Systematic Design Processes of Hypermedia Engineering: A Case Study of SpLEA-Web

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ABSTRACT

Hypermedia engineering is having a rapid growth in today's software engineering industry. Ongoing researches have proved that the efforts of designing and developing hypermedia applications is different compared to the conventional information system practices. It is not a trivial task and the development has generally been ad hoc. Hypermedia practitioners should clarify clearly the information contents structure, complex navigation links, functions and operations, and the presentation of user interface. The main objective of this paper is to present a clear structured view on the process of designing an educational web-based hypermedia application for a university's faculty, called SpLEA-Web (Self-paced Learning with Exercising Approach Website), starting from the early design stage. We used UML-based design method called UWE (UML-based Web Engineering) for this purpose. Conceptual and navigation designs will be elaborated and reviewed clearly. Finally, some arguments and future refinements for UWE will be discussed and summarized at the end of the paper.

Keywords

Web-based Hypermedia Application, Design Processes, Conceptual Design, Navigation Design, and UML Notations.

1. INTRODUCTION

Nowadays, web-based hypermedia application is one of the greatest approaches being used in most universities and schools for teaching and learning practices.

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Blended with various forms of multimedia elements such as graphics, audio, video, and animation, it gives a more natural way to express and convey ideas or information to the students. However, the efforts of design and development of hypermedia application are not relatively easy, but require deep focuses and extra efforts among the practitioners to support complex and more structured navigation linkages, a high quality of user interfaces, and more varied forms of information for the users [12]. Different hypermedia and web design methods have been proposed in the last few years, such as Relationship Management Methodology [9], Object-oriented Hypermedia Design Method [13], Website Design Method [5,6], UML-based Web Engineering [10,11], and Object-oriented Hypermedia [7]. Of the existing methods, we have chosen the UML-based Web Engineering (UWE) method as the basis for designing SpLEA-Web (Self-paced Learning with Exercising Approach Website). UWE has been selected because it is an object-oriented model driven approach that provides guidelines for the systematic design processes, and it is based on exclusively Unified Modeling Language (UML) [4] notation. The use of UML notation has the advantage of using a well known standard and most importantly it is compatible and supported by many case tools [8,11]. UWE consists of four main processes, called *requirement analysis*, *conceptual design*, *navigation design*, and *user interface design*. For each design stage, a model or diagram is constructed to present the design result.

In this paper we present the design processes involved in the development of SpLEA-Web, a website that is used mainly for teaching and learning purposes in a university's faculty environment. The main objective is to describe the application's conceptual and navigation designs that are based on UWE design method. SpLEA-Web reacts as a hypermedia application to offer learning facilities with great possibilities of multimedia features. Students can have their own self-paced study anywhere, anyhow, and anytime, without controls by lecturers, thus they become an active student. There are two main parts in this application. The first part is learning the course contents while the latter will focus on evaluating student in online quiz section. SpLEA-Web is not only a presentation system for teaching and learning, but it is also suitable for distance learning. In Section 2, we clarify functional requirements from users. Conceptual and navigation designs of SpLEA-Web will be presented and reviewed in Section 3 and 4, respectively. Finally, we conclude our works and overview some future developments in Section 5.

2. DEFINING USER REQUIREMENTS

User-centered approach has been used in [6] and [11] in order to define clearly the potential users of the hypermedia system and how they behave in the system. According to this approach, the functional requirements of the system will be easily captured according to the users' interests and navigation preferences [6]. UWE used UML-based use case models to present the functional requirements from these potential users. Defining use case model involves the following major steps:

- Define actors / potential users.
- Define the text for activities the actor will perform.
- Establish relationships between actors and use cases.

In order to get clearer view of web navigation preferences for each classified user, we implemented a *navigation-page* use case model, which mean every single webpage for the hypermedia system can be defined accordingly to each user. In the example of SpLEA-Web, the potential and most related users are mainly the registered students of the faculty, employees such as lecturer, tutor, and lab tutor, and general web users. The following figures show the details on how we capture those functional requirements.

