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A Modeling Approach for the Development of Process Driven Web Applications

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***Abstract*—Complex web applications have been developed rapidly as to support complex process and transactional workflows involved in the web domain. Although there are numerous modeling concepts exist in web applications nowadays, new issues raises in modeling approach such as user interactions, interrelated process flow, navigational issues and graphical user interface concerns. In this paper, we present and discuss user interaction diagram, Unified Modeling Language (UML) notation and object-oriented approach for necessity in complex web applications. A proposed model called UEWDM (UML-Extensions Web Design Model) emphasize on the user interaction issues as well as the interrelated process, navigation and graphical user interface. The uniqueness of UEWDM is in the design pattern modeling approaches. At the end of the paper, future works of the design model will be explained and briefly summarized.**

Keywords—web applications; web design model; design process; complex process; UML

I. INTRODUCTION

Web applications are getting important in the computing environment nowadays. It provides a natural platform for users to convey ideas and to access related information. Web application has been one of the greatest presentations of information in terms of conveying ideas that incorporates multimedia elements such as text, audio, video, graphics and animation. Furthermore, these multimedia elements are being presented interactively in web applications, non-sequential navigation and with user friendly interfaces.

A promising web application should consist more diverse forms of information, complex navigation structure and able to support high quality user interfaces for various web users [1][2]. Nevertheless, several web applications unsuccessfully to deliver accurate information, lack of qualities and fail to meet user requirements [3]. One of the reasons is existing design models are not specific and have been developed in general ways. As a result, web application has led to several complex process issues such as user requirement concerns [4], lack of functional requirements [5], complex navigational process [6] and lack of user interface features [7]. Hence, many practitioners believed that more design efforts are required to take place for supporting different way of dealing with complex web application [8] as to provide systematic and specific design process of web applications.

The main objective of this paper is to provide an overview of the web design model and processes consist in the design phase of a web application and to propose a web design model that able to cope with complex process issues in the web application design process. Section II will briefly describe the literature review of main web design models. Four existing design models in web applications development practices are presented. A design model for complex processes called UEWDM will be proposed in Section III. Section IV will discuss the compatibility of the proposed model to be implemented in the case study called Academic Management System (AMS) and finally, conclusion and future works will be provided at the end of the paper.

II. LITERATURE SURVEY OF WEB DESIGN MODELS

In the past few years, several web design models have been proposed by former researchers such as OOHDM [9], WebML [10], UWE [11], W2000 [12] and WSDM [13]. These web design models have been proven being used for web application development and found to be model driven with a number of design stages. The efforts of these design processes are normally done in incremental approach and a model is developed to present the result of the design effort for each design stages.

In the next section, four design models will be described in more details. The chosen web design models are based on their model driven architecture and similarity of web development issues in our research work.

A. UML-based Web Engineering Framework

UML-based Web Engineering Framework [14] is based on UWE [11] supports for web application development. Fundamentally, the design model of the framework presents similar design model to UWE which begin with requirements model and followed with three design stages namely conceptual, navigation and presentation modeling. The only features that differentiate the framework from UWE design model is the transformation rules element which use for mapping between different models and modeling in the framework.

Use case diagram and activity diagram are modeled to provide rough description of system functionality and details responsibilities of the users respectively. The use case framework in requirements modeling offers three types of use cases which known as user process, server process and browse while in activity diagram it includes four types of activities known as browse, client side, server side and outer side activity.

In the conceptual model, content model represents an actual content of the web applications while rendering model give a user view or content presentation. The transformation rules are applied in between content model, rendering model and navigation model.

Navigation space in navigation model determines which object can be visited by corresponding actors and in navigation structure provides how the objects reached in the web applications domain. The transformation rules are implemented in between navigation space, navigation structure and presentation modeling.

Static and dynamic presentations are represented in presentation model. The main purpose of presentation model is to give visual look on the web user interface layout at the early phase. Static presentation act as an abstract interface design model and provide structured organization of presentation given by interface objects such as text, images and menus. Dynamic presentation represents available choices for navigation from one page to another in the web application domain. The transformation rules is implemented in between static and dynamic presentations. Fig. 1 illustrates the UML-based Web Engineering Framework design modeling.

