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A generation of a Multi-Layered Application by Applying the MDA Approach for Online Learning Platforms

Aziz Srai, Fatima Guerouate, Hilal Drissi Lahsini

Abstract*: *The e-learning study reflects a trend in the integration of information and communication technologies in universities. This trend evokes a new form of teaching and learning and a new form of relationship between students and teachers. In fact, information and communication technologies, such as e-learning, call into question the ways of thinking and the ways of acting of individuals in the representation of learning. This paradigm shift requires introspection and the renewal of skills. In the face of these changes, higher education institutes must develop and make essential the courses that allow students to adapt to the new demands of the labor market. on the other hand, information and communication technologies and computer networks, These objects from daily life, are part of the immediate environment that is both professional, educational and personal of each one. With the massive arrival of personal and accessible digital tools (computers, nomadic equipment such as mobile phones and digital tablets, etc…), multiple online spaces are emerging on the Internet (discussion forums, e-learning platforms, blogs, messaging, chats, social networks like Facebook, online information sharing sites, etc…). E-learning offers features that differentiate it from others media objects such as books or television. e-learning offers quick, even instant, access to a multitude of information sources. They make it possible to store them and facilitate the possibilities of networking between individuals and groups of individuals whatever the time and place. Access to the Internet information network is "universal". You only need to connect to a computer on the network to access almost this entire network. Access is also "simultaneous" because each Internet user exists on the network in the form of information by "his digital presence", by the data that he moves or deposits and the interactions caused. We can also say that access is independent of time and distance since it is a space permanently open to human activity. Developing an e-learning application for each technology requires a lot of human resources and technical knowledge. To solve this problem we propose a development of an e-learning application according to a model-driven architecture approach. This paper is a development of our work in paper [Srai,2020].

Keywords* : Metamodel, models, MDA, e-learning, Acceleo.

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* Correspondence Author

Aziz Srai*, is a research Doctor at LASTIMI Laboratory, Superior School of Technologies of Sale, Mohammadia School of engineering, Mohamed V University city of Rabat, Morocco. Email: aziz.srai.dev@gmail.com

Fatima Guerouate, is a Research Professor at LASTIMI Laboratory, Superior School of Technologies of Sale, Mohammadia School of engineering, Mohamed V University city of Rabat, Morocco. Email: guerouate@gmail.com

Hilal Drissi Lahsini, , is a Research Professor at LASTIMI Laboratory, Superior School of Technologies of Sale, Mohammadia School of engineering, Mohamed V University city of Rabat, Morocco. Email: Hilaldrissi@gmail.com

I. INTRODUCTION

The use of the internet and its associated technologies has not persisted in organizations and the educational world; even some believe that it has evaporated as quickly as one might have wished. While the introduction of information and communication technologies in education first aimed at improving teaching methods, it was presented, in particular through the establishment of open and distance training (e - learning, open and distance learning) as a means of reducing training expenses (reduction of costs, elimination of civil servant posts) for the States and increase of revenues (opening to new markets). In particular, it will have taken the form of e - learning, producing effects either from the point of view of learners or from the point of view of establishments.

Many higher education institutions around the world (French-speaking, Spanish-speaking, English-speaking), whether public or private, have seized upon this new modality in the perspective of reaching these new audiences, forced to most (working professionals, distant students who cannot normally have access to face-to-face training, foreign students) in return for payment, most often, of a high amount. The leading country in e - learning today remains the USA. Online degree training is the main form of online education development there. The country has 1.66 million students enrolled in distance education, 134 000 people take qualifying or diploma courses. United States offers 49 000 different distance learning courses and programs, covering all disciplines and specialties of American universities and schools. Our contribution in this paper is the generation of an online learning multi-layered application through model driven architecture approach. This work is a development of our work in article [Srai,2020]. This paper is organized as follows: we begin in the first section with an introduction. The section 2 discusses the works that are related to our theme. Section 3 presents the concepts of the MDA approach (Model Driven Approach). Sections 4 and 5 present our proposed solution to develop E-learning platform. The final section concludes this paper, and outlines future work.