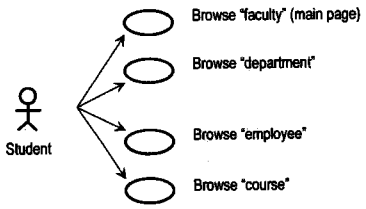

Figure 1. Defining the *navigation-page use case diagram.*

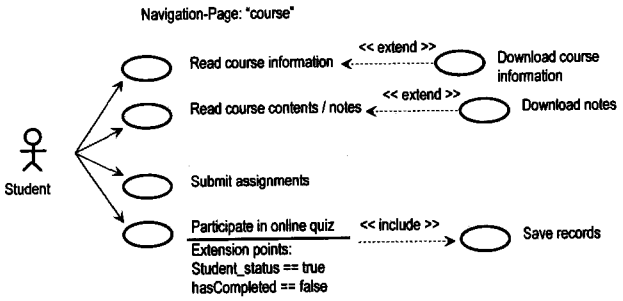

Figure 2. *Navigation-page "Course"* use case model.

Due to the limitation space in this paper, we restrict ourselves in the example to a number of use cases and a navigation page (course) only, although many other webpage examples and their related use cases should be included in the website. Some other results from different classified users can be modeled in a similar way according the given examples.

2.1 Reviews on Use Case Models

The use of UML-based use case models gives designer great facilities to present a clear and big picture of the hypermedia system requirements according to classified users. However, complex websites demand a more complicated task to identify the functional requirements. *Navigation-page* use case diagram has been implemented in our case study example to capture these requirements in a simpler view and give better way for defining what will be navigated by the users in the system. Then, for each *navigation-page,* designers have to define activities that will be performed by the specific users (to show how they behave in the real system).

3. CONCEPTUAL DESIGN MODEL

Conceptual design is the first design process included in UWE [10,11] design method, which involves identifying the classes and objects related in the website to present the application domain. According to [10], conceptual design is based on functional requirements defined in use cases models that include the objects involved and aims to build a domain model with no consideration of navigation links, user interface, and interactivity aspects. UML class diagrams are constructed to present the conceptual model. Besides, *Object Constraint Language (OCL)* is used as the restriction language of the application. Some major steps to build a conceptual model are as follows:

- Define classes including their attributes and operations.
- Determine links/associations and multiplicity between classes.
- Define relationships between classes such as inheritance, aggregation, and composition.
- Identify constraint through OCL (if required).

The conceptual model for the SpLEA-Web is shown in Figure 3. All together, nine classes have been defined namely *faculty, department, employee, non-academic, academic, course, chapter, assignment,* and *quiz.* Since SpLEA-Web is a public website and offers a general kind of information to students, no OCL restriction is defined in this example.

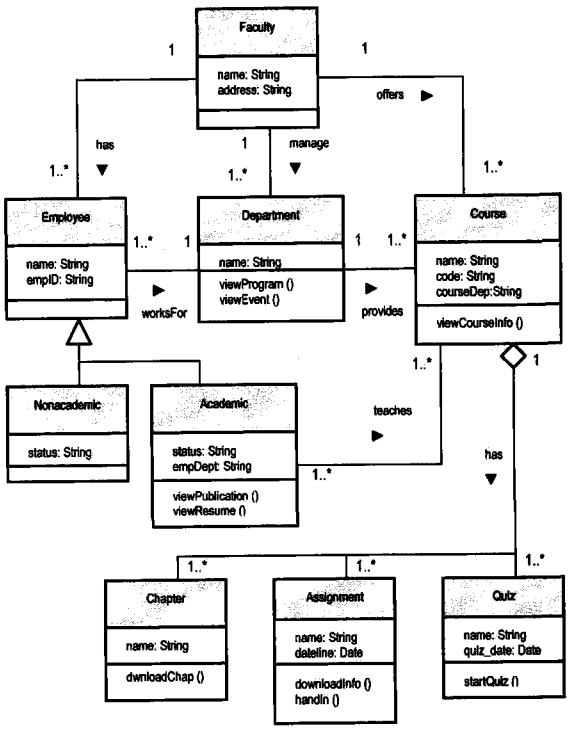

Figure 3. Conceptual Model of SpLEA-Web

3.1 Reviews on Conceptual Design

All classes defined in conceptual model are constructed according to the *navigation-page* use case models. These classes are gathered to present the application domain of the website using UML class diagram notations. However, designers are required to make crucial decision on how many classes should be provided in the model and their associations. These are important as the class number and their associations will be considered in the navigation design stage (next design step). Classes will be considered as navigation nodes while associations are the links between the navigation nodes.

4. NAVIGATION DESIGN

The main idea of navigation design is to establish the physical links of relationship between classes which have been defined in the conceptual model. UWE [10,11] proposed two types of navigation design process, called *navigation space design* and *navigation structure design*. The former will consider conceptual model as its input and present *which* objects or classes can be visited by users through the navigation links in the application. On the other hand, the latter will introduce some of navigation access elements and present *how* objects in the *navigation space model* are visited.

