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IMPLEMENTATION AND TESTING OF A PROPOSED DOMAIN MODEL FOR ADAPTIVE HYPERMEDIA

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ABSTRACT

This paper joins our implemented and tested works regarding the three fundamental models of the adaptive hypermedia systems. Namely: learner model, domain model and adaptation model. In a previous work, we introduced our proposal of the domain model that describes how the knowledge and concepts of courses are structured within the adaptive hypermedia systems. Our proposal was based on new relevant ideas and structures that were designed mainly to be more suitable for adaptation purposes. And as an extension of our workflow, we have moved from the conceptual phase to the implementation phase of this model which we will discuss in detail in this article by first discussing the small changes that we made to our model at the conceptual level, and then introducing the different web tools that we developed to manipulate our domain model, and finally presenting screenshots of our tested tools that proves the efficiency and utility of our proposed model.

Keywords: *Adaptive hypermedia system, Domain model, Adaptation model, Learner model, E-learning*

1. INTRODUCTION

Many countries around the world have closed all schools and educational institutions due to the covid-19 pandemic. This kind of decision was taken as a quick attempt to contain the spread of this disease. As a result, education has shifted toward distance learning and we have noticed a particular rise in the use of e-learning as a main method for education.

Since e-learning has been around for a long time, several methods and solutions have been developed. Some of these solutions are free while others are licensed for use. There are also some which are based on classic learning tools while others offer more functionality in terms of adaptation and customization. All of these different solutions had been well grouped and categorized by the United Nations Educational, Scientific and Cultural Organization –UNISCO- [1] in their website. However, nowadays most of these methods and solutions are considered as traditional e-learning systems because they have one major limitation that can be resumed on their inability to fit and adapt to the needs and preferences of their users.

Therefore, in order to overcome this limitation, Adaptive hypermedia systems have emerged. These systems are mainly constructed around 3 models [2], which are: learner model, adaptation model and domain model. The learner model (or user model) maintains the personal characteristics of the learner and reflects all the individual preferences and differences [3]. The domain model represents the materials of the hypermedia system and it is composed of a set of elementary knowledge, which can have relations between them [4]. The adaptation model is responsible for adapting the different aspects of the content to be delivered to the learners using both the domain and learner model [5].

During our years of research, we had two major goals: the first was the proposal of new models while the second was the development of applications that use these proposals. Regarding the first goal, we first searched for the different model proposals in the literature. Then we analyzed and compared them, and finally we came up with proposals for each model that we published in different journals [6][7][8]. Regarding the second goal, we already published an article about the

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implementation phase of our adaptation model proposal [8]. This phase allowed us to see our proposal in action and proves that it is robust and well functional, and also it allowed us to correct some conceptual errors and improve our proposal. Therefore, in a similar way, we will in this paper present the implementation phase of our domain model proposal [7]. We will first introduce our proposed domain model and explain it briefly, then we will present the major adjustments at the conceptual level that we have done to our proposal in order to make it more suitable and easier to use in development processes. Finally, we will pre-sent screenshots of our tested tools that proves the efficiency and utility of our proposed model.

2. DOMAIN MODEL

Before introducing our domain model, we will first present our design ideas and solutions based on reference models (MUNICH and AHAM) and online learning technical standards (SCORM and CMI5). Following that, we will present our domain model.

In the first phase, we continued to support our vision of abstracting the domain model, meaning that we would not introduce elements in our proposal to describe the structure and style of a page to be delivered to learners.

Secondly, we devised a new vision based on objectives, aiming to build the course around goals rather than content. This new architecture places more emphasis on the semantics and objectives behind the learning of a concept. It will also facilitate the adaptation process as the hierarchical structure of the course is no longer in the form of a content tree but in the form of an objective tree where each objective has multiples types of representation. Thus, instead of having multiple content-oriented structures for the same course [Figure 1] where each structure refers to a type of representation, we will have only one objective-oriented structure [Figure 2].