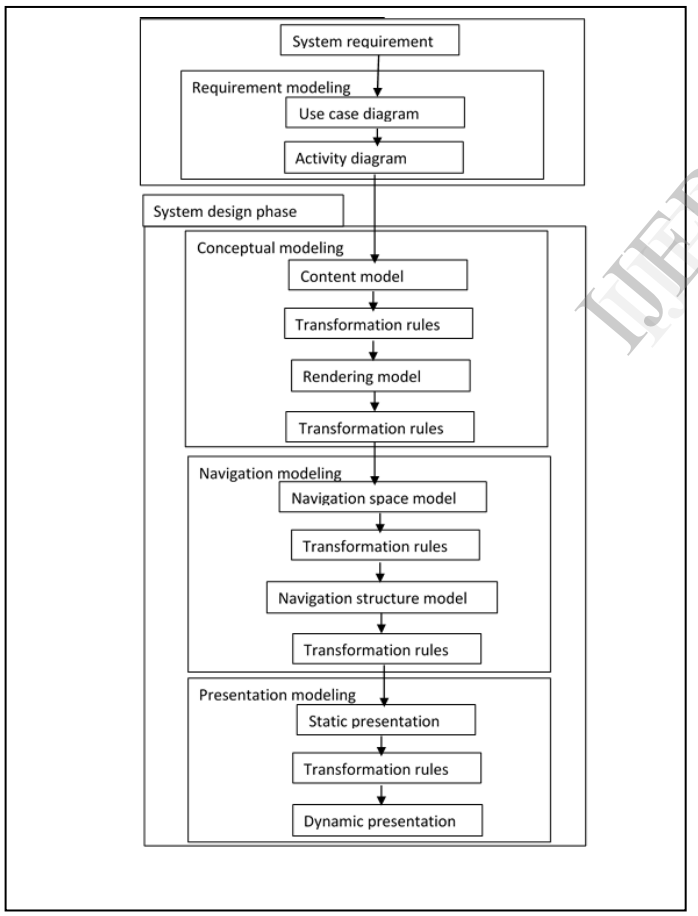

Fig. 1. Overview of the UML-based Web Engineering Framework [14].

B. *Comprehensive Hypermedia Design Method for Complex Process Modeling (Com$^+$ HDM)*

Comprehensive Hypermedia Design Method for Complex Process Modeling (Com$^+$ HDM) [15] is one of the design models in web applications which emphasize on complex process modeling issues and it is extended design model from UWE [11]. It consists of three design phases namely conceptual design, navigational design and user interface design. The design modeling is executed in increment and iterative design. Com$^+$ HDM also based on object-oriented modeling called UML modeling paradigm.

To present the application domain structures, conceptual design in Com$^+$ HDM comprises of three domains called Conceptual Class Model (CCM), Complex Process Flow Model (CFM) and Conceptual Process Model (CPM). CCM is built according to UML Class Diagram standard while CFM is created as to design the flow of the complex process. In CPM, designers can view the details of classes in the complex process and view on how conceptual classes and the complex processes can be improved in order to construct navigation models.

Navigation design is created in a manner to show how the navigation flow is conducted. It offers the navigation design with four UML-based stereotypes which known as navigation class, interaction class, hyperlinks and access structures. Hence, the implementation in navigation design phase is basically to present the details in navigation node including the interaction class, hyperlinks and access structures. In navigation design stage, Navigation Class model and Navigation Access and Interaction Model are developed.

User Interface design emphasize on page layout presentations. In Com$^+$ HDM, graphical notation is used to represent the user interface elements and the aim is to provide layout on how the navigational model designed from the previous stage able to be structured in web applications. In this design stage, user interface layout is designed by web developer according to his creativity and skills. Fig. 2 illustrates Com$^+$ HDM design modeling.

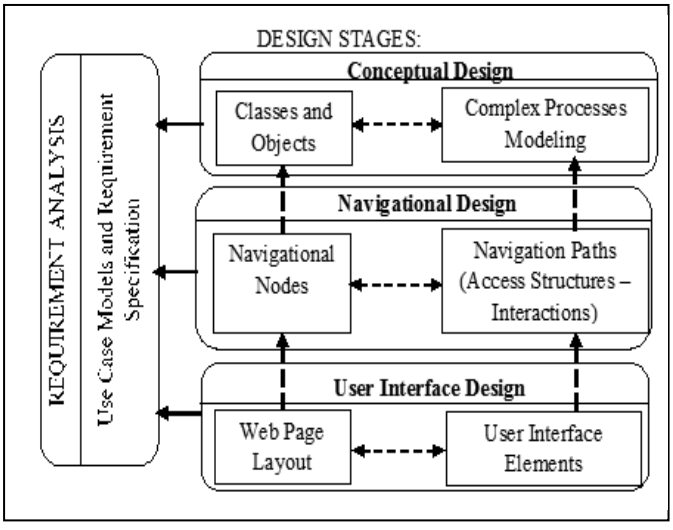

Fig. 2. Overview of the Com$^+$HDM design process [15].

C. *Web Site Design Method Using MDA (WSDMDA)*

De Troyer and Leune [13] introduced a design model called Web Site Design Method (WSDM) which later evolved to semantic web concept [16]. WSDM able to provide a complete methodology in constructing the web applications and it follows the audience driven design philosophy.

