Design Processes for Web-based Hypermedia Engineering

Azrul Hazri Jantan
Faculty of Computer Science & IT,
Universiti Putra Malaysia
Selangor, Malaysia

azrul@fsktm.upm.edu.my

Putra Sumari, Shahida Sulaiman
School of Computer Sciences,
Universiti Sains Malaysia,
Pulau Pinang, Malaysia.

{putras, shahida}@cs.usm.my

ABSTRACT

The process of designing and developing hypermedia applications is one of the big challenges for today's hypermedia engineering industry. In comparison to traditional information system design, hypermedia application demands a number of additional design aspects such as the application structure and information contents, operations and functions provided to the users and the appearance of the presentation layout. The increasing complexity of this application has raised the need to employ many designing methods in hypermedia development practice. The main objective of this paper is to describe a number of web-based hypermedia design methods within their main design processes. This paper gives an overview of the processes involve in the design phase of a web-based hypermedia application that reflect the way of hypermedia designer and developer who deal with the application. We argue that the design processes reviewed are not much concern in modeling a complex business process. Thus, we discuss this issue based on object-oriented approach for designing business process. A new design process will be proposed and summarized at the end of the paper.

Keywords:

Hypermedia Engineering, Web-based Hypermedia Applications, Design Methods, and Business Processes.

1. INTRODUCTION

To date, web-based hypermedia applications are becoming very popular with explosive growth in its computing environment [14]. It offers a more natural way to express and convey ideas or information to the users. The integration of various forms of multimedia elements such as text, graphics, audio, video, and animation that is presented on computer interactively with non-sequential navigation and user friendly interfaces making hypermedia as one of the greatest applications of expressing ideas in a richer and more natural form.

3rd Malaysian Software Engineering Conference '07, Dec 3-4, 2007, Selangor, Malaysia.

 ISBN 978-967-5026-23-2

According to [14], hypermedia applications should support a high quality of user interfaces, more complex structure of navigation mechanisms, and more varied forms of information for the hypermedia audiences. However, some hypermedia applications fail in their functionalities, lack of qualities and struggling to meet user requirements [1]. One of the reasons is hypermedia applications are getting complex on its scope [3,4,13], mainly for the business operational environments and functional requirements [2,14,21]. Besides, many hypermedia designers, developers, and practitioners are lacking of knowledge and poorly understand the concepts of the design and development practice, contributing to the applications failure [13]. In addition, choosing an appropriate design method is another challenge among the designers and thus, development practice has generally been ad hoc [1, 16], leading to poor quality results and hardly to accomplish the user requirements.

The main objective of this paper is to provide an overview of the processes involved in the design phase of a hypermedia application. Section 2 will briefly describe the main design processes involved in web-based hypermedia engineering. Four design methods that currently exist in hypermedia development practices are presented as subsections in Section 2. Section 3 will discuss an issue of modeling a business process in hypermedia applications. And finally, conclusions and some of our future works are provided at the end of the paper in Section 4.

2. HYPERMEDIA DESIGN PROCESSES

In the last few years, several methods for designing hypermedia applications have been proposed, such as RMM [10], OOHDM [15], WSDM [6,7], UWE [11,12], W2000 [2], and OO-H [9]. Of the existing methods, ongoing research efforts have found that most of the design methods that being used for web-based hypermedia application development are model driven and consist of a number of design processes [3]. Models are developed during each of design process to get the whole picture of the application domain. In this section, the main processes of the design methods will be viewed briefly, namely user requirement analysis, conceptual (contents) design, navigation space design, and user interface (presentation) design.

The effort of these design processes are normally being done in iterative and incremental approach. For each design process, a model is developed to present the result for the design effort. Some methods use their own notation for this model, while the others conform to existing standard notations such as UML [5]. Generally, all web-based hypermedia design methods have the following analysis and design processes:

- **User Requirement Analysis:** gather and analyze the information needs from the users. Results are normally presented in *Use-case diagrams*.
- **Conceptual (contents) Design:** also known as *content modeling* which deals with the contents of the application that will be presented to the users. Results are modeled as *Conceptual model* (e.g. class diagrams).
- **Navigation Space Design:** determine and identify path or links for every item (e.g. classes) in the *Conceptual model* where applicable. Designer may choose appropriate access elements (e.g. guided tours, index, etc.) as the navigation mechanisms in the *Navigation model* produced.
- **User Interface (presentation) Design:** defining the appearance of the designed application as it will be seen by the users (for each navigation page).

In the next sections, four design methods of web-based hypermedia engineering, namely WSDM [6,7], UWE [11,12], W2000 [2], and OO-H [9] will be described in more details. Each will be discussed accordingly to the four main processes in hypermedia design.

