### D8.2 – Public Final Report

**Workpackage**
WP8. Management

**Task**
T8.2. Technical Management

**Date of delivery**
- **Contractual**: 30 04 2005  
- **Actual**: 27 05 2005

**Code name**
ALFANET_D82.doc  
**Version**: draft [ ] final [x]

**Type of deliverable**
Report

**Security (distribution level)**
Public

**Contributors**
SAGE, UNED, OUNL, KLETT, EDP, ACECASE

**Authors (Partner)**
Carlos Fuentes, Mº José Carrión, Cristina Arana (SAGE); Jesús González Boticario, Carmen Barrera, Olga Santos (UNED); Peter Van Rosmalen (OUNL); Juergen A. Schmidt, Ingeborg Hoke (KLETT); Francisco Barros (EDP); Roberto Canada (ACE CASE)

**Contact Person**
Cristina Arana (SAGE)  
Ronda de la Luna, 4  
28760 Tres Cantos - Madrid  
Tel: +34 91 8079411  
Fax: +34 91 8079447  
Email: carana@softwareag.es

**WP/Task responsible**
Software AG (SAGE)

**EC Project Officer**
Mr. Colin Stewart

**Abstract (for dissemination)**
This report provides a global view of ALFANET project results in terms of technical results and Scientific results.

**Keywords List**
ALFANET system, Adaptive e-learning, pedagogical templates, IMS-LD Authoring, IMS-LD engine, IMS-QTI Authoring, IMS-QTI engine, Interactive services, Recommendation system, adaptive presentation
Executive Summary

ALFANET project provides an e-Learning 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 e-Learning standards, and can be easily integrated in other eLearning platforms. The usage of eLearning standards, as IMS Learning Design, 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 project focused on these innovative features contributes with the individual adaptive learning, and the improvement of eLearning in Europe.

Description of conclusions/results

The ALFANET project results can be summarised in terms of Technical results, Scientific results, and Evaluation outcomes. Following an overview of each of these results are described:

Technical Results

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

For the Design phase, ALFANET provides authoring tools that allow to design the course, making use of key e-Learning standards, namely:
- The LD Authoring Tool allows the course authors to generate e-learning courses based on IMS LD, including metadata IMS MD / IEEE LOM and generated the whole package as 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.

For the phases of Administration, Use and Audit, ALFANET provides an integrated platform designed as a services based architecture that provides the platform with flexibility, modularity and extensibility capabilities. The architecture is structured in three layers:
- The **Server layer** acts as an integration platform for all the services providing core functionality for the e-Learning adaptive Services and for its integration to achieve adaptation. It has been designed based on a **J2EE** architecture, and can be run into any **J2EE** server, being easily integrable in any existing system.
- The **Services layer** provides the core e-learning functionality. It is composed by 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 e-Learning standards (IMS-CP, IMS-LD, IMS-QTI, IEEE-LOM, IMS-LIP) 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 to store directly the information in the corresponding standard format.

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 with 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-LIP).
The **Evaluation and Assessment** component provides 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 for 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 personalized, adaptive interface (e.g.: according with 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.

**Scientific Results**

The ALFANET project has provided significant knowledge in different fields, that in turn have been benefit from their interactions generating new knowledge relevant for the e-Learning in Europe. In the following lines the main knowledge generated by the project is outlined:

- **Pedagogical methods and guidelines.** ALFANET focus on adaptation has been managed from a conceptual and methodological perspective that describes a baseline pedagogical model (conceptual template) to define courses together with other templates supporting the definition of adaptation, that in run-time will be supported by different ALFANET components.

- **The ALFANET project has an important experience in usage of e-Learning standards (IMS-CP, IMS-LD, IMS-QTI, IEEE-LOM, IMS-LIP) and interoperability of these standards for the purpose of adaptation along the e-learning life-cycle.**

Based on these standards and on its innovative architecture components, the ALFANET platform supports multiple adaptive scenarios, among others:

- it provides different e-learning paths for different user profiles (IMS-LD, IMS-LIP, IMS-MD/LOM, IMS-QTI),
- it offers the learner the possibility to reinforce the knowledge when the system detects bad performance (IMS-LD, IMS-QTI, IMS-MD/LOM),
- it provides the learner with adaptive assessments (IMS-QTI, IMS-MD/LOM),
- it provides the learner with a particular view of e-Learning objects as they fit with learner’s interest, etc (IMS-LIP, IMS-MD/LOM),
- it provides the learner with tutoring support (IMS-LD, Interaction module, Adaptation Module),
- it offers the learner diverse recommendations (IMS-LIP, IMS-MD/LOM, IMS-QTI, Interaction components and agent based components) about what material should be further studied, what activities should be performed, what additional tests could be made, what fora should be consulted, etc.

- In addition, the ALFANET Consortium has produced an important number of contributions to different scientific fora, making ALFANET research results available to the general public, in particular to the scientific communities. **Scientific contributions** are related to e-Learning standards and e-learning standards interoperability, the User Model supporting adaptation, etc.

- The **User Documentation** provides users with a baseline reference to use the ALFANET system at the different stages of the e-Learning life-cycle, and as such it incorporates User Manuals for the different e-learning actors: the Designer, the Administrator, Learners and Tutors, etc.
The User Experience

Four adaptive pilot courses have been designed in the project, corresponding with the four pilot sites: “Spanish course for German Learners” (KLETT), “Environment and Electrical Distribution” (EDP), “How to teach through the Internet” (UNED) and “Communication technology” (OUNL). These courses implement different adaptive features and will be used for dissemination activities by the Consortium partners. Other course has been produced with the purpose of adaptation testing and internal dissemination activities.

Experiences with pedagogical methods, and adaptation along the e-learning life-cycle have been compiled in the different Evaluation reports. D66. Evaluation Results aims to provide the basis for further development of ALFANET components, providing summary conclusions from the experiences gathered at the different stages of the eLearning life-cycle.

Use of Project results

The ALFANET project has provided significant Knowledge in different fields, that in turn have benefit from their interactions generating new knowledge relevant for the e-Learning in Europe. Other institutions in Europe can benefit from ALFANET outcomes through the Access to Project results:

- An important amount of Scientific Results have also been published by the Consortium Partners in different fora. These are fully described at D77. Compilation of Dissemination activities.
- ALFANET Components will be marketed under Open Source licences, thus offering wider opportunities for integration with e-Learning platforms, and in turn, taking advantage of the improvements on these components made by third parties. The following ALFANET Adaptive components will be provided under Open Source licences:
  - The LD Authoring component is provided under Open Source licence at Sourceforge from https://sourceforge.net/projects/alfanetat/
  - The QTI Authoring Tool is provided under GNU GPL licence, available from http://sourceforge.net and from Software AG project web-site (http://rtd.softwareag.es/alfanet).
  - The LD engine (CopperCore) is already available as GNU GPL (http://www.coppercore.org) and accessible from SourceForge.net.
  - The QTI engine is provided under GNU GPL licence, available from SourceForge.net and from Software AG project web-site (http://rtd.softwareag.es/alfanetqtitools/).
  - The Adaptation package will be distributed under GNU GPL licence, published in a general repository of Open Source code of Internet in SourceForge.net and also in the Jade project.
  - The Interaction package will be distributed under the GNU GPL licence under the OpenACS and dotLRN projects.
ALFANET aims to develop new methods and services for active and adaptive learning. The project’s target is to deliver a tested set of components for eLearning providers (mainly educational centres providing accredited courses) interoperable with their platforms and/or services, that will significantly provide enhanced individual learning, through technologies with adaptive features and approaches concerned with personalisation and adaptation.

1.1 Project Objectives

ALFANET concentrates itself on the recently emerging market of eLearning, an area that will undoubtedly take advantage of the new technologies related with the Internet, human interaction, and machine learning. More specifically:

- **ALFANET** will allow individuals to have an interactive, adaptive and personalised learning through the internet bringing them the opportunity to learn on those matters that are relevant to perform and to improve their work.
- **ALFANET** will allow service providers or educational centres to provide eLearning services adapted to the individuals background, experience and behaviour.
- **ALFANET** will allow learning content providers to produce learning contents in a way that can be adapted to the personal needs of the individual learner.

During the first review meeting, the project objectives were reassessed and a refocus was made. The project focuses on individual adaptive learning and generation of knowledge and tools for service providers. This approach allows the Consortium to investigate on new key aspects contributing to the eLearning arena.

So, the **concrete objectives** and **expected results** of the project are:

1. To develop a prototype of a Learning Management System (LMS). The focus in the development will be on a set of components that offer intelligent personalisation capabilities, addressing the problem of the effective adaptive learning.
2. At the time, the LMS will prove the concept of combining machine learning and multi-agent technology for intelligent interactive eLearning.
3. A proposal for contributing to the current standards of the eLearning field in the adaptation and personalisation on contents and pedagogical learning methods.
4. An evaluation of the prototype’s impact on the current individual learning needs, which will be measured at different scenarios.
5. A description of the project results in terms of internal usage by the Consortium and a set of components for potential exploitation by third parties (eLearning service providers)

The project will have a significant contribution to knowledge in the area of adaptive eLearning, eLearning standards usage, and the potential exploitation of some of the components by eLearning service providers.
1.2 Project Results

ALFANET aims to develop new methods and services for active and adaptive learning. The project’s target is to deliver a tested set of components for eLearning providers (mainly educational centres providing accredited courses) interoperable with their platforms and/or services, that will significantly provide enhanced individual learning, through technologies with adaptive features and approaches concerned with personalisation and adaptation.

