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Integration of learning objects for adaptative learning

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Abstract. The integration of learning management systems with learning object management systems allows to increase the availability, reuse, integration and adaptability of educational contents according to the characteristics and preferences of the clients. However, given the new trends in the integration of learning objects, software architectures and recommendation systems, it is of high added value to optimize the services offered to customers through an integrated learning management system aimed at the automatic construction of Adaptive training processes in higher education. The main result is the description of an integral system of virtual education based on the competences required by the students, which integrates learning objects (OA) through a semantic OA recommender system and then the system sequencing the OAs to respond to the required competences. The software architecture of the system is structured in two layers: The layer of OA discovery and adaptability and the layer of generation of adaptive training processes, which have as a design principle the web services in order to guarantee the interoperability of the layers.

1. Introduction

Advances in information and communication technologies have allowed innovating and adapting the business models of organizations in different areas of society, in addition, the implementation of cybernetic systems to optimize processes and generate value to through services and new products to these organizations. Education does not escape such disruption, which requires the generation of new conceptions and new paradigms such as university 4.0, which consists of the application of industry 4.0 in the field of higher education. According to [1], industry 4.0 is characterized by the transformation of the productive apparatus worldwide through cyber-systems. In particular, one of the segments in which the impact of this paradigm is evident is that of virtual education, specifically with the integration of learning object management systems into learning management systems, this integration strategy has optimized the way in which the elaboration, distribution and access processes of educational contents are executed through the reuse and integration of learning objects (OA), which are stored and managed in repositories of learning objects (ROA) [2].

On the other hand, according to [3] not all people learn in the same way, which implies a personalization and adaptability of the way to teach each student, due to this, the design of a software architecture is described to take an adaptive teaching process, which is based on web services technologies and recommendation systems. Specifically, the architecture for the adaptive integration of OA is designed in 2 layers, the first layer is semantics, which is composed of the necessary components to deliver personalized recommendations to each student. Each recommendation is made up of a set of ranked OA according to a numerical value calculated by a mating mathematical function, which indicates to what degree each OA is suitable to study a certain topic, considering the particularities defined in the profile of each user (student). Next, the integration layer is designed, which is responsible

for carrying out the automatic construction of adaptive training processes in Higher Education. In order to carry out such construction automatically, an intelligent integrating semantic service is required, which receives a training request expressed in competences (by a client application) and from that request performs an automatic composition process that generates the necessary training blocks. The semantic integration service is implemented as a web service, which incorporates planning and learning techniques in artificial intelligence. The use of artificial intelligence allows you to automatically generate, intelligent and personalized blocks of training sequenced and adapted according to the learning style, the level of knowledge, the psychological and emotional characterization of the student.

2. Methodology
The process of building the software architecture is supported by methods taken from software engineering and supported by artificial intelligence techniques. The methodological approach used in the design of the proposed architecture is the deductive, which starts from the approach of a software architectural design solution and continues with the decomposition of the architecture into layers or subsystems, in a specific way, the architecture is broken down into two layers the layer of OA discovery and adaptability and the generation layer of adaptive formation processes, in turn, each layer is structured into components. Figure 1 presents the component diagram associated with the proposed architecture.
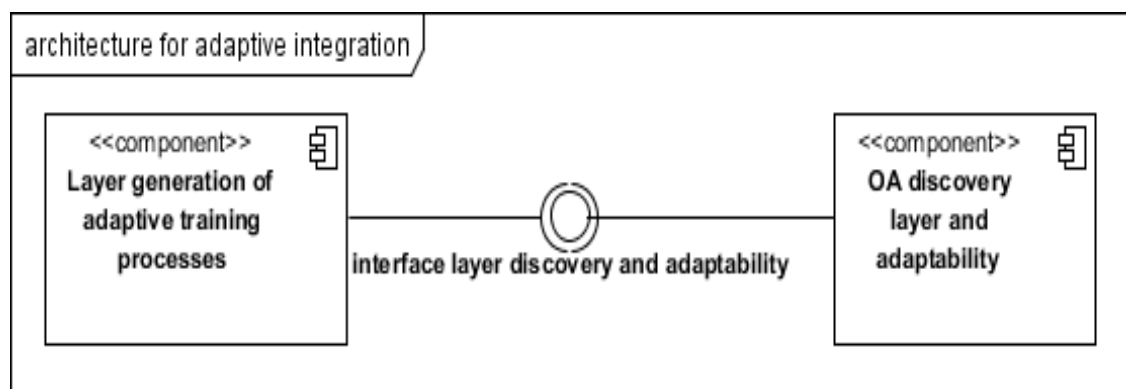

Figure 1. Architecture for adaptive integration

2.1. OA discovery layer and adaptability
According to [4], the discovery layer of OA and semantic adaptability is structured in six components as shown in Figure 2.