In the proposed mechanisms of WSDMDA [17], a new User-Interest Aware profile is added in conceptual model to extend activity diagram of UML and to consider it as Platform Independent Model (PIM). A Generic Web Application Programming Language Model is added to the WSDM implementation model and consider it as Platform Specific Model (PSM).

Finally, the proposed mechanism will be integrated with the existing WSDM. The important part of WSDMDA is redesigning conceptual design and implementation design. PIM and PSM are to be considered respectively to fulfill the main objective of Model Driven Architecture (MDA) which is the execution of model transformation from PIM to PSM.

The idea behind the proposed mechanism is to enhance the existing method which known as WSDM by applying the MDA approach in delivering the complex code of web applications faster than the conventional methods. Furthermore, the enhanced model allows the web application systems to partially deal with dynamic web instead of dealing totally with static ones. In the implementation design part, the proposed model able to be run on different platform and making it more flexible. Fig. 3 illustrates the WSDMDA design modeling.

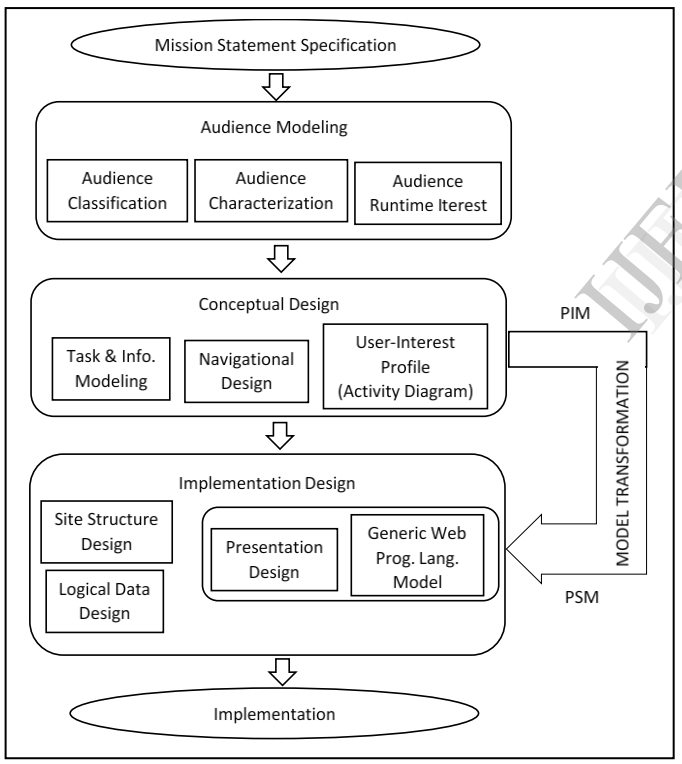

Fig. 3. Overview of the WSDMDA design modeling [17].

D. *Requirements Models as First Class Entities in Model-Driven Web Engineering*

This design model presents a model-driven engineering (MDE) approach which emphasize on requirements on early phase of software development life cycle (SDLC) [18]. The approach is based on requirement models specifications using the UWE [11] domain specific modeling language (DSML) and transform these models to the target models. A DSML able to provide the annotations needed as to enrich the standard requirement models with web features and reduce the model complexity.

The modeling approach concerns on separate models viewing of content, navigation, presentation and processes. It works similar to the other web development methods such as OOHDM [9], OOWS [19] and WebML [10]. The set of model types present the basis for the model-driven engineering (MDE) development process which is flexible and consist of modular modeling framework.

The design model comprise of content, navigation, presentation and process stages. Basically, the design stages functions and responsibilities similar to UWE design models as follows.

- Content model: Represents the domain concepts and the relationships between them.
- Navigation model: Used to provide navigable nodes and the links between the nodes.
- Presentation: Provides a visual user interface layout of a web application. It is platform-independent specification which is not consider concrete aspect of graphical user interface layout such as like colors, fonts and position of UI elements.
- Process: Present the workflows of the processes which are raised from navigation nodes.

The benefits of the design model approach lies in the requirement modeling which to provide better tools for discussions with the users of the web applications. Additionally, the basic design models generation gives an effort reduction of the time consuming task of building these design models. Fig. 4 illustrates the respective design modeling.

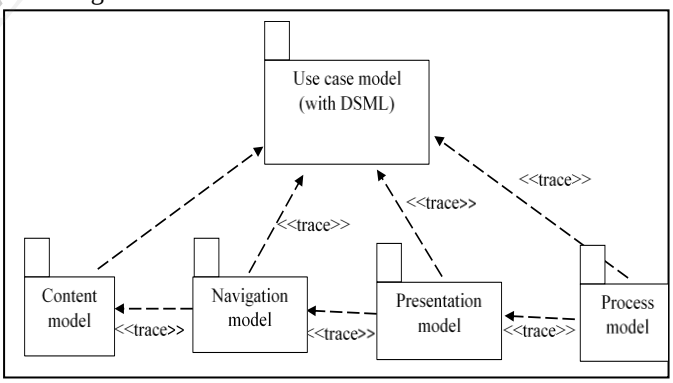

Fig. 4. Overview of the Requirements Models as First Class Entities in MDE design modeling [18].

