mars and Earth in our solar system. So she demands the appropriate service for this on the grid and starts the simulation. While the student is watching the simulation on her palmtop, the computers from a number of school laboratories (closed on Sundays) – all connected to the grid – share their CPU power to allow her to create all the data required for this service (Xenos at al., 2005).

This is just one possible scenario that illustrates the utilization of grid technologies in the everyday learning procedure. Grid technologies are a promising approach to an infrastructure that will allow the learning process actors to collaborate and share high quality learning data and innovative solutions for learning and training.

The following three projects explore the knowledge grid technology, its main opportunities and advantages (the paradigm of service-orientation, ubiquity, user-centricity, distributed resources, *etc*.) and propose different conceptual decisions for their implementation in eLearning.

ELeGI (European Learning Grid Infrastructure) is an EU-funded Integrated Project that aims at facilitating the emergence of a European grid infrastructure for eLearning and stimulating research of technologies to enhance and promote effective human learning. ELeGI promotes and supports a learning paradigm shift focused on knowledge construction using experientials based and collaborative learning approaches in a contextualized, personalized and ubiquitous way. This new paradigm is based on a learner centred approach: learning is student-centred and seen as personal and active construction of his/her own knowledge. Considering people at the centre, learning is clearly a social, constructive phenomenon. It occurs as a side effect of realistic simulations, interactions, conversations, collaborations, and enhanced presence in dynamic virtual communities.

The philosophy and approach behind grid technologies show the right characteristics for achieving an effective learning. Indeed, they allow access to and integrate the different technologies, resources and contents that are required in order to realise the new paradigm. They are the most promising approach to realise an infrastructure that will allow learning process actors to collaborate, to take part in realistic simulations, to use and share high quality learning data and to innovate solutions of learning and training. Grid will be able to support learning processes allowing each learner to use, in a transparent and collaborative manner, the

resources already existing online, by facilitating and managing dynamic conversations with other human and artificial actors available on the grid (ELeGI).

The ELeGI project has three main goals:

- to define new models of human learning enabling ubiquitous and collaborative learning, merging experiential, personalised and contextualised approaches;

- to define and implement an advanced service-oriented grid based software architecture for learning. This will allow us to access and integrate different technologies, resources and contents that are needed in order to realise the new paradigm. This objective will be driven by the pedagogical needs and by the requirements provided by the test-beds (SEES) and informed by the experience gained through implementing the demonstrators;
- to validate and evaluate the software architecture and the didactical approaches through the use of SEES and demonstrators. The project will build extensively on advanced work already done, creating new learning environments rather than creating new learning resources. (ELeGI)

Akogrimo (Access to Knowledge through the Grid in a mobile World) is a project funded by the European Commission under the FP6-IST programme. The project runs from July 2004 until June 2007. The project team comprises 14 European organisations. The idea behind the Akogrimo framework is to deal with situations where mobile dynamic virtual organizations (MDVO) should dynamically adapt the organisational structure to changing local situations, dynamically establish and process complex workflows, and access data and compute intensive services from distributed/mobile resources. The following features are exhibited:

- mobility and context awareness;
- personalisation, privacy, security;
- cross-organisational distributed resources;
- heterogeneous, dynamic environments;
- Quality of Service (QoS);
- job and data services. (Akogrimo)

The SeLeNe project uses eLearning as a test-bed application to explore novel

ways of bridging the gap between Semantic Web technology and peer-to-peer computing in a knowledge grid environment. A Self eLearning Network can be defined as a distributed repository of educational metadata describing learning objects available on the Web, collaboratively built and used by anyone who wishes to use existing learning objects (LOs) or to construct new learning objects, in any knowledge domain.

The SeLeNe project aims to elaborate new educational metaphors and tools in order to facilitate the formation of learning communities that require world-wide discovery and assimilation of knowledge. To realize this vision, SeLeNe is relying on semantic metadata describing educational material. SeLeNe offers advanced services for the discovery and sharing of learning resources, facilitating a syndicated and personalised access to such resources. These resources may be seen as the modern equivalent of textbooks, comprising rich composition structures, "how to read" prerequisite paths, subject indices, and detailed learning objectives.

Disciplines (knowledge domains) usually employ ontologies to structure information relative to their field of study. Essentially, knowledge grids provide concept spaces and services for discovering relevant information, and thus serve as an information discovery support layer. In a knowledge grid, information resources are discovered by mapping domain-specific concepts (from ontology) to the attributes (in metadata) used to describe the information resources. Knowledge grids can benefit significantly from Semantic Web technology, which offers standard languages (for example, W3C Resource Description Framework (RDF)) for describing the semantics of various kinds of information resources. SeLeNe aims to support knowledge grids, by bringing together ontologies, RDF, and peer-to-peer technology in order to develop some of the urgently needed techniques and services for managing distributed, evolving metadata repositories, for flexible semantic reconciliation of metadata, and for personalisation of the view of grid knowledge and information resources in order to match individual users' needs.

Furthermore, SeLeNe can be considered as addition to the traditional LMS because of the following considerations and available learning services:

- Presentation of content – SeLeNe is an 'intelligent catalog' allowing the registration of learning objects (LOs) and the discovery of useful LOs via their associated metadata;
- Assessment and tracking services – SeLeNe do not perform administrative functions such as tracking the progress and attainment of students. SeLeNe may be used to discover LOs that can be used for assessment, but their validation is beyond the scope of SeLeNe;

- Communication and collaboration services – SeLeNe goes beyond the standard asynchronous communication based on email within a group of users. Its ‘reactive’ functionality allows automatic notification of events and changes in LO descriptions;
- Search service – SeLeNe allows searching of LOs at many distributed sites, via their descriptions rather than their content;
- Personalisation – SeLeNe provides a wide range of personalisation techniques based on profiles, views and trails.

12. Recommendations and scenarios

This document aims to make a comprehensive analysis of innovative learning services in Web, interactive TV and mobile applications for non-formal settings. Many issues for further development have also been identified. More generally speaking, the future of ubiquitous learning requires:

- Development and implementation of knowledge-on-demand ubiquitous learning platforms, integrating learning resources and communication spaces through knowledge-on-demand learning services. The knowledge-on-demand learning services could provide semantic-led access to the virtual repositories, multilingual support and flexibility in order to produce personalised re-usable learning materials.
- Development of new educational and organisational models for integration of Web-based, DVB-based and mobile devices delivery of learning materials that focuses not on the channel alternativeness, but on their integration and mutual complementarity.
- Development of new standards and abstract architectural models for these integrated communication spaces.
- Production of interactive audiovisual learning content that takes maximum advantage of the new capabilities of networked electronic media in order to integrate all citizens into Information and Knowledge Society.
- Realisation of more economical and more easily usable tools for content production.
- Realisation of a modern learning environment providing autonomous on-the-fly learning content adaptation, with no human intervention. Adapters should be capable of self-description and a pervasive support infrastructure should take the appropriate context-based adaptation decisions, without affecting the design and implementation of multimedia servers and client applications.
- Involvement and implementation of Semantic Web technologies in the ubiquitous learning processes, *i.e.*, development of models for eLearning semantics, ontologies, ontological metadata, advanced methods, tools and services for knowledge annotation and indexing, *etc*.
- Development of advanced automatic analysis and recognition tools and systems for audio visual learning content capable of generating highly semantic metadata in a very fast and reliable way. Target services include audiovisual delivery over fixed and mobile networks (TV, VoD) and all associated functionalities, personal content management, professional content management, *etc*.