2.1.1. OAs recommender system. It is defined as a hybrid semantic recommender, which involves a knowledge-based component, a collaborative component, and a content-based component. The fundamental role of the OA recommender system is to build a set of OA recommendations, which it considers adequate to teach a topic to a student (for which the semantic integration service requested the recommendation). The recommender makes an assessment of the elements of the recommendation set, in such a way that he recommends the objects in an orderly manner according to a numerical value that represents the degree of suitability that each LO has to teach a certain competence or subject.
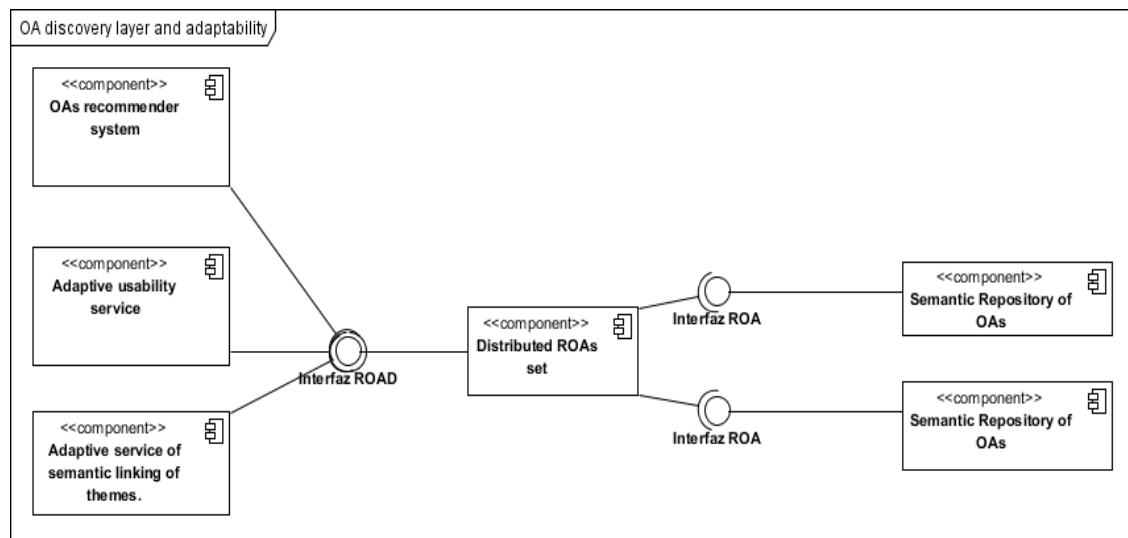
Figure 2. OA discovery layer and adaptability

2.1.2. Semantic Repository of OAs. It is an OA storage medium related to the metadata associated with the educational contents that have been submitted to a certification process. The fundamental element of the repository is an ontological model presented in [4], which was designed based on the LOM standard. This ontology contains the necessary elements, so that the recommender can make the requested recommendations.

2.1.3. Distributed ROAs set. It is made up of the different repositories of OA distributed worldwide that offer OA search services. According to [5] the distributed repositories allow to improve the levels of reuse and integration of the LOs. These sets of ROAs are used by the recommender system, only in the case that they do not have OA certificates that comply with the requested recommendation.

2.1.4. Adaptive usability service. This service is composed of a repository with the information of the user profiles, in which the knowledge regarding the preferences of each user and the use of OAs that each one makes is stored. In addition, this intelligent agent that has a web service that offers information about a user's profile, requested by whoever requires it. For the proposed architecture, the client of said web service is the recommender service, who uses this knowledge to personalize and adapt the recommendations. The information registered in the user profile comes from the dynamics generated in the system.

2.1.5. Adaptive service of semantic linking of themes. This component is designed as an intelligent agent, which is responsible for providing the recommender system with the different topics semantically linked to the topic requested in the recommendation. This agent is based on the use of an ontology of semantic linking of topics, which is useful for any application that requires it.

2.1.6. Adaptive quality service and performance evaluation. Component designed as an intelligent agent that manages all knowledge related to the quality and performance evaluation of each of the OAs that are certified. For architecture, this agent must be implemented with intelligent techniques that allow to permanently re-evaluate the quality and performance of each one of the OAs (learn), according to the dynamics of the system. That is, this agent must incorporate artificial intelligence that allows him to learn to differentiate that OA has higher quality than another for a certain user at the time of making the recommendation.

2.1.7. Adaptive service of pedagogical aspects. This component is responsible for calculating the contribution of pedagogical personalization in the function of utility of each object to be recommended, according to the student's learning style and other characteristics of their profile. The implementation of this intelligent agent requires artificial intelligence in such a way that it can determine, through experience, the didactic and methodological strategies that are most convenient for the student. The foregoing implies that an OA with suitable didactic and methodological strategies for the student requesting the recommendation will show greater contribution of pedagogical personalization for the calculation of the mating mathematical function.