ALFANET project has delivered a **e-Learning system** characterised by the following features:

- The system presents an adaptive and interactive instruction to learners in a web-based learning environment, which combines guided learning based on instructional design and other adaptive features based on user modelling and agents technologies. The system promotes collaboration between users (learners and optionally teachers).
- The above adaptive features are supported through different components along the e-Learning life-cycle (Design, Administration, Use and Audit).
- ALFANET makes use of eLearning standards such as IMS-CP, IEEE-LOM, IMS-QTI, IMS-LIP and IMS-LD, and integrates them to provide value added on the eLearning process with multiple pedagogical models.
- ALFANET is made up of interoperable components integrated in a flexible and extensible architecture based on Java technologies and e-Learning standards. Separate standard-based components can be integrated in third eLearning Platforms that can benefit from adaptation.
- Through the standard-based approach, ALFANET promotes reusability of learning objects. ALFANET will allow learning content providers and educational centres to provide learning contents in such a way that these contents can be adapted to the personal needs.

The **key innovative points of ALFANET** can be summarised and derived from the following:

- **Personalised eLearning by means of the adaptive capability**
  ALFANET provides the learner with a personalised learning experience, through the presentation of activities and materials that best suit to the learner profile (knowledge level, interest, evolution in the course, etc) and the provision of personal recommendations as use of communication channels of interest to him/her (news, shared workspaces, contact with students with similar characteristics, etc), complementary material which could be consulted, to participate in a particular project workgroup, to share a particular document.
  The adaptation is based on the use of relevant e-Learning standards and on the user model acquisition from the learner data available and interaction with the system, based on the application of a set of machine learning techniques.

- **Contribution to eLearning standards with adaptation and learning process.**
  The **ALFANET** technical platform based on both technological standards and current learning standards.
  The usage of eLearning standards, as IMS Learning Design, IMS Question and Test Interoperability 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.

The above Innovative achievements are supported by the following key project results:

- **A Open platform architecture** facilitates integration of modular components. The fact that ALFANET system makes extensive usage of technological and eLearning standards, make it open to integration with other products or platforms
- **Pedagogical methods** (templates and user cases) support diverse adaptive scenarios that can be considered at Design time.
- **Other Scientific Results** have been produced from both technological and pedagogical experiences.

ALFANET project providing the above innovative features contributes with the individual adaptive learning, and the improvement of eLearning in Europe.
1.3 Overview

This report provides a description of ALFANET project results in the different lines where the project has made an important contribution. The document is structured in the following way:

- **Chapter 1. Introduction** situates the reader with ALFANET project Objectives, project Results and major Innovative points.

- **Chapter 2. ALFANET Technical Results** enlightens the project results in terms of an open technological platform that facilitates the integration of the diverse adaptive components developed in the project. This chapter describes the overall architecture from a logical and a technical perspective, explaining also the role of the different standards within the platform and components.

- **Chapter 3. Scientific Results** provides an overview of the scientific results of different nature produced in the project regarding pedagogical aspects, adaptation through standards interoperability, etc.

- **Chapter 4. The User Experience** describes the experience of adaptation along the e-Learning life-cycle; i.e.: Authoring an Adaptive course, Administration, the Learner experience and Auditing. In addition, this chapter provides an overview of the four pilot sites produced in the project making paying special attention to the adaptive capabilities supported by each of them.

- **Chapter 5. Access to Project Results** provides an overview of the key project results that can be used by external audience.
2. ALFANET Technical Results

This chapter presents the Technical Results produced in ALFANET project. Although the core result can be generally described as the ALFANET adaptive system, these results include pieces of different nature that from a technical perspective can be used as valuable components in other systems. This is why this chapter is structured in the following sections:

- Section 2.1. ALFANET Platform provides an global view of ALFANET system and the main actors involved within ALFANET adaptive cycle. It describes the subsystems that provide the functionality along the eLearning life-cycle and identifies the core adaptive components used in each phase of the eLearning life-cycle.

- Section 2.2. ALFANET Packages and Components, describes ALFANET components and how they can be integrated in other e-Learning platforms thanks to its modular design based on standards. These components offer them added-value capabilities in terms of interaction and adaptation.

- Finally, section 2.3. Technical Architecture, provides details on ALFANET services based architecture that provides the platform with flexibility, modularity and extensibility capabilities. The platform makes extensive use of both technological and eLearning standards, thus providing core functionality for ALFANET platform. At the same time it offers open interfaces for possible integration with other platforms.

2.1 ALFANET Platform

The ALFANET Platform is a software package including the set of components integrating the corresponding product configuration. As identified above, the ALFANET platform provides complete support to eLearning services offered by eLearning Service Providers that focus on High Education market.

The basic features of ALFANET Platform are:

- Internet-based, HTML interface (only a browser is required in client workstation)
- Support of different languages in the User Interface.
- Initial support of ALFANET documentation is planned for English. Future versions should support other languages: Spanish, Portuguese, German, Dutch, and French, if required for marketing activities performed in such countries.

From a logical perspective and considering the different actors involved in the eLearning process, the ALFANET Platform as a whole is made by the following subsystems:

- **Authoring Subsystem** provides facilities for the creation of instructional-based courses defined with IMS-LD, and optionally the possibility to define adaptive questionnaires. The tools within this package will be used by Authors.

- **LMS Administration Subsystem** includes the users management, learners/tutors assignment to the courses, permissions management and users’ data privacy. It also provides facilities for the definition of new presentation layouts and static recommendations. The tools within this package will be used by Administrators.

- **LMS eLearning Instruction Subsystem** includes an adaptive course presentation depending on the learner profile and preferences, dynamic user modelling (learner profiles refinement) and tools for learning process (collaborative frameworks) and learners support. The ALFANET components included in this package are: the IMS-LD interpreter providing adaptive learning on the basis of Instructional Design and Learner User Model, the IMS-QTI component providing adaptive self-assessment, the Interactive Services providing the means for interaction and collaboration among learners and the Adaptation Module, that is in charge of generating dynamic recommendations to users during the course execution. The LMS is the system offering e-Learning to Learners and providing support facilities to Tutors.

- **Auditing Subsystem** provides assessment, getting information and reporting facilities to Authors and Tutors: This package provides feed-back to Authors about the adequacy of the instructional
design, with possible clues for improvement. It also provides Tutors and/or Managers with facilities to assess the evolution of Learners in the course.

The following figure identifies ALFANET Subsystems along the e-Learning life cycle:

![ALFANET Subsystems diagram]

**Figure 1.** ALFANET subsystems along the eLearning life-cycle

With the aim of providing a complete view of ALFANET platform functionality, in the following paragraphs we describe in more detail the functionality provided by the different ALFANET Subsystems:

### 2.1.1.1 Authoring Subsystem

The **Authoring** subsystem facilitates the author in his/her different roles:

- Generation of didactic materials that conforms the standards of the eLearning field
- Import / Export of existing didactic materials (Content Providers)
- Maintenance, update and management of different versions of a course (for Editors and Publishers)
- Facilitate the instructional design, providing templates for the modelling of educational material (for the Instructional Designer)

Optionally, the tutor of a course can take the role of a special "author" and s/he can complement the course from the authoring subsystem generating auxiliary material, basic, small but very concrete and useful things such as examples and news.

### 2.1.1.2 Administration Subsystem

The **Course Administration** subsystem provides facilities to configure, administer and maintain the whole system.

The system administrator is in charge of the system configuration, mainly

- Administration of users, courses and community portals
- Administration of alternative templates for presentation
• Administration of static recommendations

2.1.1.3 eLearning Instruction Subsystem
From a high level point of view, the eLearning Instruction package provides:
• A learning experience adapted to the individual characteristics of the learner.
• An structured learning environment with activities formalised in an instructional design and other more flexible environment for individual and collaborative work, when the learner (and potentially the tutor) can interact with the educational material and the virtual educational community in a more free way, but framed in an efficient learning environment, following his/her individual decisions (more learner oriented).
• Support facilities provided by the tutor, by the fellows or recommendations performed by the system.
• Facilities for tutoring the course (addressed to the tutor)

From a more concrete point of view, the learner obtains from this subsystem:
• A set of services that facilitates the individual work and the collaborative work (shared file storage area, bulletin boards, news, calendars, collaborative spaces and others)
• The sequencing of didactic activities according with the flow defined in the instructional design of the course (including a sequence depending on the individual learner characteristics, and thus, adaptive).
• Recommendations or suggestions about how to proceed at certain stages of the course helping the learner decide what to do when there are several actions that can be taken.