- Development of new standards and models for learning metadata descriptions.
- Wider usage of large-scale repositories of digitised text, graphics, audio, video objects, *viz.* multimedia digital libraries, as a source of digital knowledge, *etc.*

The new ubiquitous learning solutions will be driven by the following scenarios:

- Learning will be realised in different learning contexts, modelling learning process and learning materials by considering different ways and phases of cross-media authoring, access, delivery, study and assessments through different modes and levels of integrated communication spaces.
- Personal environments will be populated by personal communication and computing devices, accessories, wearables, implants. eLearning services will be adapted to the user's individual situation, location and preferences.
- Mobility and ubiquitous access will be a key challenge for in-field job training needs.
- Learning demands high bandwidth broadband, it calls for new high quality graphical environments, it stimulates the introduction of new and innovative services in digital content and software.
- Business environments will benefit from eLearning solutions creating a competitive advantage for European business and will especially facilitate SME's exploring new markets.

Executive summary (Bulgarian version)

1. УВОД

Проектът CHIRON има за цел да разработи справочни материали, включващи и анализиращи научни изследвания, експерименти и доказани практически решения за нови видове е-обучение, които са базирани на големи мрежи, цифрова телевизия и мобилни технологии за повсеместно приложения в сферата на неофициалното и неформално продължаващо обучение.

В Задача 7.1. ръководителят на задачата (IMI–BAS) със съдействието на другите партньори подготвят финална аналитична разработка на проекта, в която се интегрират, осъвременяват и обобщават анализите и заключенията, получени в рамките на проекта и се посочват образци и практически решения с оценка на тяхната ефективност.

Това е разширено резюме на доклада по Задача 7.1.

2. ИЗСЛЕДВАНЕТО

Изследването представя новите предизвикателства и ползите от приложението на широкоразпространените мрежи, интерактивната телевизия и мобилните устройства при иновационните учебни практики и новите функционални решения за повсеместен достъп по глобалните научни хранилища. В него се стига до формулирането на краткосрочни и дългосрочни прогнози за бъдещето на приложенията за повсеместно обучение под формата на възможни сценарии и препоръки.

В следващите глави обобщаваме основните части на аналитичното изследване.

2.1 Общи проблеми на иновационните учебни приложения на мрежи, интерактивна телевизия и мобилни устройства при повсеместното обучение

Бъдещите тенденции в повсеместното обучение се развиват в посока на изследването и развитието на специализирани иновационни услуги, позволяващи на голям брой учащи да имат достъп и да “посещават” курсове с помощта на мрежови и цифрови видео устройства в обучаващата институция

и/или на работното място или в къщи, комбинирани с практически повсеместна връзка на мобилните стройства.

Следвайки тази идея, в главата са дефинирани иновационни учебни услуги, предложени от няколко много важни изследователски проекта от последните години (ELENA (http://www.elena-project.org/), LOGOS (http://www.delos.info/), SeLeNe (http://www.dcs.bbk.ac.uk/selene/), MOBILearn (http://www.mobilearn.org/), MUSIS (http://www.musis.se/), *etc.*). Включени са кратки описания на тези проекти.

2.2 Нови модели, технологии и приложения за обучения "тъкмо на време" и "знание при поискване"

Невероятната скорост и подвижност на съвременните пазари изискват развитието на методи от типа "тъкмо на време", които да подпомагат *нуждата да знаят* на служители, партньори , както и тяхното разпространение. Ясно е също така, че новият начин на обучение ще се движи напред според изискванията на новата икономика: бързина, "тъкмо на време" и свързаност с проблема (релевантност). Парадигмата на "знанието при поискване" (KoD), възникнала от текущите нужди на обществото, основаващо се на знанията, поставя следните важни изисквания пред процеса на обучение: на всеки, по всяко време и на всяко място да се предоставя образование и квалификация, приспособени и съобразени със специфичните изисквания и предпочитания на всеки отделен гражданин в рамките на различните типове е-обучение и е-работа. Това изисква сериозни усилия за осъществими технически решения на концепцията KoD.

Фокусът в тази глава е поставен върху няколко технологични решения – Семантични мрежи, Интерактивна телевизия и Безжични и мобилни технологии, които да предоставят бързо, "тъкмо на време", релевантно и налично "при поискване" повсеместно обучение.

2.3 Нови организационни структури и връзки между обучението у дома, в социална среда, в движение, в училище и на работното място

Тази глава най-напред разглежда съществуващите понастоящем нужди на учащите и възможностите/избора за продължаващо обучение. По-нататък тя представя учебния процес в различни ситуации и бъдещите тенденции за осъществяване и използване на повсеместното обучение. Накрая, главата включва някои насоки за планиране приложенията на повсеместното обучение от гледна точка на различни учебни сценарии.

2.4 Методи за оценяване ефективността на повсеместното Е-обучение и относителните образователни оценки на различните подходи, продукти, учебни среди и процеси

Оценъчният процес задължително трябва да се вземе предвид, особено когато се тества ефективността на повсеместното е-обучение и се определят образователните оценки на различните подходи, продукти, учебни среди и процеси. Тази глава представя оценъчни методологии и техники, които могат да помогнат на компаниите и потребителите да проверят дали съответните продукти и услуги на повсеместното е-обучение отговарят на техните цели. Оценъчната методология се отнася до определяне доколко добре потребителите могат да използват съответния елемент (т.е. продукт и/или услуга на повсеместното е-обучение), какво мислят за него, какви са основните им проблеми от гледна точка на подобряване фазите на проектиране или ре-проектиране.

2.5 Нови стандарти и абстрактни архитектурни модели за интегрирани мрежи, интерактивна телевизия и мобилни устройства

Повсеместното обучение и неговите услуги не трябва да се разглеждат изолирано от съществуващите и нови стандарти и спецификации в тази сфера, защото целта е да се максимизира многократното повторение и преносимостта на учебния процес. В тази глава се изброяват серия от стандарти и абстрактни модели за интегрирани мрежи, интерактивна телевизия и мобилни устройства, т.е. DVB–MHP (Digital Video Broadcasting – Multimedia Home Platform), GPRS (General Packet Radio Service), 3GPP (3rd Generation Partnership Project), Wi-Fi (802.11), IrDA (Infrared Data Association), Bluetooth, WAP (Wireless Application Protocol), UMTS (Universal Mobile Telecommunications System), HSDPA (High-Speed Downlink Packet Access), 3G LTE/SAE (Long Term Evolution).

2.6 Услуги за приложения на повсеместното обучение, базиращи се на Семантични мрежови технологии и онтологии за използване на информация

Тази глава проследява ролята на онтологиите за интегриране на услугите на повсеместното обучение. На тази база е представена Семантична интеграционна рамка. Целта й е да осигури една интеграционна платформа от услуги, която предлага подпомагане на учащите с концентриране върху техните нужди при обучение, базиращо се на мрежи и семантични връзки между източниците на обучение.