III. UEWDM: OUR APPROACH

The central purpose of this section is to describe our proposed design model, called UEWDM (UML-Extensions Web Design Model) which based on Unified Modeling Language (UML) notations. The objectives are concern on; (a) to model user interaction in complex web applications through its systematic modeling, (b) to construct conceptual design model in extended domain (c) to present structured hyperlink mechanism with suitable UML stereotypes and (d) to provide user interface features and standard Graphical User Interface (GUI) environment between web users and web applications.

The methodological approach of UEWDM is shown as in Fig. 5 below:

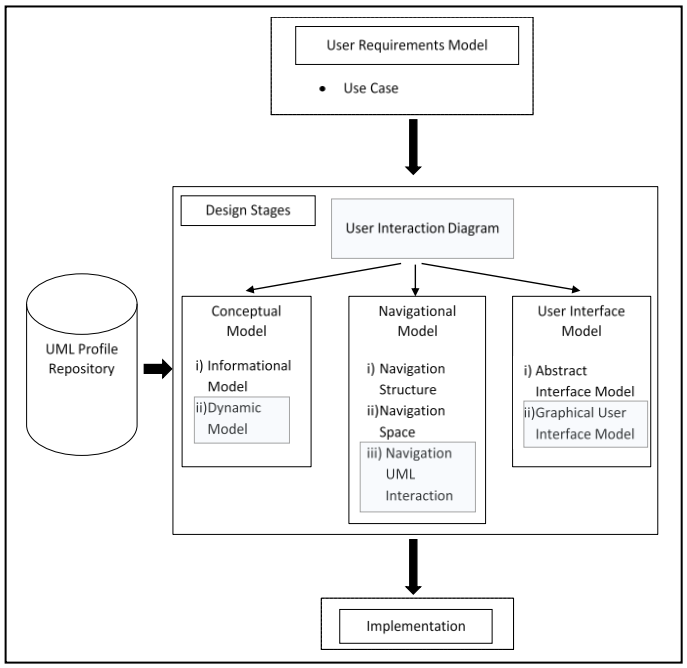

Fig. 5. Methodological approach of UEWDM.

In general, UEWDM is based on UML modeling paradigm [20] and it is an object-oriented modeling method. The design model has similarity to UML-based Web Engineering (UWE) [11] and Comprehensive Hypermedia Design Method (Com^{+} HDM) [15]. Our main idea is to enhance the existing web design model with new elements instead to build a new design model from scratch. The originality of UEWDM would base on its design pattern modeling approaches. The fundamentals of UEWDM are:

- Each of the design stages called conceptual, navigational and user interface designs are handled separately as to allow designer to focus entirely on each design stage one at a time.
- A combination of User Interaction Diagram (UID) and Use Case Diagram in UEWDM able to provide a powerful combination of user interaction features as to capture user interaction information between web applications and variety of web users.
- The uses of Dynamic Model to capture and model the application domain of the web and complex process flow in conceptual modeling stage.
- Navigational objects stereotypes are applied in navigational design to present the navigation classes in a well-organized method which are accessible by web users.
- A standard Graphical User Interface (GUI) model to present the visual interface layout and specifics graphical views between the users and web applications in user interface design stage.

The three main stages namely conceptual, navigational and user interface in UEWDM are performed in incremental design process and iterative manner. UML notations are being used in the modeling activities occurred in those design stages. User Interaction Diagram (UID) are used throughout the design process which focusing exclusively on the information exchange between web applications and the web users.

Our main concern of UEWDM is to support modeling facilities of complex process flows in web applications. Fig. 6 lists the modeling elements in UEWDM.