Specifically, some of the adaptive features are:

• Adaptive Presentation: to adapt the content of hypermedia page to user’s goals, knowledge and other information stored in the user model.
  o To provide expert users more detailed and deep information than novices, which receive more additional explanation
  o To provide an adapted review to each Learner according to the results of evaluations
• Adaptive Navigation Support: hyperspace orientation and navigation by changing the appearance of visible links via annotation, hiding, sorting or highlighting links.
  o To provide a personalized navigation path through the contents of the course
  o To provide links to information sources that can be of interest
  o To provide personalized help, relative to the user context and the skills and abilities in the use of resources
• Adaptive Collaboration Support: use of the system’s knowledge about different Learners to form a matching group for different kinds of collaboration and to induce communication among Learners in order to
  o Form a group for collaborative problem solving at a proper moment of time
  o Choose a possible leader for that group
  o Find the most competent peer to answer a question about a topic
  o Search users or groups that can be of better help
  o Detect Learners who need help, and which Learners can provide that help

2.1.1.4 Auditing Subsystem
The Auditing subsystem provides reports with indicators about the system usage, allowing Authors to assess the course evolution in order to improve course content, structure and teaching, and Tutors to make a follow-up of the learners progress. The Auditing facility is a key point in the full cycle of e-learning: assessment, feed-back and improvement.
2.2 ALFANET Packages and Components

The following figure illustrates the different Packages and Components that integrate ALFANET subsystems:

Most frequently a component will not be offered in isolate, but together with a “brother” component belonging to another subsystem. For instance the IMS-LD Component for the eLearning Instruction subsystem in charge of interpreting the Course Structure will be used together with the Course Manager in charge of preparing this structure internally for its further interpretation. This situation introduces the concept of “Package” as the set of distributed components that achieve the implementation of a full end-to-end functionality.

Figure 2.- ALFANET Packages and Components
2.2.1.1 Instructional Design Package

Description

The Instructional Design package provides the eLearning Platform with courses that can be adapted to concrete learner characteristics. This package allows Authors to define course structure based on pedagogical methods, as this is supported by the IMS-LD standard, and further upload the course preparing it to be used by different users. Additionally, this package provides the means to interpret the defined course Instructional Design at the view of the User Model (IMS-LIP extended). Finally, with Audit authors can receive feedback on the design of their courses.

Components

- **LD Authoring Tool Component.**
  The Authoring tool allows for the integration of standards contents into an instructional design that adjust to the IMS-LD standard. It allows to introduce diverse metadata that supports adaptive features.

- **CopperCore**
  CopperCore is a J2EE runtime engine for IMS Learning Design which can be used to incorporate IMS Learning Design in your own application(s). CopperCore contains the runtime engine for IMS Learning Design. It does not contain a full blown graphical interface. It is the task of a system developer to integrate CopperCore in the system at hand. In ALFANET platform the CopperCore is supporting both the Course Manager and the IMS-LD Interpreter.

  The targeted audience are therefore system developers. CopperCore provides three API's and a Test Suite. Here are some characteristics:

  - full support for IMS Learning Design including level A, B and C
  - has three API's covering publication, administration and delivery of IMS Learning Design
  - exposes J2EE, native Java and SOAP interfaces
  - provides a validation library
  - includes a command line interface to most of the API calls
  - includes an example of a publication interface
  - includes an example of a web delivery interface
  - platform independent
  - has built-in support for three relational databases (MS SQL Server/MSDE, PostgreSQL and HSQLDB)
  - is ready for use with JBoss 3.2.x application server, but runs on other application servers as well
  - licensed under the GNU GPL

- **Course Manager Component**
  This component takes as input an XML IMS-LD file (defined by the LD Authoring tool) containing the course structure and uploads it into the internal data structures that support the functioning of the IMS-LD. Additionally the Course Manager creates course instances for each user allocated to a course. The Course Manager implements a graphical interface on top of the “publication” and “administration” APIs provided by the CopperCore.

Added Value and Benefits

The Instructional Design package provides a runtime engine to incorporate Instructional Design in courses authoring and LMS. This provides support for courses that adapt to learners knowledge level.

Requirements

See Coppercore component description above or for the full details [www.coppercore.org](http://www.coppercore.org)

Technical Features

- Full support for IMS-LD standard.
- Integration/Interoperability of/with IMS-LIP, IEEE-LOM, IMS-CP and IMS-QTI.
2.2.1.2 Evaluation & Assessment Package

Description

The Evaluation and Assessment package provides support for the definition of adaptive questionnaires at design time and the presentation of these questionnaires and their evaluation at run-time.

Components

The Evaluation and Assessment package is made by the following components:

- **QTI Items definition.** This component is in charge of defining basic items of very different types and questionnaires integrating several items. Currently this component is supported by external QTI tools.
- **QTI Selection & Ordering.** This component complements the previous one to add adaptive capabilities as defined in IMS-QTI standard, supporting the definition of questionnaires that may combine items from different object banks having into account specific conditions. As this part of IMS-QTI specification is not supported by available QTI tools, this component has been developed in the ALFANET project.
- **QTI Presentation and Evaluation.** This component is in charge of presenting the questionnaires to the final user (learner) including the dynamic generation of questionnaires based on defined attributes, evaluate them, present feed-back to the user, and provide an effective integration of the overall test result with the eLearning application.

The Evaluation & Assessment Package can be exploited in eLearning platforms that do not provide facilities for structured and dynamic questionnaires. In addition this package can be exploited in other applications (not just eLearning platforms).

Added Value and Benefits

- Definition of a set of items (questions) of different types: True/False (Text), Multiple Choice (Text, Images), Multiple Choice with Slider Rendering, Multiple Response (Text, Decimal, Integer), Multiple Response with (Multiple) Image Hot Spot Rendering, Single and Multiple Fill-in-Blank (Text), Standard Short Answer (Text), Order Objects (Text, Image), Connect-the-points, Drag-and-drop (Images), and a combination of types, e.g: Multiple Choice with Fill-in-Blank, etc.
- Generation of dynamic questionnaires incorporating items from different object banks and attending to different conditions.
- The above feature can be exploited for providing self-testing capabilities launched on user demand, or promoted/suggested by the Adaptation module.
- Presentation and evaluation (assessment) of questionnaires, presenting test results in a consistent manner.
- Possibility of specific integration with the eLearning platform, i.e. it is possible to integrate the course instructional design with the tests results, thus providing control on course evolution.

Requirements

This module do not impose any condition to the target eLearning platform. The QTI module is offered as an independent service.

Current state of IMS-QTI module requires the usage of an external QTI tool to generate the basic items following the QTI standard.

Technical Features

- The IMS-QTI module is supported by the IMS-QTI standard defined by IMS.
- It takes advantage of flexibility inherent to IMS-QTI standard and thus offer the capability of integration with other standards as IMS-LD and IMS-LIP, through attributes (meta-data). Integration with IMS-LD provides Instructional Design based courses with the capability of acting upon results of questionnaires. Integration with IMS-LIP makes that this integration is based on standardised user-defined features.
2.2.1.3 Adaptation Package

Description

The Adaptation package is in charge of providing run-time adaptations to cope with the learning needs and unpredictable situations that come across while interacting with the system. In other words, it identifies relevant pedagogical situations to enhance learning experience based on previous users’ interactions.

Components

- The Recommender Subsystem launches a recommendation process consisting on the following three steps:
  1. Identify the current pedagogical and contextual scenario for the learner considering the user individual data, the existing experience with the course and the current context.
  2. Select what to recommend (learning objects, assessments, a fellow contribution, etc), focusing on the learning objective and considering the sequence of interaction already performed.
  3. Analyze interactions of similar-learners-group.
- To make this possible a complex set of models is managed by the Adaptation Package. These models are managed by the Model Subsystem and updated in the Modelling Subsystem.
- The Recommendations Configuration module facilitates the configuration of static adaptation rules. The ALFANET administrator can configure some adaptation rules in order to control the adaptive behaviour of the system.

Added Value and Benefits:

The Adaptation Package uses the system's knowledge about different Learners in order to adapt the system behaviour:

- Promotes active and collaborative learning, supporting explicit and implicit collaboration based on learners’ behaviours and explicit valuations of learning items.
- Supports individual learner on: which users contact to, what services to use, what learning materials to work with (defined by IMS-LD), promote the sharing of the learning experience, accessing to interaction items generated by peer learners.
- Supports group dynamics and communication: to form a matching group for different kinds of collaboration and to induce communication among learners.
- Automatic tutoring services to enhance individual learning and lessen the work overload of supportive activities in collaborative scenarios.
- The set of models are used as support for the adaptive functionality of the Instructional Design interpreter, the Interaction Services and the Presentation layer.

Requirements

Requires the course structure at publication time, the result of IMS-QTI assessments, the synchronization with the IMS-LD data for each user and the traces generated during the learning process (the learner interactions).

Technical Features:

- User Modelling, Machine Learning and Multi-Agent Architecture are the technological bases of this innovative package.
- FIPA standard to manage the communication among the agents (ACL language and Interaction Protocols)
- Flexible Integration via JAXM (SOAP messages)
- Uses XML schema of recommendation closer to native XML of ALFANET
- Learner model is based on IMS LIP standard
- Course model based on IMS LD and contents characterization in IMS MD/LOM
2.2.1.4 Presentation Package

Description
The Presentation package provides a personalised, adaptive interface, providing 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.