2.7 Услуги за създаване, съхраняване и предоставяне на обекти, които са индивидуализирани, многократно употребяеми и с възможност за общо ползване на съдържанието. Достъп-при-поискване до цифрови библиотеки при повсеместното обучение

В тази глава специално внимание е отделено на услугите по предоставянето на учебното съдържание, адаптирането, индивидуализирането, съхранението, индексирането (систематизиране) му, семантичното търсене, и др. основни положения и бъдещи тенденции. В нея се обяснява и как достъпът-до-поискване до знанията може да се реализира при цифровите библиотеки за осигуряване на повсеместното обучение.

2.8 Моделиране, профилиране и индивидуализиране на обучението. Обучение по специална поръчка

Тази глава представя моделирането на обучението, профилирането и индивидуализирането му, стандартите и употребите. Тя включва също и методология, базираща се на мрежови услуги за специално поръчано обучение по специфичен профил.

2.9 Услуги в индивидуализирани и адаптирани учебни среди, моделирани според контекста на индивидуалността на учащите, техните познания, нужди, учебни похвати и предпочитания

Индивидуализираните и адаптирани учебни среди изискват услуги, които са семантично основани и съобразени с контекста, които са моделирани според контекста на индивидуалността на учащите, техните познания, нужди, учебни похвати и предпочитания. Тези услуги правят възможно постигането на семантична интероперативност между хетерогенните информационни източници и услуги. Технологичната и концептуална диференциация между различните системи може да бъде преодоляна посредством използването на стандарти или чрез следващите подходи, базиращи се на добре приети модели. Най-напред тази глава представя предишна работа, свързана с изучаване на някои аспекти от индивидуализацията и е-обучението. След това се разглежда осигуряването на подходящи решения, ориентирани към учащите и базиращи се на интеграцията на учебните стандарти, на установените вече модели и подходящи за целта технологии. Главата включва също така и теми, свързани с достъпа до метаданни, съхранявани в приложими учебни системи.

2.10 Grid технологии и услуги за учебни среди. Учебна grid мрежа

Тази глава представя новата технология за гъвкаво, надеждно и координирано ползване от много потребители на хетерогенни източници и данни, наречено Grid. Главата описва неговите специфични особености, услуги, функционалност и приложения. Едно от тези приложения е повсеместното обучение. Такова концептуално решение, базиращо се на Grid-технологията е учебният grid, дефиниран като една модерна учебна среда, изградена на т. нар. Open Grid Services Architecture (Архитектура за отворени Grid услуги) – удобен за потребителя софтуер, осигуряващ разнообразие от иновационни услуги за трансформиране на информацията в знания, разпределени услуги като симулационни среди, вход в реална среда, 3D визуализационни системи, в рамките на една виртуална организация, и др.

2.11 Препоръки и сценарии

Анализът на Задача 7.1. доведе до формулиране на краткосрочни и дългосрочни прогнози за бъдещето на повсеместното обучение, неговите приложения под формата на възможни сценарии и препоръки, които са включени в тази глава.

В частност тези сценарии стигат до следните констатации:

- Обучението може да се реализира в различни учебни контексти, посредством изработване на модели на учебния процес и учебен материал, като се разглеждат различни начини и фази на кросмедии, създаващи хипертекстове, достъп, изследване и оценка посредством различни режими и нива на интегрирани комуникационни пространства.
- Индивидуални лични среди ще бъдат осъществени с персонални комуникационни и изчислителни средства, аксесоари, преносими, имплантирани устройства. Услугите в областта на е-обучение ще бъдат адаптирани съобразно индивидуалното положение, място и предпочитания на потребителя.
- Мобилността и повсеместният достъп ще бъдат ключово предизвикателство за нуждите на обучението, свързано с конкретна работа на място.
- Обучението изисква висикоскоростна комуникационна среда с широка полоса на работните честоти, тя изисква наличието на графични среди с високо качество. Обучението стимулира въвеждането на нови иновационни услуги с цифрово съдържание и

софтуер.

- Бизнес средите ще спечелят от решенията на е-обучение поради създаването на конкуриращи преимущества за европейския бизнес и по-специално от съдействието на малките и средни предприятия в изследването на нови пазари.

Executive summary (Greek version)

1. ΕΙΣΑΓΩΓΗ

Το έργο CHIRON στοχεύει στη δημιουργία υλικού αναφοράς το οποίο παρουσιάζει και αναλύει ερευνητικά αποτελέσματα, πειράματα και βέλτιστες πρακτικές για νέες μορφές ηλεκτρονικής μάθησης, που βασίζονται στην ολοκλήρωση των τεχνολογιών παγκόσμιου ιστού, ψηφιακής τηλεόρασης και κινητών συσκευών για τη δημιουργία αειφανών εφαρμογών στο πεδίο της μη τυπικής και άτυπης δια-βίου μάθησης.

Στο τμήμα εργασίας 7.1 ο υπεύθυνος εταίρος (IMI–BAS) με τη συνεργασία των άλλων συμμετεχόντων ανέπτυξε την τελική αναλυτική αναφορά του έργου, η οποία συγκεντρώνει, ενημερώνει και γενικεύει τις προηγούμενες αναλύσεις και συμπεράσματα που εξήχθησαν κατά τη διάρκεια του έργου. Επίσης εντοπίζει ενδεικτικές περιπτώσεις και βέλτιστες πρακτικές αξιολογώντας την αποτελεσματικότητά τους.

Το παρόν κείμενο αποτελεί μια εκτεταμένη περίληψη της έκθεσης του τμήματος εργασίας 7.1.

2. Η ΕΚΘΕΣΗ

Η έκθεση παρουσιάζει τις νέες προκλήσεις και ευκαιρίες της αειφανούς μάθησης μέσω παγκόσμιου ιστού, ψηφιακής τηλεόρασης και κινητών συσκευών, καλύπτοντας καινοτόμες υπηρεσίες μάθησης και τις νέες λειτουργικότητες αειφανούς πρόσβασης σε βιβλιοθήκες γνώσης. Περιλαμβάνει επίσης βραχυπρόθεσμες και μακροπρόθεσμες προβλέψεις σχετικά με το μέλλον των εφαρμογών αειφανούς μάθησης με τη μορφή σεναρίων και συστάσεων.
Στη συνέχεια συνοψίζονται τα κύρια κεφάλαια της έκθεσης.

2.1 Θεμελιώδη ζητήματα για καινοτόμες εκπαιδευτικές υπηρεσίες στον παγκόσμιο ιστό, την ψηφιακή τηλεόραση και τις κινητές συσκευές για την αειφανή μάθηση

Οι μελλοντικές τάσεις στην αειφανή μάθηση τείνουν προς την διερεύνηση και ανάπτυξη καινοτόμων υπηρεσιών που θα επιτρέψουν σε ένα ευρύ φάσμα εκπαιδευομένων να έχουν πρόσβαση και να παρακολουθούν μαθήματα μέσω εργαλείων παγκοσμίου ιστού, ψηφιακής τηλεόρασης σε εκπαιδευτικά ιδρύματα

και/ή στους χώρους εργασίας ή στο σπίτι, συνδυασμένα με την πρακτική εφαρμογή αειφανούς συνδεσιμότητας μέσω κινητών συσκευών.