II. RELATED WORKS

The authors in [Srai,2017] propose an application of the MDA approach to generate a PSM web model for E-learning platform respecting n-tiers architecture.
The goal of the work of [Wang,2003] is to develop E-learning applications through the MDA approach. But in this work the author did not expose the transformation algorithms.
The authors in [Zhang,2010] propose a model-driven approach to develop E-learning platform with the implementation of the EJB beans. The transformation rules have not been cited.

III. MODEL DRIVEN ARCHITECTURE

Model Driven Engineering (MDE) has enabled several significant improvements in the development of complex systems in allowing focusing on a concern more abstract than classical programming. This is a form of generative engineering in which all or part of an application is generated from models. A model is an abstraction, a simplification of a system that is sufficient to understand the modeled system and answer questions that arise about it. A system can be described by different models related to each other. The main idea is to use as many different modeling languages (Domain Specific Modeling Languages - DSML) as the chronological or technological aspects of the development of the system require. The definition of these DSMLs, called metamodeling, is therefore a key issue in this new engineering. Also, in order to make models operational (for code generation, documentation and testing, validation, verification, execution, etc...), another key issue is that of model transformation.
Software engineering continually provides new technologies to facilitate the implementation of computer systems. Whatever approach is used (functional, object, components, Middleware or services, etc…), the goal is always the same: to increase the quality of IT systems while facilitating their implementation on a platform execution given.
The major drawback of these platforms is their increasing complexity and rapid scalability. Faced with this situation, researchers and manufacturers have agreed that the solution to this problem should be by a rise in models, and a clearer separation between business and technology.

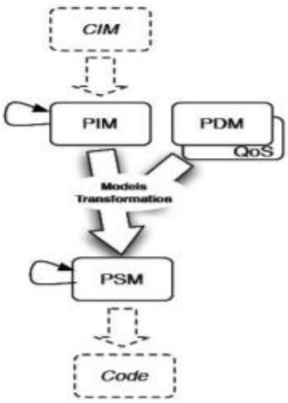

Fig. 1.Principles of the MDA Process.

A. Computation Independent Model (CIM)

CIM (Computation Independent Model) is a model where no IT considerations appear. It models the business domain and system requirements, typically through the use of separate models (eg business processes, use cases, etc...).
It shows the system in the organizational environment in which it will be run. Its purpose is to help understand the business problem, but also to establish a common vocabulary for analysts and business architects. The requirements expressed in the CIM must be traceable in the PIM and the PSM. It should be noted that the CIM model was not defined and added to the MDA approach until 2003. The OMG aims, through the introduction of the CIM, to bridge the gap between business analysts and software architects.

B. Platform Independent Model (PIM)

PIM (Platform Independent Model) is a model that describes the business concepts of the system without showing the details of its use on a particular technology platform. The PIM must be refined by the details of one or more particular architectures to achieve a PSM.

C. Platform Specific Model (PSM)

PSM (Platform Specific Model) is the model produced by the transformation of the PIM. It is suitable for specifying the implementation of the system in a single technological platform.

D. Code

Code is the final phase of development, ie the transformation of each PSM into source code. The source code is considered a template in the MDA approach.

In short, the MDA advocates the use of these four models in the following order:

- Realize the CIM requirements model that specifies and represents the system in its environment;
- Carry out the PIM analysis model from the elements of the CIM;
- Enrich the PIM with technical details relating to the choice of the execution platform, to obtain the PSM;
- Refine the PSM until the source code is obtained.

E. Model transformation

The second key concern of the IDM is to make models operational using transformations. This notion is central to the MDA approach. Indeed, MDA is based on the principle of creating a CIM model that can be refined in PIM, then in PSM to finally automatically generate the source code. Accordingly, there is a need for techniques and tools that allow this transformation of models.

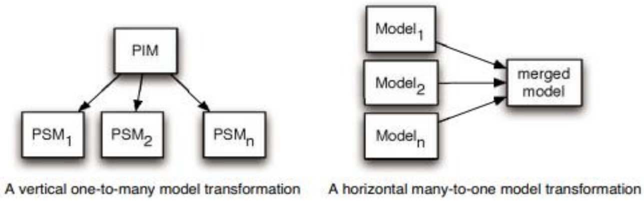

Fig. 2.Examples of model transformations.