Components
The Presentation package is made by the following components:

- **Presentation Interface** component, provides both personalised and adaptive presentation. It is made by the following modules:
  - The **Preferences presentation** module provides the user the possibility of configuring the user interface layout, defining different templates for presentation, colours, fonts, etc.
  - The **Adaptive presentation** module provides added value with respect to the previous one, as it is able to order, emphasise or remark different items as they may better suit with users' interest.
- **Presentation Administration**. This component allows an administration user to define new presentation layouts (to be further selected by the learner as presentation preference) and specific rules for adaptive presentation.

Added Value and Benefits
The Presentation components provide added value to applications, just corresponding with the functionality of the above components:

- Personalised Presentation Interface. User interface layout, defining different templates for presentation, colours, fonts, etc.
- Adaptive Presentation Interface. Order, emphasise or remark different items as they may better suit with users' interest.
- Integration with IMS LIP. The Presentation components work on IMS LIP standard, which takes advantage of possible existing User characterisation from target eLearning applications, with independence of the methods used to get user attributes. Additionally, and through the Adaptation module, this IMS LIP module can be enriched with new features.

Requirements

- Personalised presentation only imposes the requirement of having an underlying datamodel, which is supported in a XML DataBase. The DataModel is filled-in by the end-user through a preferences setting button.
- Adaptive presentation of any service requires that the information retrieved from the service is provided in an XML (xhtml-based) native language defined within ALFANET. For those services that do not adjust to this situation, but that retrieve another XML output or a well-defined html from which underlying concepts can be easily derived, ALFANET provides the means to associate a XSL to transform to the ALFANET native language.
- Additionally, either the adaptation module or a specific domain-rules definition module will be required. Both modules provide the Adaptive presentation module with baseline rules (dynamic or static) to apply in presentation time.

Technical features
The functionality of the Presentation components is supported through the following technical features:

- The LIP standard supports the User Model.
- An XML schema supports the User Preferences definition. The User interface templates are also defined in XML schema.
- Finally a XML schema supports rules structure.
- Access to Data Structures is encapsulated through a DataAccess layer which provides flexibility to update the physical definition of the Data Structures, with the possibility to accommodate to other DataBases.
2.2.1.5 Interaction Services Package

Description
The Interaction Services Package is in charge of supporting individual and collaborative users' tasks in terms of core web Technological Resources (forums, file storage area, agenda, etc) that are also included in the course definition. It includes support for as Forums, NewsGroups, Shared Storage, Document Management, Calendar. This package has been built upon OpenACS software.

Components
- Shared file storage
- Forums
- Calendar
- Notifications
- Comments
- Ratings
- Categories
- Administration of Interaction services

Added Value and Benefits
- Contributions to the individual learning process: 1) the individual work generates learning items that are available for the learner or for peers (writing forces the learner to think and organise their mental schemes). The learner has the learning items available and can access them when necessary, refine the work performed (versions), see learning items related with the rest of the course. The learner can also assess (Comment, Rate) the learning materials and the interaction items, which allows to fix ideas about the material and express the learner experience when accessed the learning items.
- Contributions to the collaborative learning: the learner can share her/his learning experience so other learners could benefit from the learning items generated by the learner and know the learner by his/her contributions (perceiving the learner with a reputation).
- The tutor, if exists, can evaluate the work performed
- Very useful information for modelling the learner (interests on objectives, how perceive the works performed by other learners, define her/his reputation).
- It provides an explicit representation of components to support their adaptive presentation
- It supports the administrative tasks to manage services and their use by learners and tutors
- Support to explicit and implicit collaboration based on learners’ behaviours and explicit valuations of learning items.

Technical Features:
- Uses OpenACS software, with a communication through HTTP requests, and a relational database (Postgress) serves to manage the information provided and potentially everything that is happening while using interaction services. OpenACS (Open Architecture Community System) is an advanced toolkit for building scalable, community-oriented web applications with strong elements of collaboration, community and knowledge sharing. OpenACS is open source and is available at http://openacs.org/.
- Facilitates the adaptation of presentation providing some answers (list of meaningful items) with XML output according to XML schema defined for ALFANET.
2.3 Technical Architecture

2.3.1 Architecture Description

The following diagram shows the global architecture of ALFANET application.

![Architecture Diagram]

Alfanet has two main subsystems:

- **Authoring Tools**: LD Authoring Tool and QTI Authoring Tool
- **LMS**

Both of them are independent components. The first one is in charge of the courses design (course structure, material and evaluation items) while the second one is the platform where the courses are executed.

The architecture of the Alfanet LMS is a three layer composition where:

- The **Server** layer is in charge of the user front-end, managing the application security, showing user interface and tracing user interactions.

- The **Services** layer is a group of services, which provide the application functionality and main logic.

- The **Data** layer comprises the data management and storage.

The architecture approach has been performed in order to allow the integration of any kind of services, both in the first development and for future services. Right now, it considers the integration of the Interaction Administration Module.
Module, IMS-LD Interpreter and new services developed in Java, but it is open to include any other type of technology by the inclusion and configuration of new services interfaces.

Next, the different components of the application grouped by their corresponding layer are described.

2.3.1.1 Server

Server layer is in charge of the user front-end, managing the application security, showing user interface and user interactions trace.

Security Layer: It is in charge of the request retrieving and control. It checks the user permissions and is connected easily to any external security control.

Dispatcher: It takes the request and distributes the work to the corresponding modules, taking the results and giving them to the presentation layer. The dispatcher represents also the interface to communicate the client side with all the different services. Communication with the new components is done based in the object model. With IMS-LD Interpreter and Interaction Module it is done in the best way to integrate them according with their existing outputs. This component calls to the Tracker in order to extract information about the user requests and to store them in the database.

Presentation Layer: It is in charge of taking the results of the different components and of generating an application response, taking into account the user profile in order to adapt the results presentation.

Tracker: It manages the information about the user interactions storing the data that is useful for the components operation, mainly for the adaptation modules.

2.3.1.2 Services

The Services layer is a group of services, which provide the application functionality and main logic.

Administration Module: It is in charge of the application configuration; mainly the centralization of the needed administration functionality for application services (System Manager), and the users management (User Manager).

Courses Manager: It is in charge of the publication (creation of runs) of the available courses. It gives the IMS-LD and the users information to IMS-LD Interpreter. The communication is based on EJBs.

IMS-LD Interpreter: It is the service that is in charge of the courses interpretation. The IMS-LD interpreter is based on CopperCore.

Interaction Module (IM): It provides the different services that allow the learners to perform a course in the system. It is based on an open source API called OpenACS adapted to the specific requirements of Alfanet.

IMS-QTI Interpreter: It is the service in charge of the QTI interpretation, assessment and their corresponding results reports.

Contents Server: It is in charge of serving the courses contents.

Multi-Agent Pedagogical Model: It has produced the learning design course template based on concept learning.

Audit Module: It is in charge of taking the database information and of generating the required reports.

Adaptation Module (AM): It provides support for the adaptive functionality of IMS-LD Interpreter, the Interaction Module and the Presentation Layer, by accepting requests from the Dispatcher and giving back a response adapted to the current context and user. There exists a multi-agent architecture that works autonomously to solve the adaptation tasks based on the knowledge that these agents can obtain. Internally, it updates this knowledge by means of a learning process, which takes users’ interactions and apply various machine learning techniques.

2.3.1.3 Data

The Data layer comprises the data management and storage.

Object Model: It represents the common model that was agreed by the different components in order to allow the communications. It provides the needed functionality to access the data repositories allowing to the rest of components to use it.
**Common Repositories:** It represents the ALFANET data repository that comprises both the data used by the new developed ALFANET components and the existing ones (IMS-LD Interpreter and Interaction Module); allowing to share data by all the components.

2.3.1.4 **LD Authoring Tool**
It is an independent component that interacts with the courses repository through interfaces that supports WebDAV protocol.

2.3.1.5 **QTI Authoring Tool**
It is an independent component that building on existing QTI files (defined with QTI compliant tools) adds on them to define adaptive and dynamic questionnaires based on the “Selection and Ordering” specification provided by the IMS-QTI standard, taking, as starting point of the process, the questions generated by authors.

The QTI Authoring tool provides two main functionalities required for further adaptation of questionnaires: items metadata definition and Dynamic questionnaires definition

2.3.2 **Communication protocols and architecture**
The main target of the architecture design is to provide an effective way to integrate existing and new components within the ALFANET project, providing an open and extensible framework and, at the time, allowing focusing the development efforts in the adaptation subjects.

The proposed architecture centralizes the integration and communication between the different modules in the Dispatcher component. It is in charge of the interpretation of communication protocols for each existing component and of providing a standard way for the new and future services integration.

The characteristics of the project forces to take into account two types of common needs that all services should cover:

- User interfaces for each available operation (responses to the user requests with a common interface, which will be provided by the presentation layout)
- Trace of the user interactions in order to provide inputs for the adaptation algorithms

On the other hand, the application takes into account other possible services needs, which are:

- Configuration facilities (integrated within the administration module)
- Communication with other modules (to provide and use functionality)

The following diagram illustrates the communication architecture:
The Dispatcher takes into account the communication needs and it is based on a set of configuration files that provide information about the Protocol Interface to be used in order to call the corresponding service with the appropriate protocol.