Ακολουθώντας αυτή την ιδέα, το κεφάλαιο αυτό προσδιορίζει ένα σύνολο καινοτόμων εκπαιδευτικών υπηρεσιών που προτείνονται από σημαντικά ερευνητικά έργα ((ELENA (http://www.elena-project.org/), LOGOS (http://www.delos.info/), SeLeNe (http://www.dcs.bbk.ac.uk/selene/), MOBILearn (http://www.mobilearn.org/), MUSIS (http://www.musis.se/), κλπ.) των τελευταίων ετών. Δίνονται επίσης συνοπτικές περιγραφές αυτών των ερευνητικών έργων.

2.2 Νέα μοντέλα, τεχνολογίες και εφαρμογές για την μάθηση ταχείας ανταπόκρισης (just-in-time) και εφαρμογής γνώσης κατ' απαίτηση

Η μεγάλη ταχύτητα και ρευστότητα που χαρακτηρίζει τις σύγχρονες αγορές επιβάλει την εφαρμογή μεθόδων ταχείας ανταπόκρισης για την υποστήριξη των αναγκών μάθησης των εργαζομένων, συνεργατών και καναλιών διανομής. Είναι επίσης καθαρό ότι αυτή η νέα προσέγγιση μάθησης θα προσδιοριστεί από τις απαιτήσεις της νέας οικονομίας: ταχύτητα, ταχεία ανταπόκριση και σχετικότητα. Το παράδειγμα της γνώσης κατ' απαίτηση καθώς αναδύεται από τις υπάρχουσες ανάγκες της κοινωνίας της γνώσης προσδιορίζει κάποιες βασικές απαιτήσεις για τη μάθηση: παροχή εκπαίδευσης και κατάρτισης σε οποιονδήποτε, οποτεδήποτε και οπουδήποτε, με προσαρμογή της στις ειδικές απαιτήσεις και προτιμήσεις κάθε πολίτη εντός διαφορετικών περιβαλλόντων ηλεκτρονικής μάθησης και εργασίας. Απαιτείται η ανάπτυξη εφικτών και αποτελεσματικών τεχνικών λύσεων για την υποστήριξη της έννοιας της γνώσης κατ΄ απαίτηση.
Η εστίαση αυτού του κεφαλαίου είναι προς την κατεύθυνση των τεχνικών αποφάσεων (σημασιολογικός παγκόσμιος ιστός, αλληλεπιδραστική τηλεόραση, ασύρματες και κινητές τεχνολογίες) που προσφέρουν γρήγορη, ταχείας ανταπόκρισης, σχετική και κατ' απαίτηση αειφανή μάθηση.

2.3 Νέες οργανωτικές δομές και σχέσεις μεταξύ της κατ' οίκον μάθησης, σε κοινωνικούς χώρους, εν κινήσει, στο σχολείο και στο χώρο εργασίας

Αρχικά αυτό το κεφάλαιο περιγράφει τις παρούσες ανάγκες των εκπαιδευομένων και τις επιλογές περαιτέρω εκπαίδευσης. Στη συνέχεια παρουσιάζει τις εκπαιδευτικές διεργασίες σε διαφορετικές περιπτώσεις καθώς και τις μελλοντικές τάσεις για την υλοποίηση αειφανούς μάθησης. Τέλος περιλαμβάνει σειρά οδηγιών και συστάσεων για τον σχεδιασμού εφαρμογών αειφανούς μάθησης μέσω διαφορετικών σεναρίων.

2.4 Μέθοδοι για την μέτρηση της αποτελεσματικότητα της ηλεκτρονικής μάθησης και τις σχετικές εκπαιδευτικές αξίες σε διαφορετικές προσεγγίσεις, προϊόντα, διεργασίες και εκπαιδευτικά περιβάλλοντα

Η διαδικασία αξιολόγησης πρέπει να λαμβάνεται υπόψη, ιδίως για τον έλεγχο της αποτελεσματικότητας της αειφανούς ηλεκτρονικής μάθησης καθώς και για την αξιολόγηση των εκπαιδευτικών αξιών διαφορετικών προσεγγίσεων, προϊόντων, διεργασιών και εκπαιδευτικών περιβαλλόντων. Αυτό το κεφάλαιο παρουσιάζει μια μεθοδολογία αξιολόγησης και τεχνικές που θα μπορούσαν να βοηθήσουν τις επιχειρήσεις και τους χρήστες να επικυρώσουν αν τα προϊόντα ηλεκτρονικής μάθησης και οι συναφείς υπηρεσίες καλύπτουν τις επιδιώξεις τους. Η μεθοδολογία αξιολόγησης αφορά την ευκολία με την οποία οι χρήστες μπορούν να χρησιμοποιήσουν κάτι (δηλ. κάποιο προϊόν ή υπηρεσία αειφανούς ηλεκτρονικής μάθησης), τι πιστεύουν γι΄ αυτό και ποια είναι τα μεγαλύτερα προβλήματα, με στόχο την βελτίωση του σχεδιασμού.

2.5 Νέα πρότυπα και μοντέλα αρχιτεκτονικής για ολοκληρωμένες εφαρμογές παγκόσμιου ιστού, ψηφιακής τηλεόρασης και κινητών συσκευών

Η αειφανής μάθηση και οι υπηρεσίες της δεν πρέπει να αντιμετωπίζονται αποκομμένες από τα υπαρκτά και αναπτυσσόμενα πρότυπα και τεχνικές προδιαγραφές της περιοχής διότι σκοπός είναι η μεγιστοποίηση της ευχρηστίας και φορητότητας των εκπαιδευτικών διεργασιών. Σε αυτό το κεφάλαιο παρουσιάζονται πρότυπα και μοντέλα για την ολοκλήρωση τεχνολογιών παγκοσμίου ιστού, ψηφιακής τηλεόρασης και κινητών συσκευών (DVB–MHP (Digital Video Broadcasting – Multimedia Home Platform), GPRS (General Packet Radio Service), 3GPP (3rd Generation Partnership Project), Wi-Fi (802.11), IrDA (Infrared Data Association), Bluetooth, WAP (Wireless Application Protocol), UMTS (Universal Mobile Telecommunications System), HSDPA (High-Speed Downlink Packet Access), 3G LTE/SAE (Long Term Evolution)).

2.6 Υπηρεσίες αειφανούς μάθησης βασισμένες σε τεχνολογίες σημασιολογικού ιστού και διαλειτουργικών οντολογιών

Αυτό το κεφάλαιο ιχνηλατεί το ρόλο των οντολογιών για την παροχή ολοκληρωμένων ηλεκτρονικών υπηρεσιών μάθησης. Παρουσιάζεται το πλαίσιο του σημασιολογικού ιστού το οποίο αποσκοπεί στην παροχή μιας ολοκληρωμένες πλατφόρμας υπηρεσιών για την υποστήριξη της προσέγγισης ανάπτυξης υπηρεσιών παγκόσμιου ιστού και σημασιολογικής αποτύπωσης των σχέσεων ανάμεσα στους εκπαιδευτικούς πόρους με επίκεντρο τον εκπαιδευόμενο.