2.2. Layer generation of adaptive training processes

This layer is responsible for performing the automatic construction of adaptive training processes. In order to carry out such construction automatically, an intelligent integrating semantic service is required, which receives a training request expressed in competences (by a client application) and, based on said request, perform an automatic composition process that generates the necessary training blocks. The semantic integration service is implemented as a web service, which incorporates planning and learning techniques in artificial intelligence. The use of artificial intelligence allows it to automatically and intelligently generate sequenced and personalized training blocks according to the learning style, the level of knowledge, the psychological and emotional characterization of the student. The semantic integration service is structured in two processes as shown in figure 3.
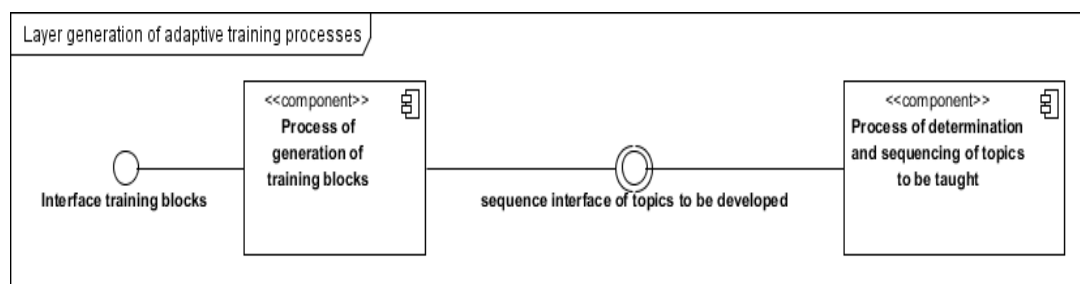

Figure 3. Layer generation of adaptative training processes

2.2.1. Process of determination and sequencing of topics to be taught. In this process, the integrating service uses an ontological domain model based on rules, which allows you to infer the different topics that must be taught to ensure that the student really learns the requested competence. In addition to determining the different subjects that must teach to achieve the competition, it is necessary that the integrating semantic service determines the order in which said topics should be taught.

2.2.2. Process of generation of training blocks. This process is responsible for integrating into each training block several existing OA that are registered in the semantic repository that has the semantic layer. To do this, the integrating semantic service uses the sequence of topics to be taught (obtained in the previous process), requesting a semantic layer recommendation for each topic that belongs to the sequence of topics to be taught. For each of the recommendation requests, the semantic layer will provide a recommendation that will serve as an input to the intelligent algorithms for generating training blocks to include the OA that best suits the student for whom it is being formed.

3. Results

The software architecture described solves a problem of integration of systems that act in isolation, specifically, the OA repository systems store educational contents packaged with metadata that are used according to the needs of the courses, later manually, the LMS add selected OAs to the course that will contain the educational content. The presented architecture integrates and automates the processes of selection and integration of OAs and additionally performs the integration process according to the

profiles of the students based on the requirements they need to develop the competencies of a training process. The presented software architecture is structured in two layers, the semantic layer and the integration layer, which use theoretical foundations of artificial intelligence and software engineering for their construction.

To assess the suitability of the proposed architecture, a panel was convened, made up of three experts in the area. Each of them was presented with the evaluation criteria presented in Table 1.

Table 1. Evaluation test for the proposed architecture

	Test
C1	Depth level of the architecture description
C2	Represents a viable solution to the problem of customization and adaptivity of teaching automatically
C3	It represents a viable solution to the problem of integration and reuse of digital teaching contents automatically
C4	The proposed architecture incorporates updated and appropriate technologies
C5	The work presented is in accordance with the current requirements in TEL
C6	The presented work includes the most relevant aspects in customization, adaptation and integration of digital contents
C7	The work is novel regarding the of arte state existing
C8	Architecture is adequate in terms of mechanisms of representation and exchange of knowledge
C9	The proposed architecture is independent of specific platforms and technologies for its implementation

The results obtained in the evaluation of the adaptive architecture are shown in table 2.

Table 2. Results obtained in the evaluation of experts

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Expert 1	4.1	5.0	4.8	5.0	5.0	4.9	4.5	4.0	5.0
Expert 2	4.5	4.6	4.7	4.8	5.0	5.0	4.8	3.8	5.0
Expert 3	3.2	4.2	4.4	5.0	5.0	4.8	4.4	3.7	5.0
Average	**3.93**	**4.6**	**4.63**	**4.93**	**5.0**	**4.9**	**4.56**	**3.83**	**5.0**

The above results make it clear that the presented work is new, is in accordance with the current requirements regarding Technology for Improvement of Learning TEL, covers the relevant aspects in terms of adaptability and personalization of the teaching and also provides a feasible mechanism to perform integration automatic digital content.

4. Conclusions

Artificial intelligence techniques constitute a field of high importance for the generation of value in the design of systems integration solutions, as is the case of the proposed architecture, which contributes to the reuse and integration of OAs automatically, complemented with features that bring and align virtual learning environments to the current needs of higher education institutions, specifically in the construction of training processes based on the individual characteristics or profiles of each of their students or clients through recommendation systems.

The teaching-learning processes are being influenced by the current disruption generated by the fourth industrial revolution, which implies that virtual learning environments should involve architectures such as the one presented here that not only integrate and reuse existing educational content, but also optimize the teaching process through the personalization and adaptation of contents according to the particularities of each student.

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