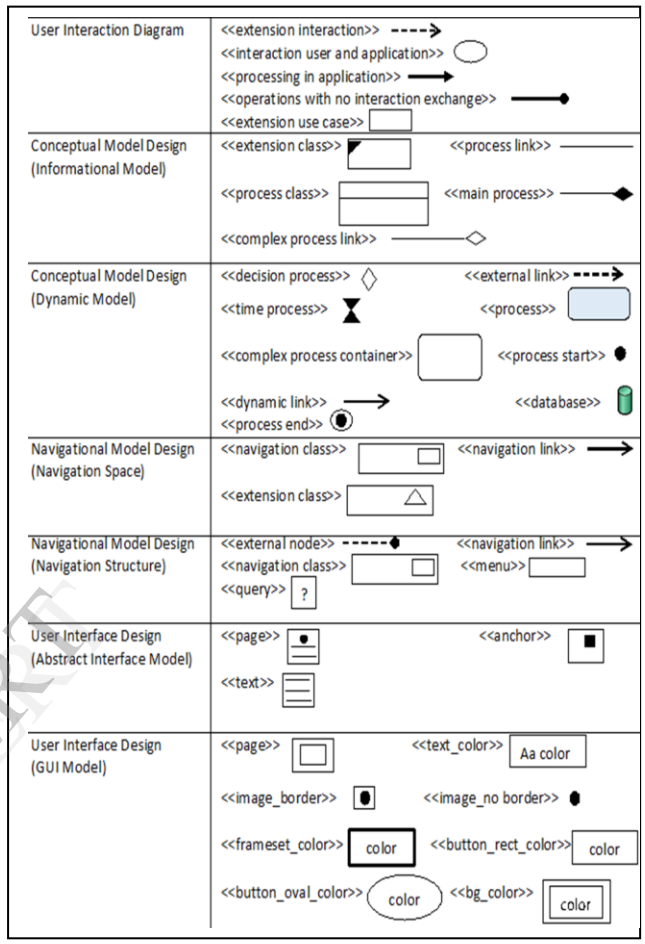

Fig. 6. Modeling elements for UEWDM.

A. *User Interaction Diagram (UID)*

The strategy in adopting UID in the design model extends an existing development process of web applications. Our main concern is to provide a user interaction features which able to capture details of activities and functions of each users in the web applications.

In UEWDM, UID will be used to capture user interactions in Conceptual, Navigational and User Interface. Furthermore, the uncertainty that occurred in interrelated process able to be tackled by UID in providing the description of information exchange in a high level of abstraction, without considering design details and specific user interface aspects.

B. *Conceptual Model Design*

The main objective of conceptual design stage is to build a domain model without any concern on navigational and user interface aspects. The application domain is captured with use cases such as finding classes and associations. As argued by [21], the existing design models of complex process flow in

web applications design are not sufficient enough and unable to support the dependent processes and interrelated data that occurred in web applications. Therefore, UEWDM provides two sub models: Informational Model and Dynamic Model to tackle the issues mentioned above.

The objective of Informational Model is to present a general structures of the web application domain. In other words, it signifies classes, objects, attributes and associations for the interaction between web users and the web applications. Additionally, independent and dependent processes will be identified in this model by utilizing UML extended stereotypes.

The identified dependent processes will be extensively designed in activity diagram and sequence diagram. Activity diagram presents the flow of activities through the web applications while sequence diagram is one of the UML interaction diagrams that shows how processes operate with one another and in what order. Those models called Dynamic Model.

C. *Navigational Model Design*

This design stage is to define set of navigation classes that are associated together through hyperlinks and access structures. In UEWDM, we concern on three navigational aspects:

- To emphasize on node and objects that can be visited by navigation through the web applications as designed in Navigation Structure.
- To focus on how the nodes and objects are reached in the web applications as modeled in Navigation Space.
- To develop new UML stereotypes that will be fully utilized in the web applications as to avoid navigation confusion among the web users.

The creation of Navigation Structure, Navigation Space and UML stereotypes will give a clear view on how navigation classes are linked and appeared on screen.

D. *User Interface Design*

The main objective of User Interface Design Model is to present abstract user interface elements through logical and physical views of the web applications. The design stage is to support content and structure of the single node and how user can interact with them.

Fundamentally, the design stage provides graphical guidance of presentation model that present web interface features of every single web page. Hence, in UEWDM, we divide the design stage into two sub activities which called Abstract Interface Model and Graphical User Interface Model.

The main concern of Abstract Interface Model is to look at structural organization design of the web applications. In the other hand, Graphical User Interface model looks into the Graphical User Interface (GUI) development environment. In this research, we propose new features called GUI Model and it provides intuitive user interface to facilitate the users of the web.

IV. DISCUSSIONS: A SUPPORT FOR ACADEMIC MANAGEMENT SYSTEM (AMS)

Our research idea is to propose design model for web applications that consists of complex processes. Our intention is not to build new design model that develop from scratch, but we compare and combine several design aspects from existing design models to improve UEWDM. In our scope of work, complex processes can be defined as (1) processes that interrelated with other processes from different class, (2) processes that need to be executed according to a certain period of time and it is not a one time through process and (3) processes that hold link to other processes module.

Current research has shown that complex processes must be considered and relied on each design process [6]. Our main idea is to construct a design model for Academic Management System (AMS) which consists of several complex process. A survey on current AMS issues has been conducted recently among web users and designers. The analysis indicates that the existing AMS still not being designed systematically and lack of user features such as parents to student's module, research grant online applications and course registrations. Hence, we propose the following design stages and features as concern to consider how complex processes can be systematically modeled in each design stages.