2.7 Υπηρεσίες για την ανάπτυξη, αποθήκευση και διανομή εξατομικευμένων, επαναχρησιμοποιήσιμων, διαμοιραζόμενων αντικειμένων περιεχόμενου και πρόσβαση κατ' απαίτηση σε ψηφιακές βιβλιοθήκες για αειφανή μάθηση

Αυτό το κεφάλαιο εστιάζει σε υπηρεσίες για την διανομή περιεχομένου, παραγωγή, προσαρμογή, εξατομίκευση, αποθήκευση, καταλογογράφηση, σημασιολογική αναζήτηση κλπ., τα κύρια ζητήματα που προκύπτουν και τις μελλοντικές τάσεις. Επίσης, εξηγεί πώς η πρόσβαση κατ' απαίτηση στη γνώση μπορεί να πραγματοποιηθεί σε ψηφιακές βιβλιοθήκες για την επίτευξη αειφανούς μάθησης.

2.8 Μοντελοποίηση εκπαιδευόμενων, συλλογή προσωπικών πληροφοριών και εξατομίκευση

Αυτό το κεφάλαιο παρουσιάζει τη μοντελοποίηση εκπαιδευομένων, την συλλογή προσωπικών πληροφοριών και την εξατομίκευση, πρότυπα και υλοποιήσεις. Επίσης συνάγει μια μεθοδολογία υπηρεσιών παγκόσμιου ιστού για την προσωποποίηση χρησιμοποιώντας προσωπικές πληροφορίες.

2.9 Υπηρεσίες σε εξατομικευμένα και προσαρμοστικά εκπαιδευτικά περιβάλλοντα για προσωπικές ανάγκες, στυλ μάθησης, προτιμήσεις και γνώσεις

Τα προσωποποιημένα και προσαρμοστικά περιβάλλοντα μάθησης απαιτούν υπηρεσίες που βασίζονται στη σημασιολογία και την επίγνωση της ιδιαίτερης κατάστασης του χρήστη προκειμένου να υποστηρίξουν προσωπικές ανάγκες, στυλ μάθησης, προτιμήσεις και γνώσεις. Αυτές οι υπηρεσίες καθιστούν εφικτή την σημασιολογική διαλειτουργικότητα μεταξύ ετερογενών πηγών πληροφοριών και υπηρεσιών. Η τεχνολογική και εννοιολογική διαφοροποίηση συστημάτων μπορεί να γεφυρωθεί μέσω της χρήσης προτύπων ή μέσω προσεγγίσεων που βασίζονται σε κοινά αποδεκτά μοντέλα. Σε αυτό το κεφάλαιο, αρχικά παρουσιάζεται η εργασία άλλων τμημάτων εργασίας του έργου σχετικών με τα μελετώμενα ζητήματα. Στη συνέχεια εξετάζεται το ζήτημα της παροχής κατάλληλων λύσεων προσανατολισμένων στο χρήστη που βασίζονται στην ολοκλήρωση εκπαιδευτικών προτύπων, στη χρήση αποδεκτών μοντέλων και προσαρμοστικών τεχνολογιών. Το κεφάλαιο περιλαμβάνει επίσης ζητήματα που σχετίζονται με την πρόσβαση στα μεταδεδομένα προσαρμοστικών συστημάτων μάθησης.

2.10 Τεχνολογίες και υπηρεσίες πλέγματος για εκπαιδευτικά περιβάλλοντα

Αυτό το κεφάλαιο παρουσιάζει τη σύγχρονη τεχνολογία για ευέλικτο, ασφαλή, συγχρονισμένο διαμοιρασμό ετερογενών πόρων και δεδομένων που ονομάζεται πλέγμα. Περιγράφονται τα ειδικά χαρακτηριστικά, υπηρεσίες, λειτουργικότητα και εφαρμογές. Η αειφανής μάθηση είναι μία από αυτές τις εφαρμογές. Το πλέγμα μάθησης ορίζεται ως ένα προχωρημένο περιβάλλον μάθησης που βασίζεται στην Ανοικτή Αρχιτεκτονική Υπηρεσιών Πλέγματος και το συναφές λογισμικό, παρέχοντας πληθώρα καινοτόμων υπηρεσιών για το μετασχηματισμό της πληροφορίας σε γνώση, κατανεμημένες υπηρεσίες όπως περιβάλλοντα προσομοίωσης, είσοδος δεδομένων από τον πραγματικό κόσμο, τρισδιάστατη απεικόνιση στο πλαίσιο εικονικών οργανισμών κλπ.

2.11 Συστάσεις και σενάρια

Η ανάλυση που έγινε σε αυτό το τμήμα εργασίας οδήγησε στη βραχυπρόθεσμη και μακροπρόθεσμη πρόγνωση σχετικά με την αειφανή μάθηση και τις σχετικές εφαρμογές με τη μορφή σεναρίων και συστάσεων.

Ειδικότερα, τα σενάρια αυτά καταδεικνύουν ότι:

- Η μάθηση θα πραγματοποιείται σε διαφορετικά περιβάλλοντα, μοντέλα και πόρους λαμβάνοντας υπόψη τους διαφορετικούς τρόπους και φάσεις της συγγραφής περιεχόμενου που συνδυάζει διαφορετικά μέσα, διανομή, μελέτη και αξιολόγηση μέσω διαφορετικών επιπέδων ολοκληρωμένων χώρων επικοινωνίας.
- Τα προσωποποιημένα περιβάλλοντα θα υποστηρίζουν προσωπική επικοινωνία και υπολογιστικές συσκευές που μπορούν να φορεθούν ή να εμφυτευθούν. Οι υπηρεσίες ηλεκτρονικής μάθησης θα προσαρμόζονται στους χρήστες και την ιδιαίτερη κατάσταση, χώρο ή προτιμήσεις τους.
- Η φορητότητα και η αειφανής πρόσβαση θα αποτελέσουν κεντρική πρόκληση για την αντιμετώπιση επιτόπου αναγκών κατάρτισης στους χώρους εργασίας.
- Η μάθηση απαιτεί δίκτυα υψηλών ταχυτήτων που προσφέρουν γραφικά περιβάλλοντα για την παροχή νέων καινοτόμων υπηρεσιών ψηφιακού περιεχόμενου και λογισμικού.
- Στο ενδοεπιχειρησιακό περιβάλλον θα καταστεί δυνατή η αξιοποίηση λύσεων ηλεκτρονικής μάθησης ώστε να αποκτηθούν (σε πανευρωπαϊκό επίπεδο) συγκριτικά πλεονεκτήματα ιδίως για τις μικρομεσαίες επιχειρήσεις, δίνοντας πρόσβαση σε νέες αγορές.