4.1 Navigation Space Design

The first objective of navigation design process is to construct a *navigation space model* from conceptual model as shown in Figure 4; with all classes that are closely related to the website application will be remained as navigation nodes while classes that are not related will be eliminated. However, the information of the class which eliminated still can be kept as a derive attribute for any other remaining class that require it.

In our case study example, class *chapter* has been eliminated and its attribute and operation have become a part of class *course*. Navigation paths must also be defined as it will offer web functionality and direct users from one navigation node to another. There are two modeling elements for constructing navigation space model, called *navigational class* and *direct navigability*. Navigational class is referring to navigational node that will be visited by users in the system and defined by UML stereotype «*navigational class*». Its name will be the same as the conceptual class. The second modeling element, direct navigability is related with associations and makes connection via an arrow between source navigational node and the target navigational node. At the end of each arrow, a role name is attached and equipped with an explicit multiplicity. Some of major steps dealing with navigation space design are:

- By referring to the conceptual model, identify classes which are not relevant to the website application. In the other word, omit classes which are not necessary and required to be one of the navigation nodes of the website. In SpLEA-Web example, we have decided to eliminate class *chapter*.
- The information of attributes and operations for the omitted classes still can be remained in the model as the attributes and operations for some other classes (see example in figure 4). Besides, attributes and operations that are irrelevant to the system (from any classes) also can be eliminated.
- Links are established between classes where additional navigation path might be added to the model for direct navigability. The purpose of direct navigability is to avoid navigation path of length greater than one.

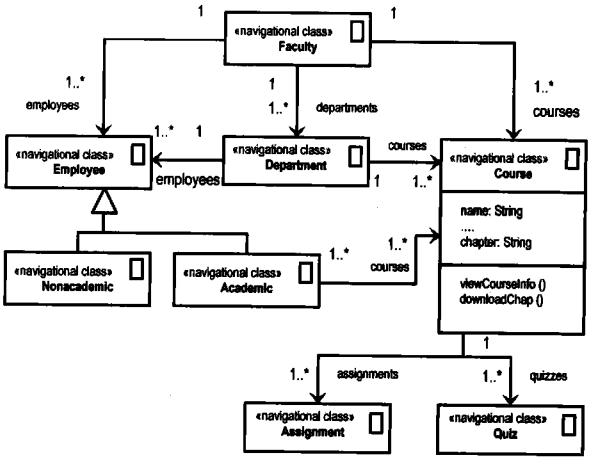

Figure 4. Navigation Space Model of SpLEA-Web

4.2 Navigation Structure Design

The next step of navigation design is to construct a *navigational structure model* from constructed navigation space model, which will describe how the nodes in the model are visited. This will involve enhancement of navigational space model by offering a number of navigation access elements such as *index*, *guided tours*, *query*, and *menu*. All these modeling elements have been defined according to their stereotypes and presented by unique icon as described by [8]. At the beginning, *index*, *guided tours*, and *query* are inserted to the appropriate links in navigational space model to present its access mechanisms. An *index* contains a number of listed name items with a link to a target navigation class. A *guided tour* will provide users with an ordered sequential access to a number of given navigation classes. While *query* is an interactive access element that provide input field for user to search item by providing input string as an input to the system. Then *menu* are provided to present links to a number of target nodes. Each item in a *menu* has its own link to a target location (e.g. navigation class or an access element). The navigation pattern described in UWE method is shown Figure 5.

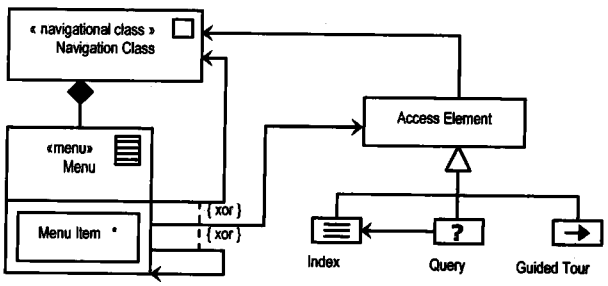

Figure 5. Navigation Pattern for Access Structures [9].