A. *User Interaction Diagram (UID)*

The goal of providing user interaction features in AMS is to capture details of activities and functions of each user in the web application. In AMS case study, main potential users will be lecturers, students, exam unit personnel, student affair personnel and finance personnel. Their role, activities and user interactions in each design stage will be captured using UID. Fig. 7 illustrates the design model of UID for medical certificate online submission process that occurred in examination attendance module of AMS.

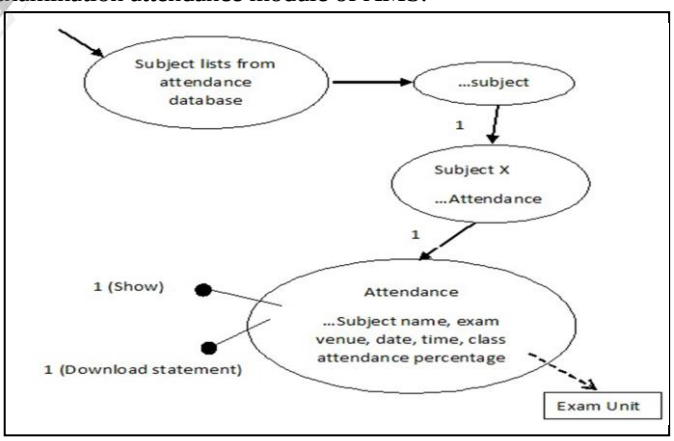

Fig. 7. UID for medical certificate online submission process in AMS.

The uncertainty in AMS tends to ignore the interrelated process occurred between modules. Hence, the uncertainty between the users and the AMS able to be tackled by UID in describing the exchange of information in a high level of abstraction.

B. *Conceptual Model Design*

In this design stage, we concentrate on information structures and application domain. Conceptual model will present which information should be made available to AMS users, including the classes, objects, attributes and association using UML standards. In order to support complex processes in AMS, the design model adopts activity diagram and

sequence diagram in order to create a Dynamic Model. The identified complex processes are derived from Informational Model as illustrate in Fig. 8. The Informational Model provides designers with complete views of information content and structures of the web application. In Fig. 8, AMS can be designed into numerous conceptual classes with their own associations between those classes. The model is equipped with association names, multiplicities and relationship to present the specifics components of each class. However, for simplicity, we hide their attributes and operation components.

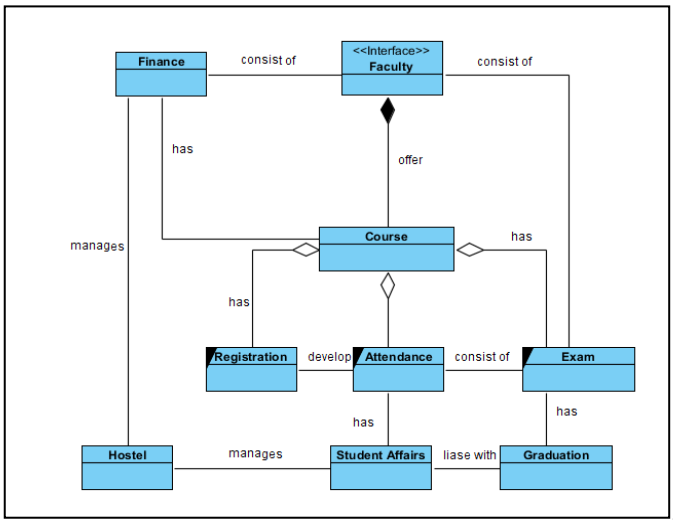

Fig. 8. Informational Model of AMS.

In AMS, course registration process needs to correlate with attendance process and same goes to exam unit process which has name of qualified students to sit for an exam from attendance process. All those processes are interrelated with each other and Dynamic Model will identify these processes and model the processes into activity diagram and sequence diagram. Each of these diagram has their own functions and responsibilities. Activity diagram responsible to present the activities flow occurred in AMS while in the other hand, sequence diagram identify the order of the processes including to show how those processes operate with one another in the AMS. Fig. 9 presents an example of Dynamic Model for medical certificate online submission process.

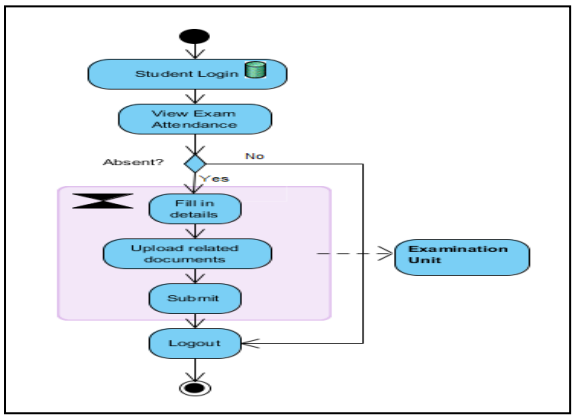

Fig. 9. Dynamic Model for medical certificate online submission process in AMS.