Executive summary (Italian version)

1. INTRODUZIONE

Il progetto CHIRON ha l'obiettivo di sviluppare materiale di riferimento che mostri e analizzi
i risultati di ricerche ed esperimenti e le migliori soluzioni pratiche per nuove forme d'apprendimento virtuale, basate sull'integrazione di canali web a banda larga, la televisione digitale e tecnologie mobili per applicazioni globali nel settore dell'apprendimento non ufficiale e informale costante.

Nella funzione 7.1 il capo progetto (IMI–BAS) con la collaborazione degli altri partner ha sviluppato l'inchiesta analitica finale del progetto, che integra, aggiorna e generalizza le analisi sviluppate e le conclusioni cui si è giunti durante il progetto, nonché identifica casi campione e le pratiche migliori valutandone l'efficacia.

Questo è un ampio compendio al resoconto della Funzione 7.1.

2. L'INCHIESTA

L'inchiesta presenta le nuove sfide e benefici della rete globale, della televisione interattiva e delle applicazioni mobili, che coprono servizi di formazione innovativi e nuove funzionalità dell'accesso globale agli archivi della conoscenza. Conduce alla formulazione di prognosi a corto e lungo termine per il futuro delle applicazione d'apprendimento globale sotto forma di possibili scenari e raccomandazioni.

Nelle sezioni a seguire riassumeremo i principali capitoli dell'analisi.

2.1 Questioni generiche per servizi di formazione innovativi del web, della televisione interattiva e delle applicazioni mobili per l'apprendimento globale

Le future tendenze nell'apprendimento globale puntano sulla ricerca e lo sviluppo di servizi innovativi specializzati che permettano ad un'ampia fascia di studenti d'avere accesso e seguire corsi attraverso strumenti basati sul web e strumenti di trasmissione video digitale presso l'istituzione formativa e/o il posto di lavoro o a

casa, combinate con la possibilità di connessione praticamente globale degli apparecchi mobili.
Seguendo quest'idea il presente capitolo definisce una serie di servizi d'apprendimento innovativi che sono suggeriti da numerosi, importantissimi progetti di ricerca (ELENA (http://www.elena-project.org/), LOGOS (http://www.logosproject.com/), SeLeNe (http://www.dcs.bbk.ac.uk/selene/), MOBILearn (http://www.mobilearn.org/), MUSIS (http://www.musis.se/), *ecc*.) sviluppati negli ultimi anni. S'include una breve descrizione di ciascun progetto.

2.2 Nuovi modelli, tecnologie e applicazioni per l'apprendimento Just-in-Time (in tempo reale) e le applicazioni Knowledge-on-Demand (conoscenza a richiesta)

L'incredibile velocità e la volatilità dei mercati moderni richiedono metodi in continuo aggiornamento per supportare il bisogno di sapere di dipendenti, soci e catene di distribuzione. E' anche chiaro che questo nuovo stile d'apprendimento sarà guidato dalle necessità della nuova economia: rapido, in tempo reale e pertinente. Il paradigma della conoscenza su richiesta come emerge dagli attuali bisogni della nostra società basata sull'informazione mostra le seguenti basilari necessità per l'apprendimento: fornitura di istruzione e formazione a chiunque, in qualsiasi momento e dovunque, ma adattata agli specifici bisogni e preferenze di ogni singolo cittadino entro diversi ambienti d'apprendimento e lavoro virtuale. Ciò richiede impegno verso soluzioni tecniche accettabili per supportare il concetto di conoscenza su richiesta.

In questo capitolo ci concentriamo soprattutto sulle numerose decisioni tecnologiche – rete semantica, televisione interattiva, tecnologie wireless e mobili – che permettono un apprendimento globale veloce, in tempo reale, pertinente e su richiesta.

2.3 Nuove strutture organizzative e relazioni tra l'apprendimento a casa, in contesti sociali, in viaggio, a scuola e sul posto di lavoro

Questo capitolo delinea per prima cosa i bisogni già in essere degli studenti e le possibilità/scelte per un ulteriore apprendimento. Poi presenta il processo di apprendimento in diverse situazioni e le tendenze future per la realizzazione dell'apprendimento globale. Infine, il capitolo include alcune linee guida per la progettazione di applicazioni globali, dall'aspetto di diversi scenari d'apprendimento.

2.4 Metodi per la misurazione dell'efficacia dell'apprendimento virtuale globale e i relativi valori educativi di differenti approcci, prodotti, ambienti e processi d'apprendimento

Il processo valutativo dovrebbe essere preso in considerazione, specialmente per testare l'efficacia dell'apprendimento virtuale globale e per stabilire i valori educativi dei differenti approcci, prodotti, ambienti e processi d'apprendimento. Il capitolo presenta metodologie e tecniche di valutazione che potrebbero aiutare le aziende e gli utenti a verificare se i prodotti e i servizi virtuali sono consoni ai loro obiettivi. La metodologia di valutazione s'interessa a scoprire quanto bene gli utenti sanno usare qualcosa (per esempio prodotti e/o servizi virtuali), cosa ne pensano e quali sono i maggiori problemi, con il fine di migliorare la progettazione e la ri-progettazione delle fasi.

2.5 Nuovi standard e modelli architettonici astratti per reti integrate, televisione interattiva e applicazioni mobili

L'apprendimento globale e i suoi servizi non devono essere considerati alieni ai nuovi standard e alle norme sviluppate per questo campo, perché il fine ultimo è di massimizzare la possibilità di rigenerazione e la portabilità del processo d'apprendimento. In questo capitolo si fornisce un elenco di una serie di standard e modelli astratti per reti integrate, televisione interattiva e tecnologie mobili, come DVB–MHP (Digital Video Broadcasting – Multimedia Home Platform), GPRS (General Packet Radio Service), 3GPP (3rd Generation Partnership Project), Wi-Fi (802.11), IrDA (Infrared Data Association), Bluetooth, WAP (Wireless Application Protocol), UMTS (Universal Mobile Telecommunications System), HSDPA (High-Speed Downlink Packet Access), 3G LTE/SAE (Long Term Evolution).

2.6 Servizi per applicazioni d'apprendimento globale che si basano su tecnologie di rete semantica e ontologie interoperabili

Questo capitolo traccia il ruolo delle ontologie per l'integrazione dei servizi di apprendimento virtuale. Viene presentata una struttura d'integrazione semantica basata su questa considerazione. L'obiettivo della struttura è di fornire una piattaforma di servizi integrativi che offra un supporto centrato sullo studente per l'apprendimento dal web e le relazioni semantiche tra le risorse e le fonti d'apprendimento.

2.7 Servizi per la creazione, l'immagazzinamento e la consegna do oggetti personalizzabili, riutilizzabili e condivisibili. Accesso su richiesta a biblioteche digitali per l'apprendimento globale

Questo capitolo si concentra specialmente sulla consegna, la creazione (produzione), l'adattamento, la personalizzazione, l'immagazzinamento, l'indicizzazione, la ricerca semantica, ecc. di contenuti, i loro principali problemi e le tendenze future. Spiega anche come l'accesso su richiesta all'informazione possa essere realizzato nelle biblioteche digitali per fornire apprendimento globale.

2.8 Modellamento, profilo e personalizzazione dello studente. Adattamento dell'apprendimento

Questo capitolo presenta il modellamento, il profilo e la personalizzazione, gli standard e le implementazioni dell'apprendimento. Include anche una metodologia basata sui servizi web per la personalizzazione dell'apprendimento secondo il profilo degli studenti.