F. Endogenous transformation versus exogenous transformation

To perform a transformation of models, it is important that these models are expressed by a certain modeling language, for example the UML formalism. A distinction can be made according to the modeling language used to express the source models and target models involved in a transformation: an endogenous transformation concerns transformations between models expressed with the same language (based on the same metamodel) and an exogenous transformation concerns models expressed with different languages (based on two different metamodels).

Table- I: Orthogonal dimensions of model transformations with examples.

	Horizontal	*Vertical*
Endogenous	Refactoring	Formal refinement
Exogenous	Language migration	Code generation

G. Horizontal transformation versus vertical transformation

The level of abstraction is an important criterion for classifying model transformations. A transformation between two models of the same level of abstraction is said to be horizontal. A typical example is a transformation between two PSMs. When the transformation involves two models of two different levels of abstraction, it is a vertical transformation. The transformation from CIM to PIM is a typical example of this type of vertical transformation.

IV. PROPOSED METHODOLOGY

A. Generation of a multi-layered application by applying the MDA approach for online learning platforms

To generate an online learning platform through an MDA approach we have considered the class diagram Fig. 3 We consider the class diagram illustrated in this figure sufficient to apply the MDA approach on online learning platforms, and letting the paper quite understandable and clear.

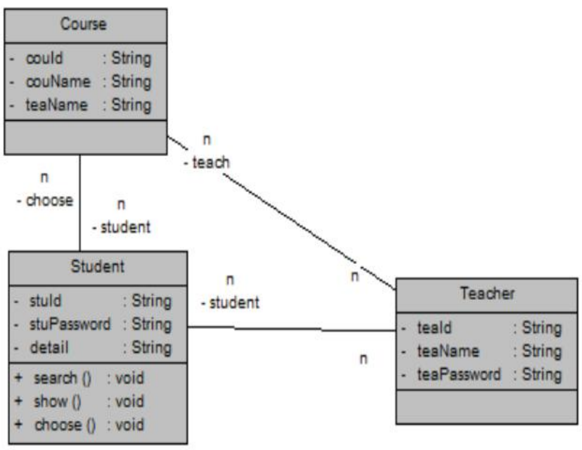

Fig. 3.Class diagram of the online learning platform.

We begin by meta-modeling the source UML meta-model presented in the fig.4

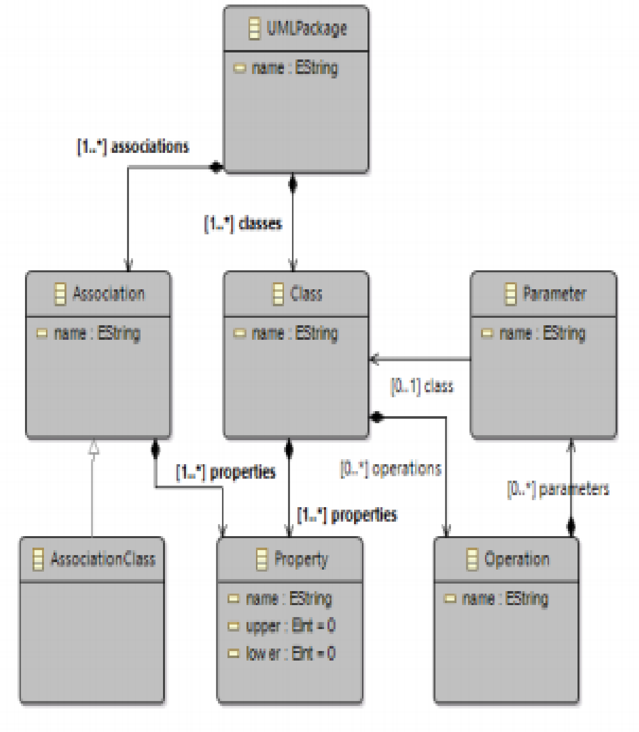

Fig. 4.UML metamodel.