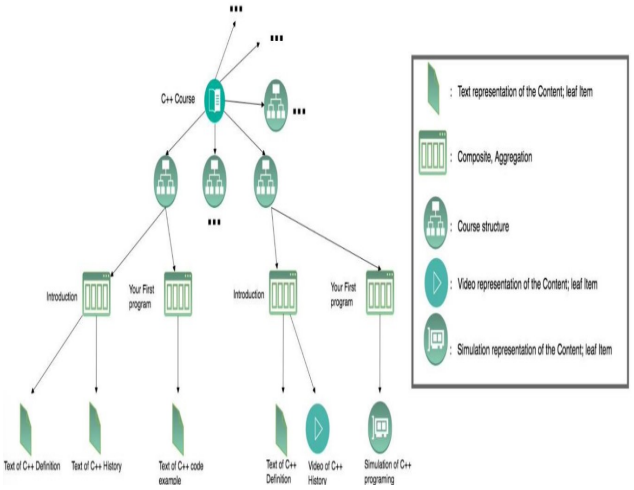

Figure 1. Example of a course structure based on content

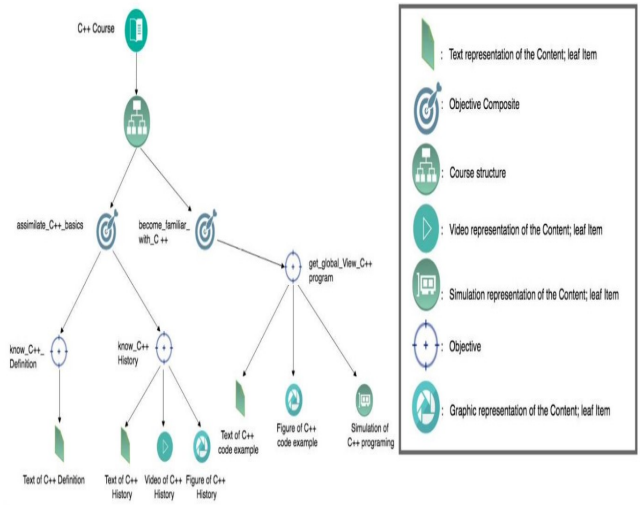

Figure 2. Example of a course structure based on objectives

Finally, regarding sequencing, we have employed two rules:

- The Assignable Unit (AU): is merely the presentation of the learning content to be delivered to learners, and to manage it, we drew inspiration from CMI5, using the 'MoveOn' criterion for the completion of individual AUs. Here are the proposed values: {"Passed," "Completed," "CompletedAndPassed," "CompletedOrPassed"}.
- The objectives: Each objective will have prerequisites that can be used either to control learning or simply for tracking purposes.

In addition to the design ideas mentioned above, we introduced into our domain model [Figure 3] an overall structure that outlines the external structure of a course, progressing from discipline to chapter. (Discipline > Course > Module > Lesson > Chapter)

The domain Model is one of the core models of the adaptive hypermedia systems. It contains all the information about the structure of the educational content and also all the resources required to represent the information [9]. In our previous work on the domain models [7] we studied in depth the major models proposals found in the literature which allowed us to identify several shortcomings, namely:

- Each educational content has only one representation
- Total absence of adaptation support except for languages
- Lack of reusability of content
- The educational content and the representation (pages) are hard linked.

And then we came up with two ideas that address these issues and give solutions to the shortcomings mentioned above.

The first idea is to have an abstraction and a separation between the educational content and the representation pages. Indeed, the domain model that we proposed will not contain any information on how the pages will be created, nor the layout and styles of representation, and it will only contain the information about the educational content and its resources.

The second idea is to implement an objective oriented vision which was well explained in our paper [7]. In short, this vision consists in building the domain model around the objectives and not around the educational content. such an approach has many advantages with regard to adaptation which is the main characteristic of hypermedia systems.

Finally, these two ideas were used to propose a new domain model [Figure 3] that we designed using the class diagram of UML2.

