

E TESTING IN VIRTUAL E LEARNING SPACE

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***Abstract.** This paper presents the functionality and overall architecture of an eTesting system designed to operate as an integrated part of a virtual eLearning space. The eTesting system provides distance eTesting facilities available to all registered users (e.g. students, educators, test content authors and all others involved in the testing process). An information model of the testing content is proposed as a fully compliant with the IMS Question and Test Interoperability Specification version 2.1 Final (QTI) [1] implementation. An architecture specifying the integration of services with an assessment agent system managing this content is proposed and explained. Finally, an overview of the proposed eTesting system is provided in aspect of its compatibility and integration with the IMS Learning Information Services Specification (IMS LIS) [2] and the Distributed eLearning Space (DeLC).*

Keywords: eTesting, eLearning, service, multi-agent system, gateway agent, QTI, portlets, DeLC

1. INTRODUCTION

The main features of a virtual learning environment define it as a social and designated information space that integrates heterogeneous technologies and pedagogical approaches that are not restricted to distance education [3]. In order a process to be able to operate successfully in this environment, its realization as a part of this environment must be designed in a way that ensures its integration in each and every of these aspects of the virtual eLearning space.

The virtual eLearning spaces which the eTesting will be integrated in are different realizations of eLearning systems. The approach for implementing an eLearning system by adopting a service-oriented architecture [4] is the starting point for modeling and implementing the eTesting as a part of the virtual eLearning space that can operate on its own or as an integrated part of an eLearning system. The same approach is chosen for the realization of the proposed eTesting system. The access to its functionalities is provided by web services for creating, modifying, assessing and analyzing digital assessment content. These services are in direct communication with a multi-agent content and testing management system that is responsible for providing the digital information resources requested

by the web services. The digital assessment content that the system manages is designed as a fully compliant with the QTI information model [5] implementation which ensures the effective execution of the processes provided by the assessment multi-agent management system. Defining the architecture and its provided services in such a way facilitates a wide range of opportunities for integrating the proposed eTesting system in virtual eLearning spaces implemented as eLearning systems (e.g. DeLC) due to its compliance with specifications that define the environment of these spaces that the eTesting system will inhabit.

2. ETESTING SYSTEM ARCHITECTURE OVERVIEW

The model for implementing an eTesting system proposed in this paper is based on several concepts:

- **Service-oriented architecture** that provides a multi-profiled execution and provisioning of content and assessment management functionalities depending on the needs and goals of the concrete user defined by its role in the testing process – authoring, assessing, providing feedback.
- A server module – **Assessment Provider Server** that manages the digital assessment content and is implemented as a set of web services grouped in the Service Layer that communicate with an underlying multi-agent system that is responsible for the digital content management. This agent-based approach towards content management provides an interactive and adaptive behavior of the content as well as a wide range of flexible mechanisms for the composition of more complex functionalities concerning its management.
- **Information modeling** of the digital assessment content as a fully compliant with the **QTI** information model implementation to provide the data with a well defined structure that ensures its ability to be portable and exchangeable between different eLearning systems. This adopted structure utilizes the translation and further management of digital data in the terms of the eTesting processes that involves composing digital tests, assessment, results reporting and further results analyses. An Item Bank is used for the storage of this digital content.
- Adopting the concept of **protlets** [7] in the implementation of the User Interaction Provisioning system modules responsible for the realization of the user interaction with the eTesting system.

The main goal that the proposed implementation of eTesting pursues is its adjustment and adaptation to virtual eLearning spaces. This is achieved by developing the eTesting processes as highly adaptive and interactive workflows over digital content capable of an intelligent behavior.

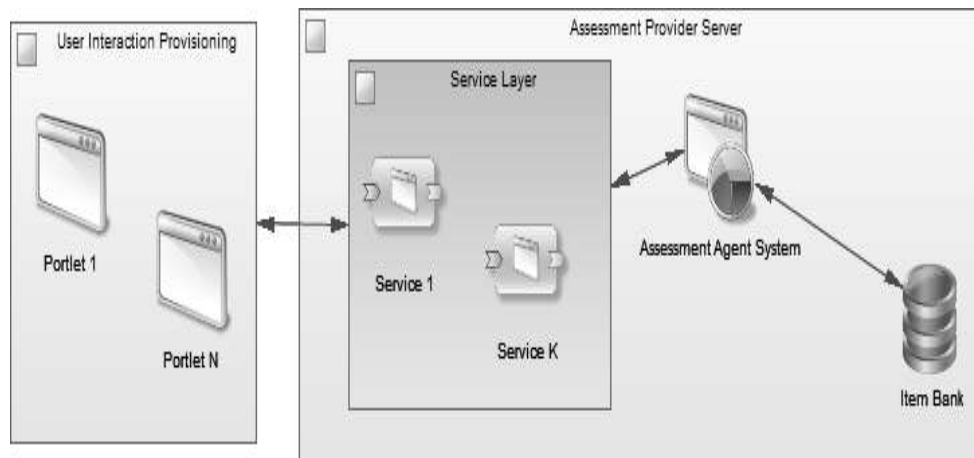


Figure 1. eTesting system architecture

3. THE ASSESSMENT PROVIDER SERVER

The server module in the architecture implements the two base aspects of the eTesting process:

- Digital assessment content management by defining and modeling information structures and functionalities over them for data manipulation.
- Management of the eTesting process by modeling patterns for different ways of its executions and workflows, different types of test assessment and results delivering.