**IMS-LD Interpreter Interface:** Which calls the IMS-LD Interpreter component and interprets its response in order to communicate it with the rest of the modules.

**OpenACS Interface:** Which is in charge of the communications with the Interaction Module, and in the same way that with the IMS-LD Interpreter module, it interprets the responses in order to communicate it with the rest of components if it is necessary via HTTP calls.

**JAXM Interface:** It is used for new developments and is based on the JAXM standard (J2EE Standard) in order to take advantage of the functionality that the J2EE Application Server provides. All the studied application services, apart from OpenACS and IMS-LD Interpreter services, are implemented based on this interface.

On the other hand, it considers to include within the Protocol Interfaces those functionality that extract information from the request and the corresponding response in order to get information about the operation and relate it with user interactions.

Finally, it has been included a mechanism that allows the services to inform to the server (and to other services) about data changes, operations or any other important issue that can be required by other services in order to work or to synchronize data. This mechanism is based on Event notifications. Each service is able to launch events to the system and to be subscribed to those ones that it needs.

### 2.3.3 Standards Used

ALFANET System has been designed as a services based architecture, thus providing the platform with a great flexibility and modularity. The architecture which is structured in three layers make extensive usage of both technological and e-learning standards:

1. In what regards **Technological standards**, the ALFANET platform is based on the well-known J2EE architecture, making usage of standards such a JCA, Servlet, EJB, JAXM, Security, etc. The usage of these standards makes ALFANET platform extensible, and ALFANET components with a modular approach for potential integration with third platforms. All the data used by the platform is stored and communicated by using XML schemas, thus reinforcing ALFANET modularity and extensibility. Moreover, the multi-agent architecture inside the Adaptation Module makes use of FIPA standards (ACL and IP) to communicate the different agents implemented.
2. As for the **e-Learning standards**, they are key elements within the ALFANET Components, namely:

- *The Content Package (IMS CP)* is supported by the LD Authoring Tool and the LD engine (CopperCore and ALFANET course managers), the QTI Authoring Tool and the QTI engine.
- *The Learning Design (IMS LD)* is fully supported by the LD engine (CopperCore), and used by the Adaptation Module.
- The Question & Test Interoperability (*IMS QTI*) supported by the QTI Authoring Tool and the QTI Engine,
- *The IMS Metadata – IEEE-LOM* is supported by the ContentServer, and used by the Adaptation Module, the QTI Components and the Adaptive Presentation component.
- *The Learner Information Package (IMS LIP)* is used by the first layer, the server one within Security Layer and Synchronisation service and used by the Adaptation Module, the QTI Components and the Adaptive Presentation component.
3. Scientific Results

The ALFANET project has provided significant knowledge in different fields, that in turn have benefit from their interactions generating new knowledge relevant for the e-Learning in Europe. In the following lines the main knowledge generated by the project is outlined:

- **Pedagogical methods and guidelines.** ALFANET focus on adaptation has been managed from a conceptual and methodological perspective that describes a baseline pedagogical model (conceptual template) to define courses together with other templates supporting the definition of adaptation, that in run-time will be supported by different ALFANET components.

- The ALFANET project has an important experience in usage of e-Learning standards (IMS-CP, IMS-LD, IMS_QTI, IEEE-LOM, IMS-LIP) and interoperability of these standards for the purpose of adaptation along the e-learning life-cycle.

Based on these standards and on its innovative architecture components, the ALFANET platform supports multiple adaptive scenarios, among others:

- it provides different e-learning paths for different user profiles (IMS-LD, IMS-LIP, IMS-MD/LOM, IMS-QTI),
- it offers the learner the possibility to reinforce the knowledge when the system detects bad performance (IMS-LD, IMS-MD/LOM),
- it provides the learner with adaptive assessments (IMS_QTI),
- it provides the learner with a particular view of e-Learning objects as they fit with learner’s interest, etc (IMS-LIP, IMS-MD/LOM),
- it provides the learner with tutoring support (IMS-LD, Interaction module),
- it offers the learner diverse recommendations (IMS-LIP, IMS-MD/LOM, IMS-QTI, Interaction components and agent based components) about what material should be further studied, what activities should be performed, what additional tests could be made, what fora should be consulted, etc.

The report D32. Standards Contribution report provides a full description of the ALFANET contribution to standards and the experienced pedagogical methods.

- **Adaptive pilot courses.** Four adaptive pilot courses have been designed in the project, corresponding with the four pilot sites: "Spanish course for German Learners" (KLETT), “Ambient maintenance” (EDP), "Aprender a Formar en Internet" (UNED) and “Communication technology” (OUNL). These courses implement different adaptive features and can be used for dissemination activities by the Consortium partners.

- **Evaluation Results.** Experiences with pedagogical methods, and adaptation along the e-learning life-cycle have been compiled at D66. Compilation of Evaluation activities, this providing the basis for further development of ALFANET components.

- In addition, the ALFANET Consortium has produced an important number of contributions to different scientific fora, making ALFANET research results available to the general public, in particular to the scientific communities. Scientific contributions are related to e-Learning standards and e-learning standards interoperability, the User Model supporting adaptation, etc. A summary of these results is provided at D77. Compilation of Dissemination activities.

- **The D65. User Documentation** provides users with a baseline reference to use the ALFANET system at the different stages of the e-Learning life-cycle, and as such it incorporates User Manuals for the different e-Learning actors: the Designer, the Administrator, Learners and Tutors, etc.

In the following section more detail is provided for the Pedagogical methods used, and the way ALFANET provides adaptation based on standards interoperability.
3.1 Pedagogical templates and Use Cases

This section intends to provide an overview of LD, with some samples of usage in courses; providing thus an overview of the potential of LD design.

3.1.1 A baseline course template

The learning design course template is the underlying conceptual and operational framework of the ALFANET multiagent pedagogical model (see for more details T 42, D 4.1 and D 4.3 reports). The template has a three-folded purpose. It is aimed at functionally operationalizing the concept of adaptation as defined during the user needs identification task (see for more details User Needs Identification report – T11 and specifically the OUNL supplement to the report). Further, the template provides the course designers with a common pedagogical platform. Finally, the template builds conceptual and functional bridges to the Adaptation and the Audit modules.

The template presents a simplified version of the concept of adaptation as defined within the framework of this project. The concept of adaptation consists of the following dimensions: single v/s multiple adaptation; pre-assessment v/s tracking adaptation; system-centred v/s user-centred adaptation; and preferential v/s development adaptation. The concept of adaptation was positively peer-reviewed in the journal of Educational Technology Research & Development (vol. 52, No 2, 2004, pp. 41-56; see also Dissemination activities). Many research studies on adaptation report attempts that target a single personal construct. This is level of knowledge in most of the cases, and occasionally learning styles. The comparative analysis in a recent representative report on the enterprise learning content management system indicates that all of the sampled systems apply single adaptation (Brandon Hall 2004-2005 Report, 2005). The LD template prescribes multiple adaptation that takes into account three constructs: level of knowledge (beginner, advanced), learning styles (inductive, deductive) and perceptual modality (visualiser, verbaliser). Different combinations are possible as the values of the constructs can be extended as well.

The current version of the template implements adaptation that is based on pre-assessment of the level of knowledge, learning styles and perceptual modality. Pre-assessment adaptation is a system-centered type of adaptation. The templates supports also learner-centered type of adaptation as learners can select particular learning objects, available in the environment, thus creating their own configuration of learning objects. We call this type of adaptation, embedded adaptation. Currently the template realizes the idea of preferential adaptation, no matter whether the source is a pre-assessment of personal constructs or a selection of learning objects. In summary the adaptation in the ALFANET system is multiple, either system- or learner-centered, and preferential.

The concept of adaptation as operationalised in the template is an outcome for the Adaptation module for further elaboration.

Apart from describing adaptation in operational terms, the template brings some more contributions to the development of the ALFANET system. It provides course developers with a set of guidelines for designing a concept learning lesson. In addition, the template emphases on the way in which learning objectives are described. It is a direct output for the Audit module as far as one of the functions of the auditing is to report on students’ achievements taking into account two of the components of the learning objectives description – ‘standard’ and ‘measuring instruments’.

3.1.2 Different e-learning paths for different user profiles

This refers to different pieces of LD we have used in the pilot sites, particularly:

- going to a particular chapter depending on the knowledge level of the user
- going to a specific activity depending on a particular configuration of the user model, based on a combination of learning style (inductive/deductive) and perceptual modality constructs (visual/verbal).

3.1.3 Recommendation scenario

The recommendation scenario has two formats: promotional and remmediation ones. The direction of the recommendation activities depends on the QTI testing of the ‘Practice’ activities. It is always related to the instructional feedback, which is aimed at informing learners about the level of performance, determining the recommendation activities and motivating. The ‘Feedback’ compares the performance of learners during practising with QTI test items with the ‘standard’ element of learning objectives. QTI testing provides an immediate feedback: If a learner reaches the required level as described in learning objectives, then she/he
gets a more complex task (promotional format of recommendation scenario). In a case, a learner does not arrived at the required level of performance, she/he is assigned to a sequence of remediation activities. They are based on the identified learning style and perceptual modality preferences of learners. The basic idea is that the remediation scenario tries first to help learners providing more support based on learning preferences on tasks with the same level of complexity. The current version of the LD template explores a remediation based on perceptual modality and level of knowledge variables. For example, if a learner has a difficulty and she/he is identified as visualizer, then the learning material is explained within some picture, graphics and concept maps. If it does not help, the next step is a learning task with a reduced level of complexity.