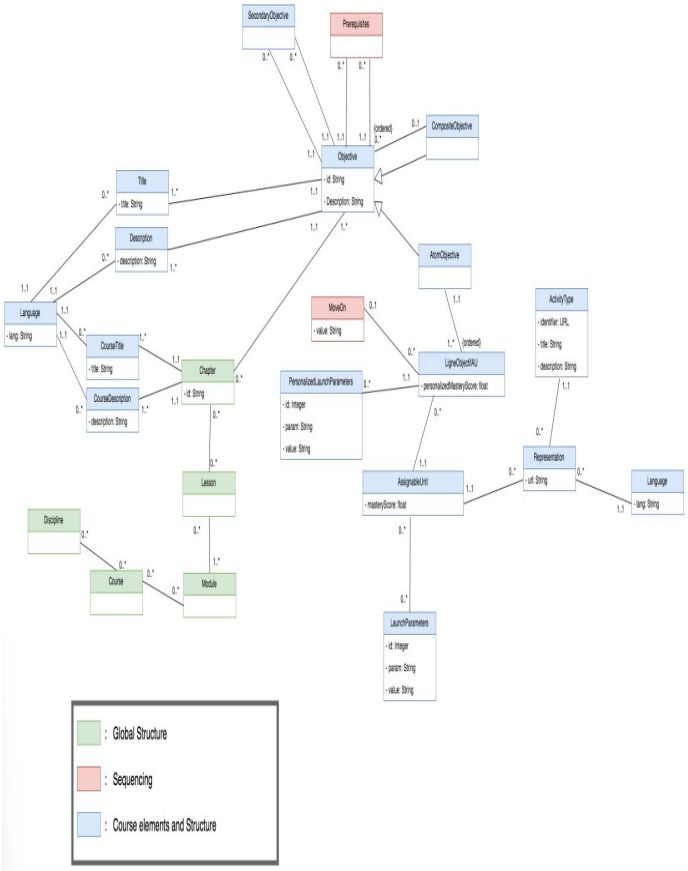

Figure 3. UML2 class diagram of our previous domain model proposal

The smallest logical grouping of concepts and knowledge to be delivered to the learner consists of multiple objectives that have three types of relationships:

- The 'composite' design pattern: The composite is used to form a logical structure of objectives in the form of a tree.
- Prerequisites: These relationships are here to express rules that can be used either to control learning – sequencing – or just for informational and tracking purposes.
- Secondary Objectives: In addition to the primary/main objective, each objective can be linked to numerous secondary objectives. This type of relationship will often

be used either for descriptive and informational purposes or for recommending to learners and will have no influence on the sequencing process.

The 'Objective' class is the main element of our model, which is based on the objective-oriented structure. Composite objectives (CompositeObjective Class) are considered as containers for atomic and composite objectives. Only atomic objectives -leaf- are allowed to have an ordered list of learning units (AssignedLearningUnit Class).

The learning unit –Assignable Unit AU– represents the abstract definition of the resource used to achieve certain objectives. Since the AU can reside anywhere, even outside the system, we have used a relative or complete URL specifying the launch point of the AU.

Also, the same AU can be used by multiple objectives and can have multiple representations in different types of activities (Text, image, video) and languages. These types of activities are identified by URLs; this choice aligns with our plan to now include the vocabulary of the Experience API and the semantic web.

Finally, the Launch Parameters class and the 'masteryScore' attribute have been intentionally included twice, first in the learning unit and then in the atomic objective, for the simple reason of giving course designers the choice to provide their own values while recommending the use of the default ones.

3. CONCEPTUAL ADJUSTMENT

While developing the various web tools that manipulate and test our domain model, we have made some modifications and adjustments to our domain model proposal in order to improve it and make it easy to use. The main adjustment concerns the way the course objective tree has been developed. In our old proposal we used the composite design pattern [10] to reflect the parent-child relation between objectives. The main issues we found is that the final items in the course tree (called Leaf - AtomObjective) can't have children and also the 'Composite Objective' which is the component that groups other objectives is not allowed to have educational content associated with it.

All these issues are due to the composite design pattern that we decided to re-place it with a reflexive relationship [Figure 4] that will allow our model to be more flexible and easier to expand and to be implemented.