2.9 I servizi negli ambienti d'apprendimento personalizzato e adattabile su misura ai contesti, alla conoscenza, ai bisogni, agli stili d'apprendimento e alle preferenze dei singoli studenti

Gli ambienti d'apprendimento personalizzato e adattabile richiedono servizi basati sul web e sensibili al contesto per adeguarsi alle situazioni, alla conoscenza, ai bisogni, agli stili d'apprendimento e alle preferenze dei singoli studenti. Questi servizi rendono possibile il conseguimento dell'inter-operabilità semantica tra servizi e risorse informative eterogenei. La differenziazione tecnologica e concettuale tra vari sistemi può essere superata attraverso l'uso di standard comuni o seguendo approcci basati su modelli largamente accettati. Per prima cosa questo capitolo presenta lavori precedenti relazionati alle questioni in corso di studio sulla personalizzazione e l'apprendimento virtuale. Poi introduce il problema di fornire soluzioni appropriate orientate allo studente e basate sull'integrazione di standard d'apprendimento, modelli stabiliti e tecnologie adattabili. Il capitolo include anche questioni relative all'accesso di meta-dati immagazzinati in sistemi d'apprendimento adattabili.

2.10 Tecnologie e servizi di griglia per ambienti d'apprendimento. Griglia d'apprendimento

Questo capitolo presenta le nuove tecnologie per una condivisione flessibile, sicura e coordinata delle risorse e dei dati distribuiti eterogeneamente, chiamata griglia. Il

capitolo descrive le sue caratteristiche speciali, i servizi, le funzionalità e le applicazioni.

L'apprendimento globale è una di tali applicazioni. La decisione concettuale basata sulla griglia è la griglia d'apprendimento, definita come un sofisticato ambiente costruito su un software d'architettura dei servizi in griglia aperta, che fornisce una serie di servizi innovativi per la trasformazione dell'informazione in conoscenza, distribuiti come ambienti di simulazione, ingresso nel mondo reale, sistemi di visualizzazione in 3D, nella struttura di un'organizzazione virtuale, ecc.

2.11 Raccomandazioni e scenari

L'analisi durante la funzione 7.1 conduce alla formulazione di previsioni a breve e lungo termine per il futuro di applicazioni d'apprendimento globale sotto forma di possibili scenari e
raccomandazioni, inclusi nel presente capitolo.

In particolare, questi scenari determinano che:

- L'apprendimento sarà realizzato in diversi contesti, che modelleranno il processo e i materiali d'apprendimento tenendo in considerazione diversi modi e fasi di creazione, l'accesso, la consegna, lo studio e la valutazione dell'incrocio di mezzi attraverso differenti modi e livelli di spazi di comunicazione integrati.
- Gli ambienti saranno popolati da strumenti, accessori e impianti portabili di comunicazione e calcolo personali. I servizi di apprendimento virtuale si adatteranno alle situazioni, alla localizzazione e alle preferenze del singolo individuo.
- La mobilità e l'accesso globali saranno una questione chiave per i bisogni di formazione in campo lavorativo.
- L'apprendimento esige canali a banda larga, richiede nuovi ambienti ad alta qualità grafica, stimola l'introduzione di nuovi e innovativi servizi in contenuto digitale e in software.
- Gli ambienti aziendali beneficeranno delle soluzioni d'apprendimento virtuale, creando un vantaggio competitivo per l'economia europea, e soprattutto faciliteranno l'esplorazione di nuovi mercati, ecc.

Executive summary (French version)

1. INTRODUCTION

Le projet CHIRON vise à développer de la documentation de référence qui montre et analyse des résultats de recherches, des expériences et des solutions de meilleures pratiques pour de nouveaux genres de e-learning, basés sur l'intégration des technologies de diffusion à bande large, de la TV numérique et des technologies mobiles pour des applications ubiquitaires dans l'apprentissage tout au long de la vie, non-formel et informel.

Dans la tâche 7.1, le responsable (IMI–BAS) avec la coopération des autres partenaires a développé l'enquête analytique finale du projet, qui intègre, met à jour et généralise les analyses développées et les conclusions induites pendant le projet, et identifie des cas témoins et des meilleures pratiques avec l'évaluation de leur efficacité.

Ceci est un résumé du rapport de la tâche 7.1.

2. L'ENQUETE

L'enquête présente les nouveaux défis et avantages du Web ubiquitaire, de la TV interactive et des applications mobiles, couvrant des services d'apprentissage innovateurs et de nouvelles fonctionnalités de l'accès ubiquitaire aux répertoires globaux de la connaissance. Il mène à la formulation du pronostic à court et long terme de l'avenir des applications de l'apprentissage ubiquitaire sous forme de scénarios et de recommandations possibles.
Dans les sections suivantes nous récapitulons les chapitres principaux de l'analyse.

2.1 Questions génériques pour des services d'apprentissage innovateurs du Web, de la TV interactive et des applications mobiles de l'apprentissage ubiquitaire

Les futures tendances dans l'apprentissage ubiquitaire visent la recherche et le développement des services innovateurs spécialisés permettant à un large éventail d'étudiants d'accéder et de suivre des cours avec des outils basés sur le Web et des outils de diffusion de vidéos numériques dans des établissements de formation et/ou sur le lieu de travail ou à la maison, combiné avec la connectivité pratiquement ubiquitaire des dispositifs mobiles.

En suivant cette idée, ce chapitre définit un ensemble de services d'apprentissage innovateurs qui sont suggérés dans plusieurs projets de recherche très important (ELENA (http://www.elena-project.org/), LOGOS (http://www.delos.info/), SeLeNe (http://www.dcs.bbk.ac.uk/selene/), MOBILearn (http://www.mobilearn.org/), MUSIS (http://www.musis.se/), *etc.*) qui date de ces dernières années. De courtes descriptions de ces projets sont incluses.

2.2 Nouveaux modèles, nouvelles technologies et applications d'apprentissage "juste à temps" et de "savoir à la demande"

La vitesse et la volatilité incroyables des marchés d'aujourd'hui exigent des méthodes "juste à temps" pour soutenir le besoin de connaissance des employés, des partenaires et des chemins de distribution. Il est également clair que ce nouveau modèle d'apprentissage sera conduit suivant les conditions de la nouvelle économie : rapide, "juste à temps" et approprié. Le paradigme du savoir à la demande (knowledge-on-demand – KoD), comme il émerge des besoins courants de la société basée sur la connaissance, précise les conditions de base suivantes pour l'apprentissage : distribution de l'apprentissage et de la formation, à n'importe qui, n'importe quand, n'importe où, et adaptée aux conditions et aux préférences spécifiques de chaque individu dans différents cadres de e-learning et de e-working. Ceci exige un travail vers les solutions techniques faisables de soutien du concept de KoD.

Notre cible dans ce chapitre concernent plusieurs décisions technologiques – le Web sémantique, la TV interactive et les technologies mobiles et sans fil – qui permettent l'apprentissage ubiquitaire rapide, "juste à temps", appropriée et à la demande.

