UML-based Conceptual Design Approach for Modeling Complex Processes in Web Application

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Abstract-
Different complex features in web applications have raised new issues on the modeling approach. Web designers should define complex processes in web applications and provide a clear view of the application domain. In this paper, we propose a design model called UEWDM, which applies UML Profiles as the graphical notation in the modeling stage. UEWDM cope with conceptual design by divided it into two-sub design called informational class and dynamic process design. Our contributions rely on new UML specific modeling elements to support those complex process modeling. To validate our design modeling, a case study of Academic Management System is provided.

Keywords: Complex process, Conceptual design model, Web applications, Model-driven, UML Profiles.

INTRODUCTION
Designing web applications getting challenging and raise many issues especially on modeling approaches [1]. From designing static web applications to dynamic web applications, it requires a proper and systematic design modeling. Dynamic web applications consists of many user interactions and hence, the processes getting complex and interactive [2][3]. According to [4], complex web applications involve database, user interactions, non-linear navigations and friendly user interface. Thus, a number of design models of web applications have been extended for the past few years such as OOHDM [5], UWE [6], W2000 [7], WSDM [8], COM+HDM [9] and many more. However, some design models not sufficient enough to cope with current issues and challenges in designing and developing web applications [4]. There are content and process complexity, continuous evolution, variety group of users, developed in shorter time of period and with smaller budgets.

Reviews have been done on existing design models of web applications [3][10] and the authors claimed that more design efforts are required to support more complex processes compare to normal processes in web applications. Normal process can be defined as a simple process with simple navigation, require less behavior modeling and consist of static information. Hence, in our work, we focus on design effort on complex process where we define complex process in web applications in three terms. Firstly, processes that consist of time frame process which need to be executed at one time through. In example, an online discount voucher that only valid for certain period of time. Secondly, processes that dependent and interrelated with other processes as occurred in flight and hotel booking process. The flight booking process is interrelated with online bank transaction and hotel booking process. Finally, processes that user dependent or involve more user interactions in the particular web applications. In example graduation clearance process in universities, which require a process to check student library clearance and financial clearance status before it can proceed to payment of graduation.

Conceptual design framework offers an overall view of the applications from the viewpoint of the designers and it is the right starting point to implement complex process structures. However, lack of existing web design models emphasize on complex processes design framework in the conceptual design stage. If complex process design specifications are not provided, then it makes the use conceptual design methodologies insufficient for the development of web applications.

One of our main objectives is to present UEWDM-UML Extension Web Design Model. The proposed design model is based on Unified Modeling Language (UML). UEWDM uses UML 2.0 Profiles for modeling conceptual design model, navigational design model and user interface design model. In this paper, we only highlight our discussion on the conceptual design model. Our main concerns are:

(a) to designate application domain through class diagram in Informational Model (IM),
(b) to model flow of complex processes through dynamic conceptual model, and
(c) to solve complex processes issues through extended UML Profiles (stereotypes).

We deliver a case study of Academic Management System (AMS) as a prototype to validate our design model and to indicate how the complex process suits into the modeling paradigm.

This paper is structured as follows. In next section, a brief description of general web design modeling in web applications will be presented. Followed by explanations on UWE design methodology as our research motivations. Then, UEWDM and its modeling approach will be presented. Followed by two designs modeling in conceptual modeling stage called Informational Model (IM) and Dynamic Model (DM). Our main contributions and benefits of the approach
are defined in the following section. Related works will be explained after the benefits section. Finally, we conclude and summarize our work in the last section of this paper.

BACKGROUND AND MOTIVATIONS

A General Framework for the Development of Web Applications

According to the literature review, there exists several design stages in web application design modeling [3]. In general, web design modeling comprises of three design stages, which called conceptual design, navigational design and presentation design. The web application design process begins with use case modeling which signify the requirements specification design modeling and followed by the design stages. Each design stage has its own functions and objectives. Specifically, it will provide design models as the result of the design process. Conceptual design emphasizes on the content and domain structure of the web applications. Moreover, classes, attributes, objects and associations for the interactions between the users and the web applications also provided in conceptual design stage.

Navigational design stage is executed once conceptual model has been constructed from the previous design stage. Basically, this particular design stage focus on the hypertext structure and defines how nodes and objects are reached in the web application. Specifically, navigational design stage can be presented in two sub design schemes, which called navigation class scheme and navigation context scheme [11]. In navigation class scheme, navigation nodes are presented and it is defined according to conceptual model. Meanwhile for navigation context scheme, it provides those navigation nodes with access elements.