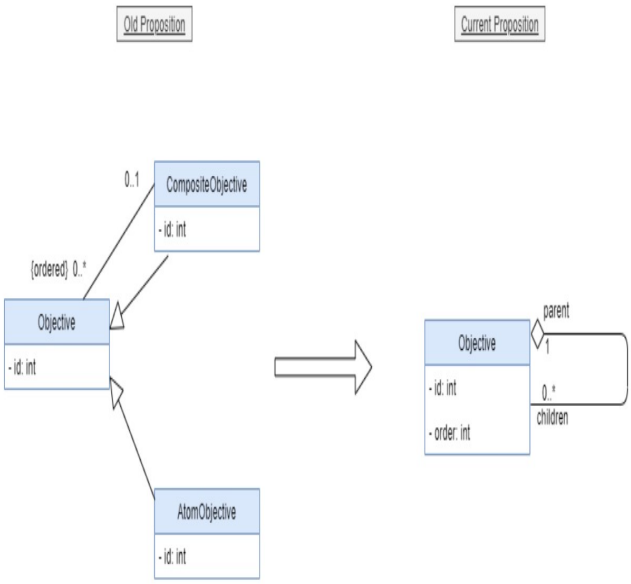

Figure 4. UML2 class diagram of our previous domain model proposal

Some other adjustments were also made like the addition of the concept of objective details level, this new concept can have three values (low, medium and high) which will be used for adaptation purposes. All these adjustments and changes are shown in the new class diagram [Figure 5], we can also notice that some classes (MoveOn, LigneObjectifAU) have been removed and some attributes have changed places for simplification which were revealed during development.

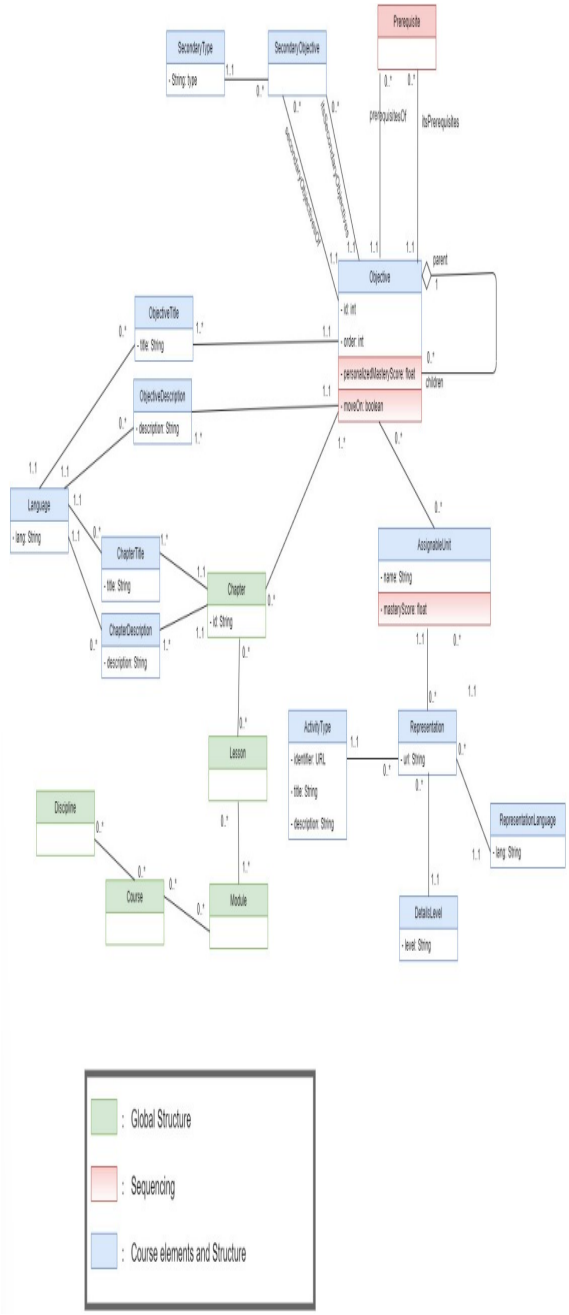

Figure 5. UML2 class diagram of our new domain model proposal

4. IMPLEMENTATION AND TESTES

In this section, we are going to present the global architecture of our test project and then share some screenshots of the different web tools that we developed in order to verify and prove that our domain model proposal is well operational.

4.1. Global architecture

The architecture that we used is based on modern technologies, but it can be developed with any other development tools and technologies.

We suggest having a single web service that will be consumed with different client applications (desktop, web, mobile, etc.). Indeed, we first developed the web service then we moved to the client side where we developed a web application [Figure 6]. The following is a brief description of the technologies used:

- Backend which will provide services (web service) to manipulate our domain model data. To develop this web service, we used Spring boot framework [11] and its dependencies, such as: spring web, spring data jpa and spring security.
- Front end which will consume this web service and represent data to the user. We used Angular10 [12] to develop this client.