3.1.4 Self-Assessment and adaptive testing

ALFANET imposes two types of controls on QTI assessment and testing: (a) system's locus of control and (b) learner's locus of control. The system's locus of control on assessment has two forms: (a) pre-assessment to determine the appropriate learning path for a learner and (b) an evaluation to define recommendation activities, related to either a selection of more complex learning task, or a remediation. Learner's locus of control on assessment means that learners have an opportunity for a self-assessment to get an idea how well they perform and where they are in the learning content hierarchy. One of the distinguishing characteristics of the QTI evaluation implemented in the ALFANET system is that the test items, measuring a particular level of learning achievement, are ordered randomly (see for more details sections 3.5.2 and 4.2.1.2. of this report). QTI testing is closely related to LD templates, adaptive functionality and auditing reporting.

3.1.5 Tutoring support

The QTI authoring tool provides tutors with embedded support for content and construct validity of the tests. From one side, it affords construction of different types of items. From another, it generates randomly a set of test items for different learning purposes (see sections 3.5.2 and 4.2.1.2 for details).

3.2 Adaptation through learning standards interoperability

This section provides an overview of the adaptation that has been realized by applying several learning technology standards. Each of them provide limited functionality such that the desired adaptive functionality of the system as a whole could not have been feasible by their own, making them interoperable.

The used learning technology standards are:
- IMS-Meta Data (IMS-MD) or IEEE-LOM
- IMS-Content Packaging (IMS-CP)
- IMS-Learning Design (IMS-LD)
- IMS-Question and Test Interoperability (IMS-QTI)

These learning technology standards were used to realize:

a. Adapt the course entry point of a learner depending on the learners' pre-knowledge on the subject the course deals with
b. Adapt course content according to the learners' learning characteristics
c. Adapt an assessment in a course part depending on scores realized on self tests throughout the course part
d. Adapt recommendations to learners based on study progress, learning activity, and activities of other learners studying the same subject.

Each of the above mentioned course adaptations needed one or more of the learning technology standards to achieve the desired functionality besides the system modules that handle the complex data streams and interpretation of the learning events.

Next short descriptions are given on how the course adaptations were done using the learning and technology standards.
3.2.1 Course entry point adaptation

The objective of this type of adaptation is to customize the course delivery to the needs of an individual learner without having to customize the course design as a whole. This means that a course is designed meeting the needs of a generic learner but the moment an individual learner takes the course is determined what parts of the course are relevant for this learner. One way of using this functionality is to ascertain a learner’s knowledge on the course subject and match this with the course objectives of the course. Those parts that the learner already masters can be left out, for learning objectives of which it is not entirely clear that the learner masters them, only the assessments are provided to determine if these objectives need to be studied, and learning objectives clearly not mastered by the learner are entirely placed in the course.

For this adaptation the course content should be described with IMS-LD. IMS-LD provides generic functionality that otherwise had to be programmed into the system per individual courses. Learning Design offers the possibility to cluster learning activities in structures, thereby creating course modules. Attached to such a module are course objectives, and to be able to measure if a learner has mastered the learning objectives questions are defined per learning objective. In the Learning Design conditions are defined that react on the change of properties, that are also defined in the Learning Design. The properties are defined such that they represent the mastery of a learning objective in the course. When the property value indicates that a learning objective is already mastered by the learner then the condition corresponding with this property changes the visibility of a course module. The result for the learner is that the content corresponding with the mastered learning objectives is omitted from the course. When the property value indicates that there is the possibility that the learner has mastered a course objective but not very convincing, then the condition corresponding with this property hides the course content corresponding to this learning objective and only shows the assessment for this learning objective. The idea behind this mechanism is that the pre-knowledge assessment contains a representative sample of the assessment of a learning objective. In other words when there is reasonable doubt whether or not the learner has mastered a learning objective based on the pre-knowledge assessment the whole assessment corresponding to the learning objective is used to ascertain the learner’s knowledge on that learning objective. When the property value indicates that the learner has not mastered the learning objective the corresponding condition realizes that both learning content and assessment are shown to the learner.

The questions used in the course should be described with IMS-QTI as well as the assessments. Each test item or question is provided with meta-data (using IMS-MD) that makes it possible to select individual test items for a given learning objective and include this in the pre-knowledge test presented to the learner. An assessment results in an overall score for the whole test and also in scores for the covered learning objectives.

Data exchange takes place in the system from the IMS-LD interpreter, the IMS-QTI interpreter, and the administration module. First, when the learner starts the pre-knowledge assessment the QTI package is transferred from the common repository to the IMS-QTI interpreter. This transfer is triggered by the IMS-LD interpreter. The assessment results in scores which need to be transferred to the IMS-LD interpreter. The scores are stored in the user portfolio which is stored in the administration module. When a change in property is detected in the user’s portfolio the IMS-LD interpreter is triggered and the conditions are evaluated with the new property values.

3.2.2 Content adaptation

The objective of this adaptation is to facilitate the learner with learning content that is formatted such that it corresponds with the learner’s characteristics. Content adaptation takes place on two dimensions; learning style and cognitive modality. Cognitive modality determines if the learner is confronted first with examples then with the rules and vice versa, learning style determines whether the format of the content is visually oriented or verbally oriented.

For this type of adaptation the course should be described with IMS-LD. It requires that more than one version of the content is made available; depending on the dimensions the author wants to include. Dimensions can also be combined in for example Inductive/visual and Inductive/verbal resulting in an even finer grade of adaptation towards a learner’s preferred way of learning. In the learning design properties and conditions are defined. The properties hold the preferences of a learner on the two dimensions; learning style and cognitive modality. The conditions translate these preferences into the selection of only those content blocks that are feasible for that learner. This means that only those content blocks are shown that evaluate true on the properties representing the learning style and cognitive modality, all other content is hidden from the learner.
To determine the learner’s learning style and cognitive modality questionnaires are used which should be described with IMS-QTI. The responses to the items in the questionnaire are translated to preferences on one of the two dimensions. The resulting score is stored in the learners’ portfolio. When one of these properties of the learners’ portfolio is changed then the IMS-LD interpreter is triggered and the new property values are evaluated.

### 3.2.3 Test adaptation

The objective of this adaptation is to encourage learners to test their knowledge on a regular basis through self-tests that are provided after each course module. The assessment, which is provided after each lesson, is made adaptive to prevent those questions covering modules that were already mastered before as proven by the self-test are repeated in the assessment.

For this type of adaptation is necessary that the self-tests and the assessments are described with IMS-QTI. The items of the self-test and the assessment are provided with meta-data using IMS-MD to indicate the learning objective it covers but also the course module it covers. The self-test results in individual scores for each module it covers and an overall score of the test. These scores are placed in the learners portfolio. When the learner decides to start the assessment, the property values of the self-test that are of relevance for the assessment are read. When the score on a self-test is above a certain threshold, then those questions that address that particular module will be omitted from the assessment. This way only those questions for modules that are not yet mastered will be presented to the learner.

The course should be described with IMS-LD from where the self-test and the assessment are started. In the course properties are defined that contain the scores on lesson modules of the course. When a learner takes a self-test scores are set in the learner’s portfolio. Both the self-tests and the assessments are wrapped-up as content packages using IMS-CP.

### 3.2.4 Learner recommendation adaptation

The objective of this adaptation is to guide and motivate learners through a course when they encounter problems related with the course content or when they only partly use the facilities present in the learning environment.

This adaptation requires that the course content is provided with extra information which can be interpreted by the Interaction module. The extra information is described with IMS-MD, and contains descriptions like the learning objectives and the part of the course this material is contributing to. Based on the learner profile that uses the IMS-LIP specification the Adaptation module monitors each individual learner and keeps track of actions taken, contributions provided, and participation in collaborative services. When a learner takes for example a self-test of a lesson and fails this test the adaptation module is able to search for remedial activities for an individual learner based on meta-tagging of the course material and on what other learners have done after failing that particular test.

Another example of this type of adaptations occurs when a learner is working on a part of a course and progresses at a high pace while at the same time another learner is having difficulties progressing through that part of the course. The adaptation module has the capability to detect that one learner is having difficulties and other learners not, and can generate a recommendation stimulating the learners to take part in a forum and exchange information with each other.
4. The User Experience

4.1 Experiencing adaptation along the e-Learning life-cycle

Adaptation in the context of eLearning is about creating a learner experience that purposely adjusts to various conditions (e.g. personal characteristics, pedagogical knowledge, the learner interactions, the outcome of the actual learning processes) over a period of time with the intention of increasing pre-defined success criteria (e.g. effectiveness of e-learning: score, time, economical costs, user satisfaction).

Adaptation is not an idea that can be plugged in a learning environment, but it influences the full life cycle of the learning process.