2.3 Nouvelles structures d'organisation et relations entre l'apprentissage à la maison, dans les lieux de rencontres sociaux, dans les transports, à l'école et sur le lieu de travail

Ce premier chapitre décrit les besoins et les possibilités/les choix de l'apprenant pour un apprentissage ultérieur. Il présente donc le processus d'apprentissage dans différentes situations et la future tendance pour des réalisations d'apprentissage ubiquitaire. En conclusion, le chapitre inclut quelques directives pour planifier des applications d'apprentissage ubiquitaire, à partir de l'aspect de différents scénarios d'apprentissage.

2.4 Méthodes pour mesurer l'efficacité du e-learning ubiquitaire et les valeurs éducatives relatives de différentes approches, de produits, d'environnements d'apprentissage et de processus

Le processus d'évaluation devrait être pris en considération, particulièrement pour examiner l'efficacité du e-learning ubiquitaire et évaluer les valeurs éducatives de différentes approches, de produits, d'environnements d'apprentissage et de processus. Ce chapitre présente la méthodologie d'évaluation et les techniques qui pourraient aider des compagnies et des utilisateurs à vérifier si les produits de e-learning ubiquitaires et les services répondent à leurs objectifs. La méthodologie d'évaluation étudie comment les utilisateurs peuvent employer quelque chose (c.-à-d. un produit de e-learning ubiquitaire et/ou un service), ce qu'ils pensent de cela, et quels sont les problèmes principaux, dans le but d'améliorer les phases de conception et de re-conception.

2.5 Nouvelles normes et modèles architecturaux abstraits pour le Web intégré, la TV interactive et les applications mobiles

L'apprentissage ubiquitaire et ses services ne doivent pas être considérés comme isolés des nouvelles normes et des spécifications développées dans le secteur parce que le but est de maximiser la réutilisabilité et la portabilité du processus d'apprentissage. Dans ce chapitre un ensemble de normes et de modèles abstraits pour le Web intégré, la TV interactive et les technologies mobiles sont énumérés, à savoir:

DVB–MHP (Digital Video Broadcasting – Multimedia Home Platform), GPRS (General Packet Radio Service), 3GPP (3rd Generation Partnership Project), Wi-Fi (802.11), IrDA (Infrared Data Association), Bluetooth, WAP (Wireless Application Protocol), UMTS (Universal Mobile Telecommunications System), HSDPA (High-Speed Downlink Packet Access), 3G LTE/SAE (Long Term Evolution).

2.6 Services pour des applications d'apprentissage ubiquitaire basées sur des technologies de Web sémantiques et des ontologies interopérables

Ce chapitre trace le rôle des ontologies pour l'intégration des services de e-learning. Sur la base sur cette considération un cadre sémantique d'intégration est présenté. Le but de ce cadre est de fournir une plateforme de service d'intégration qui offre un soutien centré sur l'apprenant pour l'apprentissage basé sur le Web et des relations sémantiques entre les ressources d'apprentissage.

2.7 Services pour la création, le stockage et la délivrance des objets de contenu personnalisés, réutilisables, partageables. Accès-sur-demande aux bibliothèques numériques pour l'apprentissage ubiquitaire

Ce chapitre porte une attention spécifique aux services de délivrance de contenu, la création (production), l'adaptation, la personnalisation, le stockage, l'indexation, la recherche sémantique, *etc.*, leurs problèmes principaux et les tendances futures. Il explique également comment l'accès à la demande à la connaissance peut être réalisé dans les bibliothèques numériques pour fournir l'apprentissage ubiquitaire.

2.8 Modélisation, profil et personnalisation de l'apprenant. Personnalisation de l'apprentissage

Ce chapitre présente la modélisation, le profil et la personnalisation, les normes et les réalisations de l'apprentissage. Il inclut également une méthodologie basée sur le Web pour la personnalisation de l'apprentissage par profil.

2.9 Services dans les environnements d'apprentissage personnalisés et adaptatifs conçu en fonction des différents contextes, de la connaissance, des besoins, des modèles d'apprentissage et des préférences des apprenants

Les environnements d'apprentissage personnalisés et adaptatifs exigent des services contextualisés et basés sur la sémantique pour concevoir en fonction des différents contextes, de la connaissance, des besoins, des modèles d'apprentissage et des préférences de l'apprenant. Ces services permettent de réaliser l'interopérabilité sémantique entre les ressources d'information et les services hétérogènes. La différentiation technologique et conceptuelle entre divers systèmes peut être réalisée en utilisant des normes ou en suivant des approches basées sur les modèles bien admis. En premier, ce chapitre présente les travaux précédents liés aux questions d'apprentissage dans la personnalisation et le e-learning. Il aborde alors la question de fournir des solutions appropriées orientées apprenant basées sur l'intégration des normes d'apprentissage, des modèles établis et des technologies adaptatives. Le chapitre inclut également des questions liées à l'accès des méta-données stockées dans les systèmes d'apprentissage adaptatifs.

2.10 Technologies et services de grille pour les environnements d'apprentissage. Grille d'apprentissage

Ce chapitre présente la nouvelle technologie pour le partage flexible, sécurisé et coordonné des ressources et des données hétérogènes distribuées, appelé grille. Le chapitre décrit ses usages spécifiques, ses services, ses fonctionnalités et ses

applications. L'apprentissage ubiquitaire est l'une de ces applications. La décision conceptuelle basée sur la grille est la grille d'apprentissage, définie comme un environnement d'apprentissage avancé établi sur la le logiciel conforme Open Grid Services Architecture, fournissant une variété de services innovateurs pour la transformation d'information dans la connaissance, de services distribués tels que des environnements de simulation, l'entrée réelle, les systèmes de visualisation 3D, dans le cadre d'une organisation virtuelle, *etc.*

2.11 Recommandations et scénarios

L'analyse dans la tâche 7.1 mène à la formulation du pronostic à court et long terme du futur des applications d'apprentissage ubiquitaire sous forme de scénarios et de recommandations possibles, inclus dans ce chapitre.

En particulier, ces scénarios déterminent que :

- L'apprentissage sera réalisé dans différents contextes d'apprentissage, modélisant des processus et des matériaux d'apprentissage en considérant différentes manières et phases des médias croisés d'authoring, l'accès, la distribution, l'étude et des évaluations par différents modes et niveaux d'espaces intégrés de communication.
- Des environnements personnels seront peuplés par les dispositifs personnels de communication et de calcul, des accessoires, des ordinateurs vêtements, des implants. Des services de e-learning seront adaptés à la situation individuelle, aux lieux et aux préférences de l'utilisateur
- La mobilité et l'accès ubiquitaire seront un défi principal pour des besoins de formation du travail interne
- L'apprentissage exige une bande passante élevée, cela réclame des nouveaux environnements graphiques de qualité élevée, il stimule l'introduction de services nouveaux et innovateurs dans le contenu numérique et le logiciel.
- Les environnements d'affaires tireront bénéfice des solutions de e-learning en créant un avantage concurrentiel pour des affaires européennes et faciliteront particulièrement les PME qui explorent de nouveaux marchés, *etc.*

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