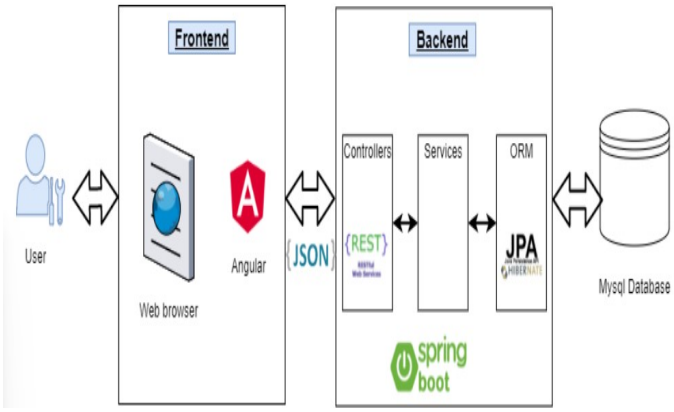

Figure 6. Global Architecture

4.2. Developed web tools

In the first web tool [Figure 7], the user can perform various operations concerning the courses. Such as adding, updating and deleting a course. We also support the multi languages regarding the title and description of a course. Finally, we show statistics of the level of adaptation support (media types, details level, relations with other subjects, languages) for each course.

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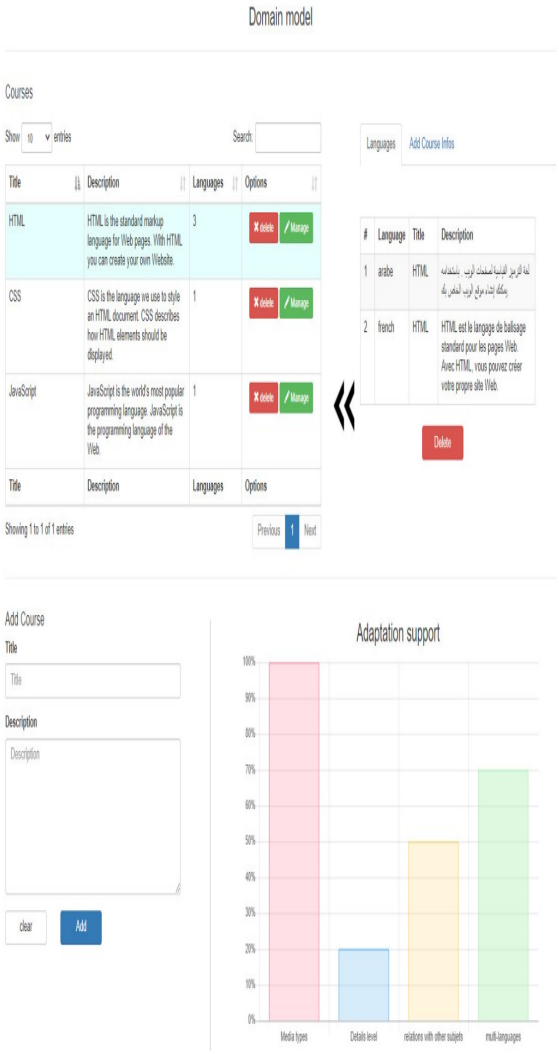

Figure 7. Screenshot of the course management Tool

When the user chooses to manage a course (the green button in Figure 7), he will be redirected to another web tool [Figure 8], where he can construct his own course tree. As shown in Figure 8, the User is constructing a course about CSS. Each node of this tree represents an objective and he is assigned to many resources (videos, figures, text).