To be able to implement these two basic aspects of eTesting the assessment provider server is composed of two components that collaborate and communicate constantly to provide the needed data and functionalities:

- **Service Layer** – a set of the provided web services that act as a mediator between the User Interaction Provisioning modules (portlets) and the Assessment Agent System.
- **Assessment Agent System** – the actual eTesting realization as a multi-agent system that provides the management and implementation of the digital assessment content and processes in an intelligent and adaptive fashion.

Due to the fact that the assessment content implementation is fully compliant with the information model defined by the QTI specification [3], the set of functionalities implemented as services that can be performed over and with the data are well defined and can be classified in three main groups:

- **Delivery Services** – responsible for delivering the assessment content as a part of a real-time testing process or for exploring.
- **Reporting Services** – they manage the outcome data produced by the processes of eTesting by providing analyzing and statistics facilities.

- **Storage Services** – basic data management functionalities for the creation and administration of the electronic assessment content.

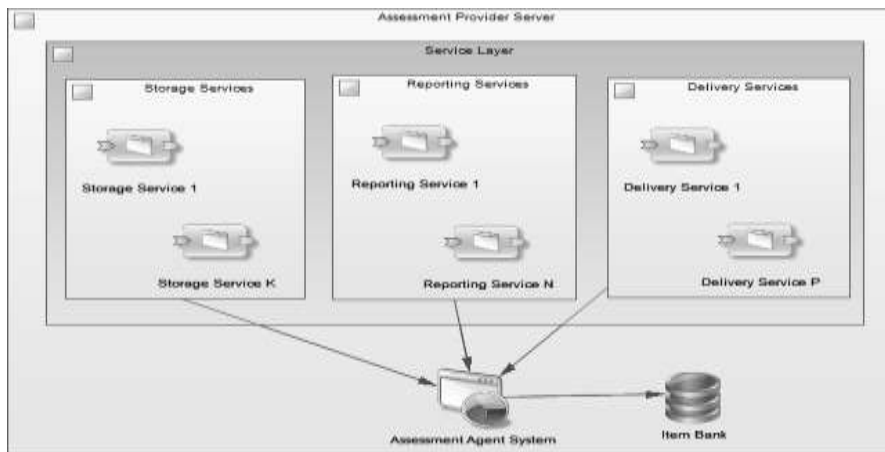


Figure 2. The Assessment Provider Server components

The core of the server implementation is the multi-agent assessment system. The service layer acts as a user accessible wrapper of this core that makes the processes of assessment and content management transparent to the users. The two basic aspects of information management concerning eTesting – assessment content and assessment processes management – distinguish two groups of agents in the assessment multi-agent system to perform the specific operations defined by the concrete aspect of management – Content Management and Delivery agents.

The Content Management Agents (CMA) are the ones responsible for the modeling of the digital content compliant with the QTI specification as well as implementing the basic manipulations over it. Since the structural approach defined by the QTI and adopted in the proposed eTesting system is based on the concept of composition, two groups of CMA can be defined:

- **Assessment Item CMA** – they are responsible for managing the basic content structures defined in the QTI as assessment items that correspond to a single question in the terms of tests composing.
- **Assessment Test CMA** – these agents are the ones that handle the management of the complex content structures that are in fact compositions of simple ones and correspond to tests defined by the QTI as assessment tests.

These basic content manipulation operations include creation, modification, removal and applying different data filters over digital information structures on the two composition levels. Implementing the data management functionalities adopting the agent-based approach is a key feature for providing an intelligent and proactive behavior of the system when it comes to content authoring and management – the system is not only a set of user interfaces for importing or visualizing information – it can act and react to operations performed by the user in

an intelligent and proactive way – validate and analyze new and existing content, provide feedback as a result.

Assessment Delivery Agents (ADA) are the ones that implement the functional facilities for the modeling and realization of the testing processes workflows. These facilities implement the interactivity and adaptivity of the testing itself by providing the means for defining a wide range of behaviors for delivering the tests and the assessments of these digital tests. For every aspect of content delivering there is a subclass of agents designed to utilize the concrete functionalities concerning the aspect:

- **Response Processing ADA** – they implement the different ways that the system can behave and react to user responses received as a result of their interaction with the assessment content through the eTesting workflow.
- **Outcome Processing ADA** – they provide functionalities for creating flexible patterns for scoring tests and calculating the final outcomes of an assessment cycle that are further delivered for analyses and statistics generation.

These two main groups of agents work in a constant collaboration because the testing as a process is based on the provided by the CMA assessment content which on its behalf generates such content too – test outcomes - that in pure digital data terms are also administered by CMA for further analyses, reports and statistics generation.