C. *Navigational Model Design*

In navigational model design stage, every class that is defined from conceptual design stage will be used as navigation guidance to derive nodes of the application domain. In this design stage, navigation space and navigation structure will be developed to show which nodes and links can be visited by the web users and to show how nodes and links are being visited through access elements such as indexes, guided tours, query and menu. In UEWDM, navigation UML interaction acts as a feature which consist of extensive UML stereotypes which able to cope with different possibilities of navigation in complex web application.

In AMS case study, the interrelated process flow occurred in the complex process tends to lead to navigation confusion among web users if it is not designed and presented in details. In example, attendance process requires lecturers to key in students' attendance report while in the other hand, it is also allowed for exam unit personnel and students to access the process to view the attendance report. Therefore, a number of access elements for navigation purposes such as index, guided tours, query and menu need to be involved and carefully chosen for respective users and usage. Fig. 10 presents navigation space of classes and hyperlinks in AMS derived from Informational Model.

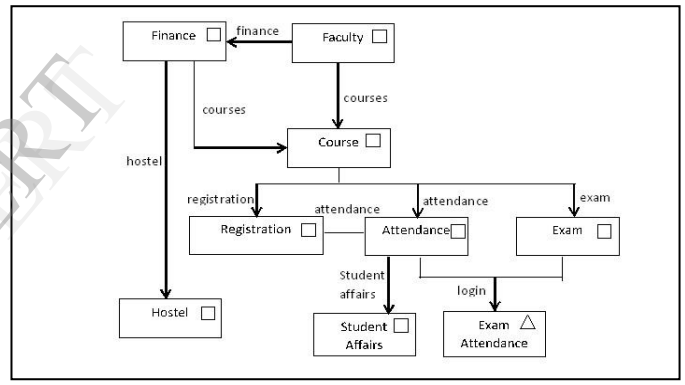

Fig. 10. Navigation space in AMS.

Navigation space and hyperlinks in Fig. 10 are then equipped with navigation structure as illustrate in Fig. 11. The idea is to present how navigation classes are reached by web users in AMS. UEWDM introduced several types of modeling elements for navigation UML interaction as shows in Fig. 6. Navigation UML interaction is proposed by providing appropriate modeling navigation elements according to designer preferences.

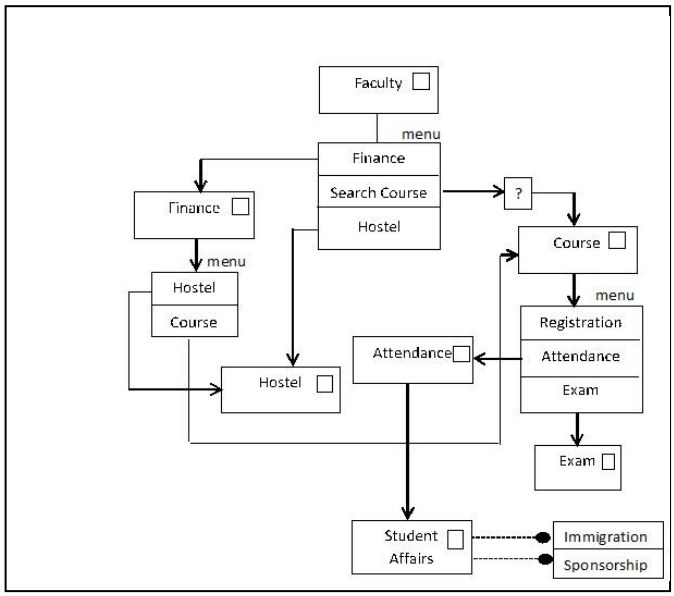

Fig. 11. Navigation structure in AMS.

D. User Interface Design

Classes, navigation links and navigations structures from previous design stage are getting into further details on how to present the classes in the real appearance. In the other word, this design stage supports content and structure of the single node and how web users can interact with the web application.

The two sub design models introduce in this stage called Abstract Interface Model and Graphical User Interface (GUI) Model. Abstract Interface Model focus on structural organization design of the web applications. Fig. 12 illustrate the Abstract Interface Model for examination attendance page.

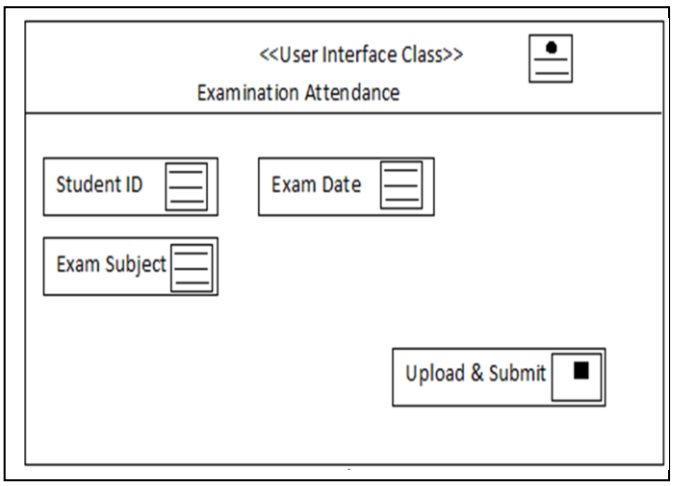

Fig. 12. Abstract Interface Model for examination attendance.