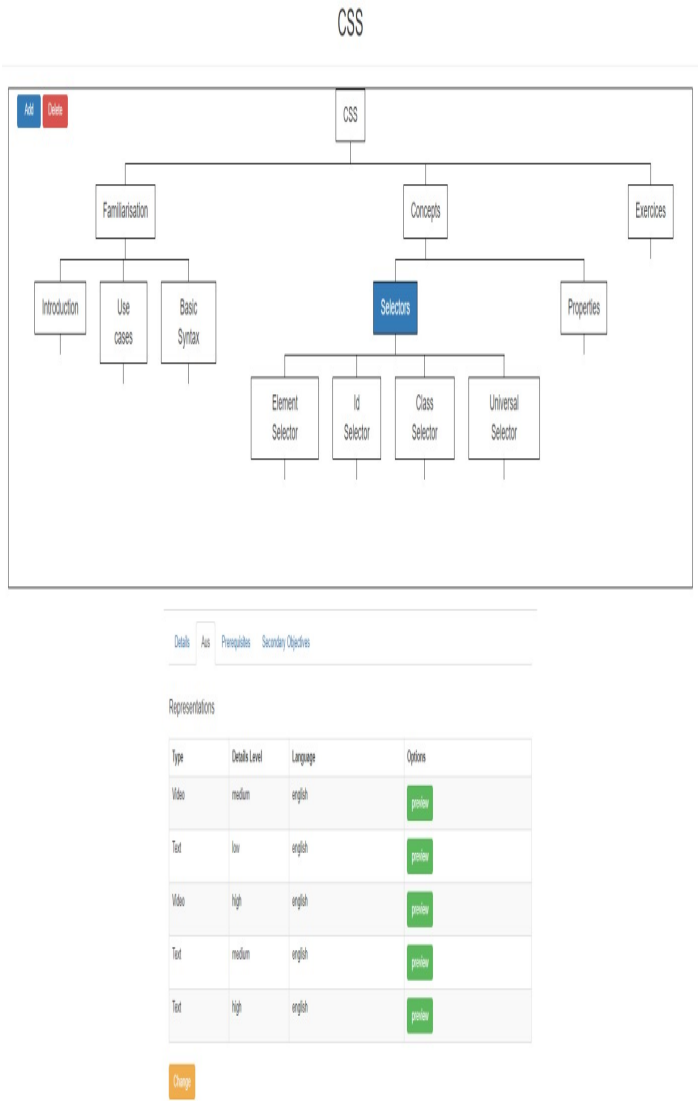

Figure 8. Screenshot of the course objective tree management

Finally, we developed a web tool [Figure 9] to manage the representation re-sources such as videos, simulations, texts etc. These representations are re-grouped on what we call an assignable unit. Each assignable unit can have an infinite number of representations, these representations are provided physically or remotely by a URL and they can be viewed by clicking on the button 'Preview'.

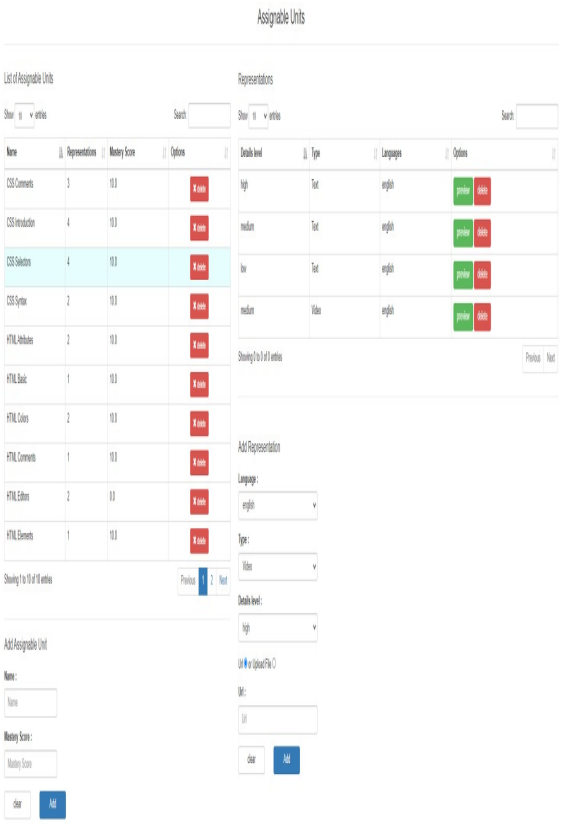

Figure 9. Screenshot of the assignable units management

These tools can be easily integrated into our adaptive hypermedia, to offer a learning style that meets the specific and variable needs of each learner. This domain model combined with the learner model and the adaptation model will provide a new and robust system that will be tested for students at Sidi Mohamed Ben Abdellah University in Morocco.

This implemented version will be a beta version which will subsequently be improved in order to create it in the form of a standard component that can be integrated into the various hypermedia.

6. CONCLUSION

The implementation phase was very important in our studies. In fact, all the major adjustments that we made regarding our previous proposal of the domain model were only discovered during this phase. In addition, the web tools that we developed still need visual and functional improvements that we will be working on soon.

Finally, we can really say that we now have an updated version of the domain model that is tested and that it will be added to our proven models. Moreover, as a continuation of our work, we will now move on to studies dedicated to the design and development of our adaptive hypermedia system.

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