In the following we outline the main outcomes coming from the ALFANET experiences at the different phases of the e-Learning life-cycle, from Design to Audit:

4.1.1 Authoring an Adaptive course

The Design stage, the first in the e-Learning cycle is in charge of defining didactic materials integrating the course. This phase is key in the process as it is responsible of one of the key factors in the success of e-Learning: quality of materials. Different e-Learning systems afford it through a set of integrated tools for the generation of contents. When these Learning Content Management Systems are based on the usage of e-Learning standards as IEEE-LOM, IMS-CP, SCORM, contents can be reused in different course, and can be understood by different e-Learning Management systems.

But what makes the difference between ALFANET and other e-Learning Systems is the adaptation. This makes also a difference at Design time, that is conceived to prepare the course for adaptation to different learners:

- Central in the ALFANET adaptation process is the design created in LD. The design contains the logic for the pre-designed adaptations and provides the hooks and the information upon which the runtime adaptation bases its reasoning.
- In order to design the course, the author can select one or more pedagogical models templates and apply them for the course at hand. These templates are a translation of the results of research in learning and instructional design. Their objective is to ease authors the complex task of designing their courses.
- Since the author’s design is to be applied in runtime, norms to be monitored during the execution of the course and metadata to the activities and to the learning objects are needed to compare the real interaction with the author design and to provide the appropriate material according to the design.

Translating this to a practical approach, the creation of an Adaptive course within ALFANET follows the following steps:

- Definition of course structure and organisation according with the pedagogical template (Concept Learning Template).
- Creation of content materials. This is not supported in ALFANET, but can be done using other Authoring tools. It must be mentioned that ALFANET is able to import Learning Objects defined in other tools as well as other types of contents as hipertext documents, text documents, pdf format, etc.
- Special attention must be paid to the creation of Assessment which pay an special role in ALFANET adaptation. It is suggested to design the course with a set of questions (items) that will serve for the purpose of measuring the degree of understanding by the learner. ALFANET does not support the creation of question items and suggest the usage of a QTI compliant tool for the purpose of creating these items.
- Once the items are created, ALFANET provides a QTI Authoring Tool that allows the definition of dynamic questionnaires that can be adapted to each user depending on the user characteristics, course behaviour and questions metadata that is included also using the tool.
- Authoring the course with the LD authoring tool that supports the definition of the course components and method in IMS LD, generating the complete course package (IMS CP) that contains both the course definition and all of the course resources.

Adding rules for adaptation using the instruments provided by the Authoring tool in level B. LD definition could take advantage of information derived from QTI questionnaires. QTI assessment process is in charge of evaluating an exam and generating a score value (or several score values) according to item definition. QTI process hasn’t information in order to determinate if an assessment is failed or not. Information about required score for passing an exam lies in LD design. For instance from adaptation point of view, is very useful to know in which materials the learner has weakness, and to recommend additional materials in order to overcome such weakness. To do this it is necessary to generate several scoring variables in item definition time, and in LD definition to manage these variables in order to determine if the learner has suitable level of mastery or not.

- Adding metadata: The system contains mining tools to trace and identify usage patterns based on the actual interactions of the learners. A rule based engine filled with rules of thumb and pedagogical knowledge acts upon the patterns identified. If the author wants support for his/her learners by these rules, s/he needs to add the additional (meta)data to enable the rules. This includes adding data to QTI-items, LD-activities, LO’s.

The four Pilot sites have experienced the Design stage according with the above defined steps.

Overall we can say that the Design phase is experienced as a complex task. It requires specialised personnel to define the course, which involves having a global idea of the course (objectives and contents) and experience in use of systems for course definition.

In the particular case of ALFANET, these difficulties are more visible because of the following reasons:

- ALFANET incorporates Instructional Design, which requires knowledge on pedagogical methods, and on the Authoring tool implemented in the projects. LD design (LD Authoring) requires further refinement to be usable.
- The effectiveness of the Design process will be further improved with a set of integrated tools (current experience is based on the usage of independent tools) or a Design methodology.

4.1.2 Administration

The administration phase of the system is supported by several services, namely: User Manager, Course Publisher, User Interface configuration and Static Recommendations configuration:

- The first one, the User Manager is in charge of the definition of the system users and their characteristics. It provides the system with the initial basic user profile and defines an initial characterisation of the user based on several questionnaires that are proposed to the learner.
- The Course Publisher is in charge of preparing the run-time environment for the execution of a course by the learners: it stores the courses in the common repositories and informs to all the services about the course characteristics in order to allow them to generate the required data structures. Special attention must be paid to the Course Manager of the CopperCore service, which is in charge of the interpretation of the Learning Design in order to provide the needed data structures to allow to CopperCore to act as the LD Engine.
- The User Interface configuration service allows all kind of users to personalise their interfaces by selecting the presentation templates that they wants and personalizing more specific interface characteristics, as fonts, colours, etc.
- The Static Recommendations configuration allows tutors to configure static recommendations to be provided in their courses in terms of services to use, learning objects to read, or motivational messages to improve the learners’ experience.

Evaluation activities in this phase have encountered problems of interoperability between IMS-LD definition delivered by the Authoring tool and the definition validated by the CopperCore (IMS-LD). These problems have been solved along the validation stage.
4.1.3 The Learner and Tutor experience

This phase focuses on the environment and tools available for the student and tutors while active within a course. From a high level point of view, the eLearning Instruction subsystem supports of the Use phase provides:

- A learning experience adapted to the individual characteristics of the learner.
- A wide spectrum of learning approach, form an structured learning environment with activities formalised in an instructional design to more flexible environment for individual and collaborative work, where the learner (and potentially the tutor) can interact with the educational material and the virtual educational community in a more free way, but framed in an efficient learning environment, following his/her individual decisions (more learner oriented).
- Recommendations as supported facilities suggested by the system.
- Support facilities provided by the tutor
- Facilities for tutoring the course (addressed to the tutor).

The outcomes from evaluation activities at Use phase are:
- The effectiveness of the LMS is rated positive. It is possible to reach the learning objectives with the Alfanet system.
- The efficiency is rated less positive. The participants suffered performance problems.
- The usability and navigation using the current interfaces is seen as a weak point. Nevertheless it is noted that the personalization and the possibility of defining different presentation templates may help to fix this problem.

As strengths of the Alfanet system students mention:
- Adaptivity
- Good guidance and feedback by the use of tests
- It gives more structure.
- All information is available and can be updated. The information can be accessed more easily than using books.
- Course material is adapted at your own learning profile.
- Interactivity and direct self-assessment of the level of understanding of the course material.

Although the adaptivity of the system regarding recommendations was not sufficiently evaluated, important feedback and suggestions for improvement have been collected.

4.1.4 Audit

Auditing closes the e-Learning cycle. It collects data depending on the author’s requirements on the actual use of the course and presents them to the author in a clear way (e.g. study hours for a given learner and activity). The author gets reports showing how successful the course design has been. Therefore, depending of the outcome he or she can decide if there is a need to reconsider the design.

The Audit functionality, can be summarized as:
- Data analysis and reports: It consists on a component that is in charge of the user interactions and other information analysis in order to provide complete reports about the each course and users results.
- Users satisfaction statistics.
- The consultation of questionnaires that have been performed by the learners.

The outcomes from this stage can be summarises as Participants:
- think positive about the usefulness and supportiveness of the concept of auditing in future, but it can’t replace talking with students.
- rate the effectiveness of the this prototyped module negative: they cannot produce all audit reports wanted, only a fixed set of basic reports is possible. They prefer audit reports that provide information about results of examinations and dynamic data related to learning paths chosen by students.
are not satisfied with the quality of the produced audit reports, because the reports still produce raw data instead of valuable information that can be used for improvement of courses.

find it easy to learn to handle and use the audit module, but remark the few possibilities of reports in this prototype.

4.2 ALFANET Pilot Sites

This section briefly describes the four pilot sites generated in the project and the main adaptive features that they implement.

4.2.1 Spanish course for German speaking people

KLETT language course ‘Spanish for Beginners’ consists of four lessons of progressive difficulty. Each lesson contains concept learning materials of four modules: Listening and reading comprehension (RC), Grammar (G), Communication abilities (CA), and Intercultural competencies (IC). For RC, G, and CA modules assessments are provided.

The course is offered in two versions: for inductive visual learners as well as for deductive verbal learners. Both learning style and cognitive modality of the individual learner are defined by two questionnaires the learner fills in before starting with the course. According to this evaluation of the user’s learning style and cognitive modality the system presents the respective version of the course.

Each lesson contains concept learning materials, collaborative tasks and assessments (optional self assessment, mandatory lesson assessment, and – if lesson assessment failed – remediation assessment). The learner can choose freely in what order to study concept learning materials and do collaborative tasks within a lesson. But before s/he is allowed to proceed to the next lesson s/he needs to pass the lesson assessment or – if necessary – the remediation assessment. Assessments are highly adaptive:

- First of all the learner – prior to starting with the first lesson - is offered a pre-knowledge assessment: If s/he has some prior knowledge of Spanish language the learner is advised do the pre-knowledge assessment and according to his/her scoring might be allowed to immediately start with lesson 2 or a higher lesson.

- The learner has the opportunity and sometimes (after having finished activities related with a certain module) receives the recommendation to do self assessment. If s/he performed well and the self assessment is passed, the respective questionnaire(s) will no more be included in the lesson assessment.