In UEWDM, the strategy to tackle GUI issues in this design stage is place in GUI model. More web users and information are interrelated when it comes to complex process in web application. Hence, a standard model is necessary to ensure proper creation of GUI design. The GUI standard model scopes the modeling efforts into physical characteristics of the web application. Fig. 13 presents the example of GUI model of Examination Attendance page layout. The web page should contain several information such as student's names, examination subjects, attendance percentage, upload button, submission button, etc. Those content should positioned exactly as being designed in the user interface layout presentation model.

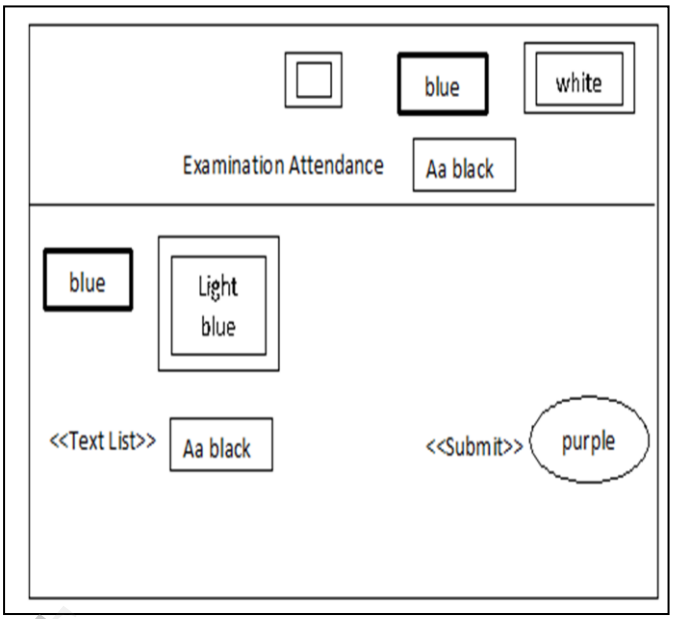

Fig. 13. GUI model in Examination Attendance page layout.

In AMS case study, the user interface design will be modeled into both characteristics, logical and physical. It gives definition that our approach not just in terms of providing abstract overview of how various pieces of information and navigational objects positioned onto screen layout, but in the other hand, it provides layout and presentation on physical elements of GUI itself.

For example, design of button menus, shortcuts and accelerators of the common task by frequent web users. The basic principle is user interface should be as much intuitive as it is possible to facilitate the web users. Thus, as to fulfill the gap, GUI model is designed to meet user's overall satisfactions [22].

V. CONCLUSIONS AND FUTURE WORKS

This paper has overview several existing web design models that consists of numbers of design stages and cope with complex processes. Four web design models have been chosen to be reviewed in this paper which named UML-based Web Engineering Framework [14], Com$^+$ HDM [15], WSDMDA [17] and Requirements Model as First Class Entities in Model-Driven Web Engineering [18]. Those four web design models have been selected for reviewing purpose because of their model-driven approach and deal with similarity issues in our research work. Model-driven approach has proven to present the web design model in terms of simplicity and clarify the for the web applications.

Most of the reviewed web design models are the extension design models from UWE [11] and WSDM [13]. Design models such as UWE use a well-known UML notation while

WSDM only use their own notation modeling language. In our research work, fully UML notation will be used as it offers more compatibility and easy-to-use features. In addition, it is greatly used by many case tools [23].

The issue however, arises when complexity of the web demands the adoption of a systematic development method. In this paper, we introduced a design model for complex web applications called UEWDM (UML-Extensions Web Design Model) which based on UML notation and model-driven approach. UEWDM is divided into three main design stages, namely conceptual model, navigational model and user interface model. User interaction diagram acts as an interaction features that cope with all those three main design stages as to describe the exchange of users' interaction information without considering design details and specific user interface aspects. In conclusion, we summarize UEWDM as a design model that capable to incorporate with complex web applications.

Further refinement works will be focus onwards to UEWDM in order to offer more systematic and yet, powerful facilities in complex web application design. We will work on proposing more stereotypes of UML profiles for designing purposes and GUI elements for GUI Model design. Through the propose notations and the new modeling stereotypes, UEWDM will be implemented in a case study called Academic Management System (AMS) as to illustrate the effectiveness of the proposed design. We believe that our design approach will be able to solve complex process design issues in web applications specifically occurred in AMS.

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