The key concept that makes it possible for the assessment agent system to communicate with the provided web services in the proposed eTesting system is the adoption of the Web Services Integration Gateway (WSIG) architecture [6] that defines one agent (Gateway Agent - GA) that mediates the communication between externally provided to the multi-agent system web services (Service Layer) and all other agents on the platform that wish to exchange data with these services (CMA, ADA).

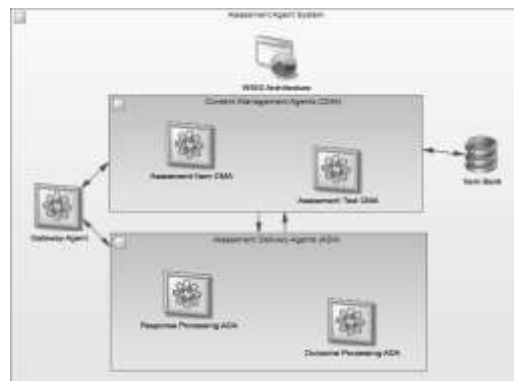


Figure 3. Adopting the WSIG Architecture approach in the Assessment Agent System

The eTesting functionalities are implemented as goals set by the GA when a service request from the Service Layer is received or autonomously generated by

the GA or other agents. These goals are achieved by the deliberate actions of a single or a group of CMA or ADA as a result of their collaboration. This approach for implementing the eTesting functionalities provides flexible mechanisms for adding new functionalities to the eTesting management system that enrich the provided business logic in both functional diversity and complexity aspects.

4. USER INTERACTION PROVISIONING

Since the proposed implementation of eTesting pursues its integration in the virtual eLearning space, its components must be realized by technologies and approaches that guarantee their integrability in the eLearning system representing the realization of this space. The concept of portlets [7] is adopted in the realization of the modules responsible for providing interfaces facilitating the user interaction with the eTesting system. This concept ensures the portability and integrability of the user interfaces in the webspace (e.g. integrating them in web portals such as Liferay). The provided interfaces are synchronized with the provided eTesting functionalities in order to make them accessible to the system users so they can be classified using the same functional criteria in three corresponding groups:

- **Assessment Delivery Portlets (ADP)** – they provide well structured assessment content to the users for testing (e.g. Player, RT Notifier ADP) and exploring purposes (Explorer ADP).
- **Assessment Authoring Portlets (AAP)** – they provide the interfaces for creating assessment items (Authoring Tool AAP) that can be further used for constructing tests as compositions of existing assessment items (Test Construction Tool AAP).
- **Assessment Manager Portlets (AMP)** – they facilitate the assessment estimation (Assessment Estimator AMP) and production of eTesting workflow outcomes, graphical presentation of statistics and analyses based on these outcomes (Assessment Monitor AMP), as well as real-time monitoring of the testing processes (Assessment Monitor AMP).

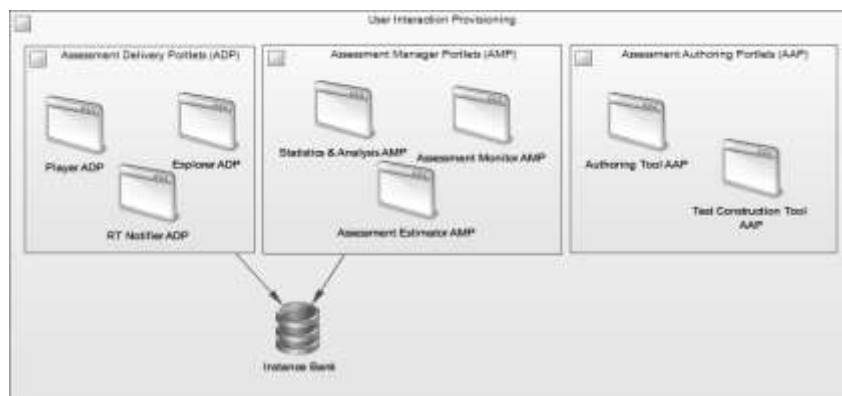


Figure 4. User Interaction Provisioning provided by the eTesting system

Since the ADP and the AMP cooperate by exchanging common content resources this data is cached in and provided by an Instance Bank that is the container of this content and facilitates its shared usage.

5. INTEGRATION WITH DELC AND OTHER ELEARNING SYSTEMS

The architecture of the proposed eTesting system makes it adaptive to the open architecture of DeLC [8] by enlarging the provided by DeLC set of eServices with the ones implemented by the eTesting system. The provided eTesting services are in a direct relationship with the roles that the users have in the eTesting workflow as well as in the whole eLearning process concerning different courses. They also provide the results of the eLearning lifecycle as test outcomes. These functional features are well defined and classified by the IMS LIS in six basic components that together provide the functional frame that the eTesting system corresponds to. This makes the proposed eTesting system compliant with the specification as well as with any other IMS LIS compliant eLearning system. This guarantees the unrestricted sharing of resources that the eTesting system is managing by providing them autonomously or as an integrated unit in an eLearning system which makes it a part of the eLearning space beyond limitations.

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