Upon the completion of navigation models, the final design stage is called presentation design, which produce presentation model at the end of the design process. This design stage supports content and structure of those navigation nodes in the presentation layout. In the other words, it provides visual design and represents the look of the particular web page to the users. Figure 1 illustrates general design modeling stages consist in web application design process [3].

However, web applications nowadays are getting challenging with many issues on design modeling aspects [10]. Many practitioners believe that more design efforts are needed in order to produce promising web applications [14]. One of the issues is on the navigational design where UWE still could not capture certain navigation elements that involve in current web applications navigation paths [15]. In conceptual design aspect, former design models not emphasize on complex processes, exclusively. The definition of complex process can be found in [1][3]. There is a need on complex processes refinement design in the conceptual design stage. Additionally, most of the existing web design models focus on the logical design instead of the physical layout of the web page, including UWE designs methodology [1].

UEWDM APPROACH

Design Overview

This paper emphasize on web application design model called UEWDM-UML Extension Web Design Model to support complex web application design and modeling, which consist of complex processes. Our proposed design model is not develop from scratch, but we extend the existing web design model with new ideas to improve the final results. UEWDM is based on Unified Modeling Language (UML) Profiles and the design model is similar to UML-based Web Engineering (UWE) [6], which briefly explained in the previous section. UEWDM is an object-oriented approach and exclusively on UML notation and UML extension mechanisms. The design model concentrate on the structured conceptual design, navigation modeling and user interface interaction. To give a clear view on the approach, Figure 3 illustrates the methodological approach of UEWDM.
Our model can be separated into use case model and three main design stages namely conceptual design, navigational design and user interface design. All design stages are executed in incremental and iterative manner. Overall, we practice UML stereotypes and UML modeling elements in our UEWDM design modeling. The stereotypes needed to specify the descriptive and restrictive properties that the modeling elements have in comparison to standard UML modeling elements. We describe and defined the uses of UML standard modeling elements and UML stereotypes in the following sections.

The Conceptual Design

Use Case Design Model

Most of web application design models such as UWE [6], WebML [16] and W2000 [7] practice use case diagram in a requirement analysis stage. Use case diagram technique able to define potential users and how they react towards the activity and flow of processes in the web application. Use case diagram results are normally presented in Use Case Models [17]. In this section, we present a number of functional requirements only, although in our case study there are many other components included in the web application. Figure 4 shows some of processes performed by a student while navigating online assignment submission webpage.

In the online assignment submission webpage (which we defined as one of the complex process in our case study), a student can login, fill in few details about the assignments, upload the assignments and submit. Other use cases can be demonstrated in a similar approach according to the given examples.

Informational Model Design

In Informational Model (IM), a normal class diagram will be designed based on the use case model. The main purpose of this design is to construct a conceptual domain model of an application without considering navigation and user interface characteristics. The aims of IM are: (1) to determine all classes and objects that are interrelated in application domain, and (2) to show a clear view on the classes’ relations in the application domain. Nevertheless, this design process is not much concerning on identifying complex processes. The outcome of the design process of our case study is presented in IM as illustrated in Figure 5.

Figure 5: Informational Model of AMS

We construct IM using standard modeling elements in UML such as class name, multiplicity, relationships, attributes, etc. In our case study, we use University class as the homepage. Main classes that associate with it are classes named Graduation, Library, Finance and Faculty. We design those major modules at the first place because these modules are
interrelated each other and certain processes required extension in the design flow. Due to the limited space in this paper, we hide the class’s attributes and operations.

**Dynamic Model Design: Our Approach**

For modeling complex processes, we proposed Dynamic Model (DM), which is based on the previous Informational Model (IM). In IM, we had identified classes, interrelated objects, attributes, multiplicity, etc. that involved in this particular case study. Hence, in DM stage, we present and propose several numbers of stereotypes. In the next section, we will explain on how those DM and proposed stereotypes are able to support complex processes modeling.

Web applications are getting complex in terms of its content, process flow, navigation and user interface [4]. In our work, complex processes are processes that involve interactions between user and web. It is defined as; (1) processes that depend on user’s input (user dependent processes) such as graduation clearance process where the flow of activity depends on user’s input (2) processes that relied on defined time frame, such as real-time online quiz where the students having quiz online with start and end time defined by the lecturers and (3) processes that interrelated with other external processes such as online assignment submission where the assignment submitted will be automatically cross check with plagiarism software.