We have performed the different transformations from the metatodels described in figures Fig. 5 and Fig. 6 for the generation of a multilayer online learning application.

The different algorithms which translate these transformation rules are described in Fig.7, Fig.8.

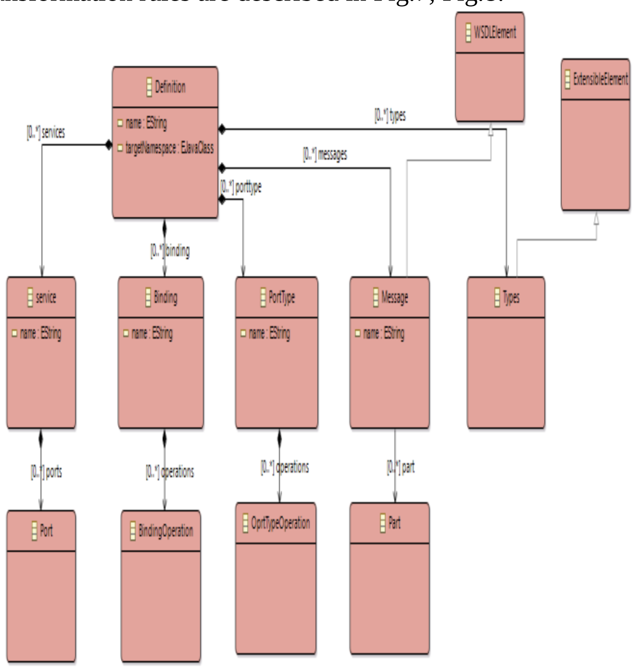

Fig. 5.Web service Meta-Model.

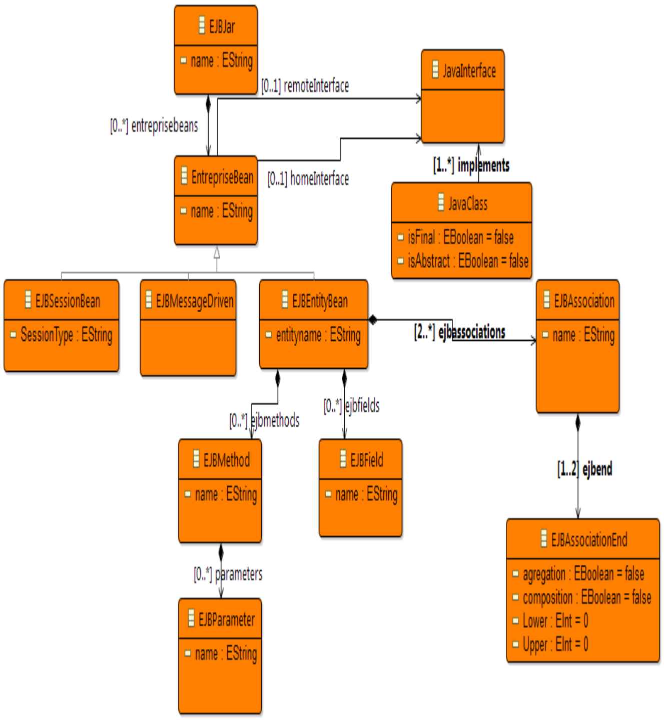

Fig. 6.EJB Meta-Model.

```
[comment encoding = UTF-8 /]
[module generate('http://webservice.mm')]

[template public generateService(aService : Service)]
[comment @main/]
[file (aService.name.concat('.java'), false, 'UTF-8')]

@WebService
Public class [aService.name.toUpperFirst()/] {
@EJB
Private homeInterfaceLearning  metier;
@WebMethod
[for (o: Operation | aService.operations) separator('\n')]
    public [o.type/] [o.name/]() {
        ...
    }
  [/for]
  ...
[/file]
[/template]
```

Fig. 7.Model-to-text transformation with acceleo to generate the web service layer of the multi-layered online learning platform.

```
[template public generateService(aEJBJar : EJBJar)]
[comment @main/]
[file (aEJBJar.name.concat('.java'), false, 'UTF-8')]

@Stateless
public class [aEJBJar.name.toUpperFirst()/] implements  ...,...{
@PersistenceContext (unitName="elearning")
   private EntityManager em;
@Override
   public List <Student> Search(...) {
          Query req= em.create Query("select s from Student s ...");
      return req.getResultList();
   }
   ...
[/file]
[/template]
```

Fig. 8.Model-to-text transformation with acceleo to generate the business layer represented by EJB of the multi-layered online learning platform.