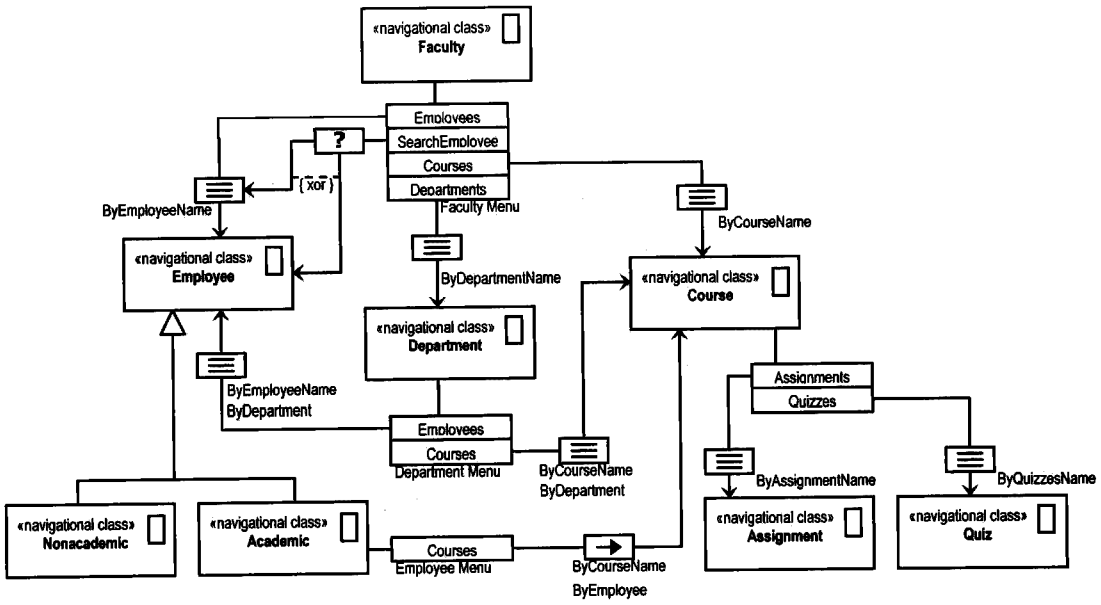

Figure 6. Navigational Structure Model of SpLEA-Web

Using those access structures provided by UWE, we have enhanced our navigational space model so that it can include access elements in the final navigation design presentation. The result, *navigational structure model* is shown in Figure 6.

4.3 Reviews on Navigation Design

To conclude, both models constructed in navigation design stage are important in order to present the navigation links that are available and types of access elements on the whole system. The employment of UML stereotypes from conceptual model makes the design process of navigation become more systematic and models constructed in a structured way. However, hypermedia designer have to select appropriate links and access elements to make sure that the website users who navigate the system are not lost in the navigation space and confuse with the system functionality.

Somehow, we argue that UWE is lack of its access elements. Thus, current access elements (*index, guided tours, query,* and *menu*) are not sufficient to support a huge and complex website, especially those involve with complex business process (operations) and complicated navigation structure such as a multimedia-based website.

5. CONCLUSIONS AND FUTURE DEVELOPMENT

Currently, our project on SpLEA-Web is still at the earlier stage of designing process. In this paper, we have demonstrated a clear structured view of the design processes involved in this website application using a systematic hypermedia design method called UWE. UWE has been chosen for its clarities and simplicity on presenting the design results based on UML graphical notations. Our works start with defining functional requirements from the potential users of the website and we have implemented the use of *navigation-page use case diagrams* (base on UML use case model) that directly define web navigation pages that will be navigated by the users and activities performed on each webpage. We have also described UWE's core modeling design processes namely *conceptual design* and *navigation design*. Both designs are strongly related each other to clearly present how classes in class diagrams or conceptual model being considered as navigation nodes that should available in the website and how they are reached by access elements.

However, we argue that in navigation structure design process, there is lack of access elements notations provided by UWE and they are not totally emphasizing a complex operation and navigation structure. UWE only promotes four types of access elements which practically are not sufficient to accomplish the needs of complex navigation structure for huge multimedia-based website, for example. Some limitations of the current existing access elements have been defined and discussed in [2]. Therefore, enhancement works on these modeling elements should be necessarily conducted in order to get a deeper and detail view to support those complex navigation links. A new navigation pattern for navigation access structures comprises of all access elements should be enhanced and proposed.

The existence of database in the hypermedia system also needs to be considered in future refinement works. UWE has no graphical notation support on how to present a database table and field in the system design, neither in conceptual design nor navigation design. Thus, the design result seems to be static and no dynamic operation can took place in the system, even though they are implemented in the real system environment.

Our future works will focuses on constructing the final design model called presentational model that deals with as much as user interface modeling elements which have been defined and described by UWE. By referring the navigational structure model presented in Figure 6, each navigation node will becomes a presentation node and enhancement is done to clearly view the presentation of user interface for each node.

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