Thus, complex processes need to be considered and taken care in each design stage in order to ensure the final product of the web applications are full of content, smooth navigation and user friendly interface. According to [3], complex web applications additionally require the modeling of behavioral aspects and most of the existing web application design models still focused on the hypertext structure of web sites compare to user interaction web concepts. The navigation structure built so far is not sufficient enough to define how nodes can be reached by navigation. Thus, all those issues require web designers to take care of the design modeling from the earlier stage.

A comparative study has been made by [3] and most of the web applications design modeling gives less concern on modeling functionality of complex process and user interaction modeling. Additionally, current design model does not have enough elements to represent the complexity of the web itself [15]. Hence, we will present and define our propose UML stereotypes for designing complex process in complex web applications in the next section.

**The Dynamic Model Stereotypes**

Complex web application modeling has been discussed in [18]. To deal with complex web application modeling, we introduce and propose UML stereotypes to cope with complex processes modeling in conceptual design stage. The stereotypes are shown in Table 1. Table 1 shows the list of UML stereotypes in Dynamic Model (DM). These stereotypes are implemented to cooperate with each other as to build the DM. This approach differs from other current web applications design modeling in a way the complex processes detail is integrated and independently designed in the conceptual application domain. The UML stereotypes are implemented according to the usability and necessity of the complex processes in the design modeling stage. In example of our case study, time frame stereotypes are applicable only to time frame complex processes flow, not to interrelate external processes flow in the web applications. Hence, the defined UML stereotypes able to assist web designer in designing complex processes from the earlier design stage. In our case study, we have considered IM to design the DM. In DM, we include conceptual classes from IM to implement our new proposed UML stereotypes (refer Table 1). The DM of our AMS case study is shown in Figure 6.

<table>
<thead>
<tr>
<th>Stereotype / Graphical Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;&lt;Timeframe process class&gt;&gt;</td>
<td>Model the time frame activities that need to be executed time (process need to be done end time throughout).</td>
</tr>
<tr>
<td>&lt;&lt;Timeframe class&gt;&gt;</td>
<td>Group time frame process class and all of its objects in order to indicate their relationships and processes.</td>
</tr>
<tr>
<td>&lt;ontime class&gt;&gt;</td>
<td>Inhibit the definition of time frame process class.</td>
</tr>
<tr>
<td>&lt;ontime class&gt;&gt;</td>
<td>Models the acceptable process class activity defined by time frame.</td>
</tr>
<tr>
<td>&lt;&lt;Database class&gt;&gt;</td>
<td>Models the database operations that occurred between process class and database class.</td>
</tr>
<tr>
<td>&lt;&lt;External class&gt;&gt;</td>
<td>Class that associate with different modules and external class of web applications.</td>
</tr>
<tr>
<td>&lt;&lt;External container&gt;&gt;</td>
<td>Group external class and all of its objects in order to indicate their relationships and processes.</td>
</tr>
<tr>
<td>&lt;&lt;Database link&gt;&gt;</td>
<td>Association between classes to database classes.</td>
</tr>
<tr>
<td>&lt;&lt;External link&gt;&gt;</td>
<td>Association between operations taken by users in different module external class of web applications.</td>
</tr>
<tr>
<td>&lt;&lt;process link&gt;&gt;</td>
<td>Association between two separated classes.</td>
</tr>
<tr>
<td>&lt;&lt;External_entity&gt;&gt;</td>
<td>External classes and processes that associate with current operations and database.</td>
</tr>
<tr>
<td>&lt;&lt;internal_entity&gt;&gt;</td>
<td>Model the internal classes and processes in the web application.</td>
</tr>
</tbody>
</table>
Figure 6: Dynamic Model (DM) of AMS

Figure 6 shows a DM of assignment submission process. This is a time frame process and hence, we used time frame container to indicate the complex process. According to Figure 6, the process is divided into two entities which known as internal entity and external entity. Internal entity is referring to internal process or class that occurred in the application. In the other hand, external entity present external process or classes that happened towards and interrelated with applications. Each student must have a valid login ID and password to submit assignments to the application. Once validated, the process will check the defined time frame of the assignment submission. If the activity time is not within defined time frame, the upload and submission button will be disabled and students need to end the process by signing out the activity. However, if within timeframe defined, the respective student is allowed to fill in particular details, upload and submit the assignment to the application. These also required time frame process where the submitted assignments will be validated for the submission time. For example, the student is login the application at 11:57pm but he or she click the submission button at 12:01am (defined assignment time frame is at 12:00am). In this case, the process will be examined for acceptation or rejection. Nevertheless, all assignments submitted (accepted or rejected) are still saved in lecturer’s database for reference purpose. Success submission of assignments will be sent to plagiarism checker called Turnitin for marking automation. Finally assignments’ marks will be recorded in student’s mark class and database.