V. RESULT ANALYSIS

After the various transformations we were able to generate the following codes Fig.9 and Fig. 10 which represent a multilayer online learning application. For the database, the tables were created dynamically thanks to the notion of relational object mapping.

```
@WebService
Public class StudentSOAPService {
@EJB
Private homeInterfaceLearning  metier;
@WebMethod
      public  List <Student> Search() {
          ...
      }
    ...
```

Fig. 9.Generator code representing the presentation layer of a multilayer online learning platform.

```
@Stateless
public class eLearningPersistentBean implements  ...,... {
@PersistenceContext (unitName="elearning")
   private EntityManager em;
@Override
   public List <Student> Search(...) {
          Query req= em.create Query("select s from Student s ...");
      return req.getResultList();
   }
   ...
```

Fig. 10. Generator code representing the business layer of a multilayer online learning platform.

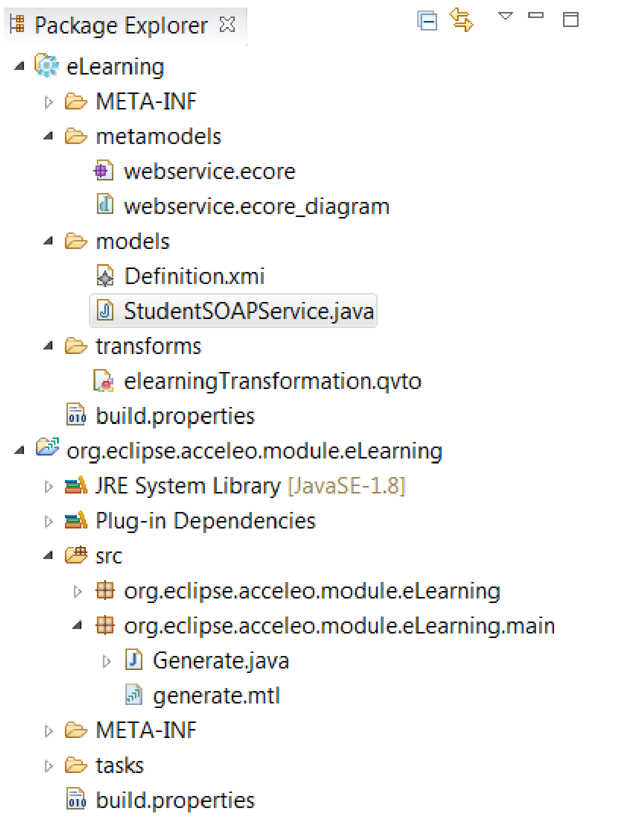

Fig. 11. Set of Acceleo elements on EMF of our project.

VI. CONCLUSION

In this paper, we have applied an MDA approach on an online learning platform in order to facilitate the development of this type of application and to remain independent of the implementation technology. We can support programming by model because it saves time and costs during the entire development cycle. In perspective, we are working to develop a multilayer application through MDA approach with the use of NoSQL databases like Cassandra and MongoDB.

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AUTHORS PROFILE

Aziz Srai, is a research Doctor at LASTIMI Laboratory, Superior School of Technologies of Sale, Mohammadia School of engineering, Mohamed V University city of Rabat, Morocco. Email: aziz.srai.dev@gmail.com

Fatima Guerouate, is a Research Professor at LASTIMI Laboratory, Superior School of Technologies of Sale, Mohammadia School of engineering, Mohamed V University city of Rabat, Morocco. Email: guerouate@gmail.com

Hilal Drissi Lahsini, is a Research Professor at LASTIMI Laboratory, Superior School of Technologies of Sale, Mohammadia School of engineering, Mohamed V University city of Rabat, Morocco.