- If a learner has difficulties with a certain assessment (either in the self-assessment phase or in the lesson assessment phase) s/he is recommended to do remediation activities to overcome his/her weaknesses. If problems had been coming up in the lesson assessment phase the respective questionnaires have to be repeated (remediation assessment).

- Thus the learner might get the same kind of assessment twice, but the selection & ordering functionality takes care that the content of the single questionnaire randomly varies.

Next figure shows the structure of the lesson 1. The other lessons have a similar structure:
4.2.2 Environment and Electrical Distribution

**EDP pilot site** is focused on the corporate training in the environmental area, specifically in what implies environmental sensibleness in Electrical Distribution, addressing people in a professional context.

The test course presents a modular structure, being each module constituted by lessons or units of learning, some of them without precedence. Mandatory and optional exercises are available to learners within each lesson. Every module has an evaluation whose results are complemented by those coming from a global assessment, done at the end of the course.

Next figure offers the structure of Module 2 composed by 5 lessons.
The course makes use of LD design but adaptation is not mainly implemented in LD but facilitated by the Adaptation module based on metadata. The learning design is developed according to the existence of:

- Different levels of knowledge and/or interest within each learning unit
- Connections between learning units allowing several sequences

### 4.2.3 How to teach through the Internet

The UNED pilot defined a course about “How to teach through the Internet” taking as starting point some didactic material belonging to the existing course (in a program of teachers’ training) active during 4-5 years. The course: “Aprender a Formar en Internet “ is composed of four modules, the first one includes ten activities for introducing the learner with the ALFANET services and collect initial data with the profile questionnaires; the next two modules follow the templates guidelines; the fourth module configures collaborative activities using the Collaborative Framework. The course finalises with a Final Assessment.

Next image shows the course structure as viewed (in Spanish) by the learners.
The duration of the course is estimated on 20 hours.

The course is designed in IMS-LD and includes diversity in learning material (for inductive / deductive; for beginner / advanced); learning objects characterised with IMS-MD / LOM metadata, adaptation rules defined at design and static adaptation rules defined within the Configuration of Recommendations module. Also several banks of items are defined for self-assessment, questionnaires and final exam, experiencing the use of QTI standard. The learning objectives has an important role for the evaluation of this pilot site. Learning activities, Learning objects and QTI Items have associated Learning Objectives.

Thanks to the element characterization described above, rich dynamic recommendations are generated during the course execution.

### 4.2.4 Communication technology, Architecture and applications

The Commtech course of the OUNL consists of three modules that follow the didactical model of the Multiagent Pedagogical Model subproject and the resulting template closely.
The three modules in the Alfanet electronic course contain adapted parts of the existing OUNL course “Communication technology”, which consists of four main parts and is published as written text in a course book:

- Introduction: five chapters in which the field communication technology and the topics in the rest of the course are introduced, based on case studies.
- Fundamentals: six chapters about the fundamentals of communication technology, like signal theory, information theory, modulation and multiplex techniques.
- Architecture: four chapters about architectural aspects like the OSI (seven)-layer model, topologies and dynamical aspects of communication networks
- Applications: three chapters about applications of the theory learned. Topics which are treated are: fixed networks, local networks and mobile networks.

We discuss the structure of the electronic course used in the Alfanet validation. The activity-structure is shown (in Dutch) in the next figure.
• Recommendations about functionality are given.

The first module (an introduction on the internet and the www) consists of a study text and is finished by an assessment of multiple-choice questions. In this module there is no interactivity. If a student doesn’t pass the assessment, he or she is advised to study this module again.

The second module (principles of decomposition and protocols) consists of two parts: firstly a study text about the topics decomposition and protocols, and secondly a web-based tool by which students are able to investigate an internet protocol. Again, this module is finished by an assessment of multiple-choice questions. If a student doesn’t pass the assessment, he or she is advised to study this module again.

The third module treats signal theory. The module structure is as follows. First a unit about “oscillations and sinusoidal waves” is presented. Based on the first assessment outcome (student’s learning style) the content is presented in an inductive (first examples followed by definitions) or in a deductive way (first definitions followed by examples). This part is finished by an assessment of multiple-choice questions. If a student doesn’t pass the assessment, remedial teaching is offered. Again based on the first assessments outcome (student’s cognitive modality) the learning material is delivered verbal (text and symbols) or visual (animations, which are supported by explanations).

Beside this advised learning path (activity structure), which is based on a pre assessment, students are able to select learning objects and activities. For that purpose all learning objects and activities are collected and presented in a list.

The course is implemented using three standards: IMS-LD, IEEE-LOM and IMS-QTI.
5. Access to Project Results

The ALFANET project has provided significant Knowledge in different fields, that in turn have benefit from their interactions generating new knowledge relevant for the e-Learning in Europe.

Other institutions in Europe can benefit from ALFANET outcomes through the Access to Project results:

**Access to Relevant Project Documentation.**

In the following lines the main knowledge publically available and generated by the project is outlined:

- **D12. State of the art**, describes the results of the study into the State-of-the-art of technologies related to the Alfanet project. The study identified existing systems for potential usage as components of the Alfanet system, technologies that could be used for the design of the system and peripheral systems and/or standards that the system should interface with or adhere to. Preliminary conclusions for the development of the Alfanet system are included in the document.

- **D31. Existing Standards Analysis**, provides an overview of existing bodies for standardization and an introduction to existing standards (or specifications) in the areas relevant for ALFANET including learning standards, knowledge management standards, human capital profiles, multi agent architecture standards and other general technical standards. The report, elaborated at the first project stage concludes with a selection of the standards proposed to be used within ALFANET.

- **D32. Standard Contribution Report.** It includes and analysis the contribution of the project to the educational standardisation

- **D43. Final System**, provides an overview of ALFANET architecture and a description of the functionality provided by each of ALFANET components, which are put in place with their particular contribution to the e-Learning life cycle: Design, Administration, Use and Audit.

- **D66. Evaluation Results.** It compiles and analyse the results of the evaluation activities performed in the project, gathering experiences with pedagogical methods, and adaptation along the e-learning life-cycle, and thus providing the basis for further development of ALFANET components.

- **D72. Initial Market Studies** describes the outcomes of the initial market studies which investigated: 1) new tools and products for e-learning, 2) expectations for adaptive e-learning in the European Union, 3) characteristics of potential clients for ALFANET, 4) and user characteristics which need to be addressed in the design of ALFANET. After a description of the key questions, design and outcomes of the market studies, the deliverable describes the conclusions and recommendations for the project ALFANET.

- **D77. Compilation of dissemination activities.** It includes an iterative compilation of the different dissemination materials, with a summary of the dissemination actions of different nature, carried out in the project.

- **D82. Public Final Report.** It includes a global view of ALFANET project results: from the ALFANET adaptation concept, the logical architecture, the underlying technical architecture, the features of pilot sites supported, the particular contribution of ALFANET to e-Learning standards, the outcomes of Evaluation activities, and the activities already initiated for a wider usage of project results.


The above reports can be downloaded from the project websites: [http://rtd.softwareag.es/alfanet/index.html#Resources](http://rtd.softwareag.es/alfanet/index.html#Resources) and [http://dspace.learningnetworks.org/](http://dspace.learningnetworks.org/), this last one including advanced search facilities. At [http://alfanet.ia.uned.es/](http://alfanet.ia.uned.es/) you will find general information about the project.

All these reports correspond with project results initially identified in the Description of Work. Nevertheless the context and scope of these reports have been analysed by the Consortium with the aim to provide a stronger contribution to the e-Learning arena, and in turn major visibility in the e-Learning field. Additionally some of the reports have been transformed from “Internal” to “Public” nature (D43. Final System, D65_1. LD
Authoring Tool manual, D65_2. QTI Authoring manual and D66. Evaluation Results). In addition, a public
version of the Final version has been created, being this report D82. Public Final Report.

An important amount of Scientific Results have also been published by the Consortium Partners in different
fora. These are fully described at D77. Compilation of Dissemination activities.

**ALFANET components delivered as Open Source**

ALFANET Components will be marketed under Open Source licences, thus offering wider opportunities for
integration with e-Learning platforms, and in turn, taking advantage of the improvements on these
components made by third parties.

The following ALFANET Adaptive components will be provided under Open Source licences:

- The LD Authoring component is provided under Open Source licence at Sourceforge from
  https://sourceforge.net/projects/alfanetat/

- The QTI Authoring Tool is provided under GNU GPL licence, available from SourceForge.net
  (http://sourceforge.net/projects/alfaqtiautor/) and from Software AG project web-site
  (http://rtd.softwareag.es/alfanetqtitools/).

- The LD engine (CopperCore) is already available as GNU GPL:

- The QTI engine is provided under GNU GPL licence, available from SourceForge.net
  (http://sourceforge.net/projects/alfaqtiengine/) and from Software AG project web-site
  (http://rtd.softwareag.es/alfanetqtitools/).

- The Adaptation package will be distributed under GNU GPL licence, published in a general repository of
  Open Source code of Internet, such as SourceForge.net and also in the Jade project.

- The Interaction package will be distributed under the GNU GPL licence under the OpenACS and dotLRN
  projects.