Figure 7: Complex Process Conceptual Design Pattern of UEWDM

BENEFITS OF THE APPROACH

Currently, many web design models have been introduced to cope with web design issues as explained in the previous section. The addition of design model in web application development design phases causes the design process to extend and complicate, hence more effort is needed if supporting elements towards complex processes are not provided. The supporting elements can be provided in terms of systematic design structure and well-defined design patterns.

On the other hand, those elements provide web designers with clear visualization of complex processes design occurred in real applications. In fact, UEWDM conceptual design approach assist web designers in development of web applications via:

- Refine details of complex processes design, as it able to provide web designers with expressive design of web applications conceptual domain.
- Design process classification, as it identifies internal and external container design of a conceptual domain in early design stage.
- Expressive UML stereotypes, as it offers graphical notation for specific elements in the conceptual domain to design the complex processes flow occurred in the design process.

The proposed approach, by expressing the Informational Model (IM) and Dynamic Model (DM), makes it possible to establish relationships between the conceptual domain and real web applications. The case study of AMS has validated the proposed design approach in terms of the suitability of the design framework.

RELATED WORK

According to [1], complex web applications involve dynamic information, complex navigational paths and rich interfaces. Thus, several design models of web applications has been extended for the past few years such as OOHDM [19], W2000 [14], WSDMDA [20] and UWE [15]. However, some design models are not sufficient enough to cope with current issues and challenges in designing and developing web applications [3]. Moreover, to support the claim, a review has been done
on existing design model of web applications [14] and the authors argued that more design efforts are required to support more complex processes compare to normal processes in web applications.

A model-driven approach to develop high performance web applications has been proposed in order to reduce cost and complexity of web applications development due to the incorporation of a model-driven architecture [21]. This particular design framework extends the UML profile with new concepts extracted from web domain and the new framework supports the web application development by composing heterogeneous web elements. Then, a transformation models generates web application from the UML extensions.

Alternatively, Com+HDM [9] extends UWE design methodologies by utilizing the UML stereotypes to cope with the complex processes issues occurred in web design process. The design approach provides an expressive modeling element to support the design of higher-level views of domain structures. However, in conceptual design view, the design framework not emphasizes on external processes and the scopes of complex processes are not within our complex processes definition.

Another work in UML stereotypes extension is proposed by [22] in a way that used to generate corresponding audit rules via model transformations. The design models utilize UML extensions for the audit properties specification due to the importance pre-requisite of definition of audit requirement at modeling level in the software system policies. Yet, the proposed UML stereotypes is not fully utilized for complex processes design.

Mentioned related works are based on UML stereotypes extensions and describes how they utilize those extensions in the design process. Similar with our proposed approach, the UML stereotypes are extends according to the needs of the complex processes design structure and integrate with the suitable graphical notations as to represents the appropriate processes in the design framework.

CONCLUSION
We have introduced and proposed a UML-based approach of complex web application called UEWDM. Our aim is to present a systematic and to gain a clear view of conceptual design modeling in complex web applications. We choose UML notation as our modeling language because the advantage of modeling language standardization. Additionally, UML also offers its own systematic model-driven approach in design modeling. Our approach utilizes UML stereotypes as the modeling elements in the conceptual design stage. UEWDM major conceptual design stage is divided into two major steps called informational class design and dynamic process design which each steps will produce a model namely Informational Model (IM) and Dynamic Model (DM), respectively. As part of our work, we proposed a several number of new UML stereotypes to model a complex web applications. Each UML stereotype has its own purposes and responds to separate complex process classification.

To ensure our work is not restricted to one type of web application, we are currently working on case study of Flight and Hotel Booking System to illustrate the effectiveness of the proposed design model. To conclude our work in this paper, we summarize that the resulting approach able to provide a set of design structure for designing a conceptual domain of a web applications which focusing on complex processes issues.

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