2.1 Web Site Design Method (WSDM)

The Web Site Design Method or WSDM [6,7], is a user-centered approach that defines the information objects of a web application based on user requirements. WSDM is not a data driven approach but it gives consideration to the fact that all web-based applications have different types of users who may have a lot of different information requirements. It comprises of three main phases, namely *user modeling*, *conceptual design*, and *implementation design*.

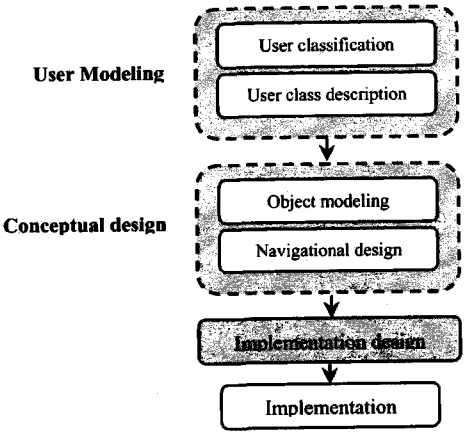

Figure 1. Overview of the WSDM phases [7].

User requirements are being defined and gathered in the *user modeling* phase. The idea is to identify the potential users of the website according to their interests and navigation preferences. This effort is done in two sub-phases called *user classification* and *user class description*. The former will identify and differentiate a number of user classes, depends on their information requirements, while the latter will describe the perspectives or different characteristics for each of user class. For example, users from same class will have the same information requirements but they might view them in a different way of presentation. Class and object modeling are done in *conceptual or contents design* phase. The main objective is to develop *User Object Models (UOM)* that presents both information requirements and perspectives according to each user class identified.

WSDM has its own notation for designing navigation of the website, called *components* and *links*. The navigation model comprises of a number of navigation tracks, each for describing the information requirements or perspectives that will be navigated by users. Generally there are three layers in navigation model, namely *context layer* for connecting different navigation tracks, *navigation layer* for providing different ways to access information, and *information layer* that provides the actual information. Finally, *implementation design* phase is to create and design the presentation or user interface layout including the look and feel of the web-based applications.

2.2 UML-based Web Engineering Design Method (UWE)

UML-based Web Engineering Method (UWE) [11,12], is an iterative design method for web-based hypermedia applications that provides guidelines for the systematic design processes, supports personalization and semi automatic generation of web applications. Models or diagrams developed in UWE are based on exclusively Unified Modeling Language (UML) [5] notations. The processes have generally divided into four main phases, called *requirement analysis*, *conceptual design*, *navigational design*, and *presentational design*.

UWE starts with *requirement analysis* that is to provide and classify the potential users and identify the functional requirement of each user. The concepts of object oriented modeling are mandatory in *conceptual design*. Objects and classes that are relevant to the web-based application are determined. Class diagrams is developed to represent the objects and identify the domain semantics including the name of classes, attributes, operations, associations, and relationships.

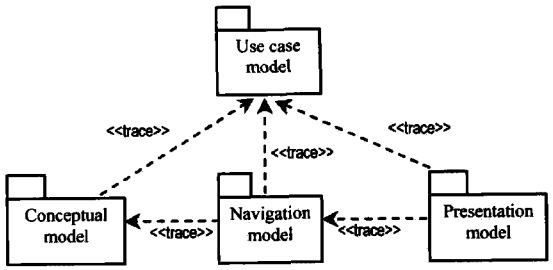

Figure 2. Overview of the UWE Design Processes [11].

In *navigation design*, every class that is defined will be used as navigation guidance to derive nodes of the application structures. There are two objectives in *navigation design*, first, to show which classes of the conceptual model can be visited by users as navigational nodes and secondly, to describe how those navigational nodes are visited using access elements. To achieve the first objective, *navigation space model* is built. This model is a

sub-graph of the conceptual model where classes that are not related or appropriate for the navigation will be eliminated. *Navigation structure model* is then developed to show how classes are being visited through access elements such as indexes, guided tours, query, and menu.

The idea of *presentation design* is to provide abstract user interfaces, both in static and dynamic that show how the navigational structures are presented to the users. A *static presentational model* is developed to define how navigational nodes are presented to the users using UML composite objects. And, a *dynamic presentational model* defines the action or behavior of the presentational objects, i.e. the changes on the user interface when user interacts with the application.

2.3 W2000 Framework

W2000 [2], is a framework for designing a complex web applications that integrates two main approaches, namely Hypermedia Design Model [8] and Unified Modeling Language [5]. W2000 provides five main design phases called *visibility* design, *hypermedia information* design, *hypermedia navigation* design, *functional* design, and *state evolution* design. Requirement analysis is done by developing two different diagrams, called *functional use case diagram* and *navigational use case diagram*. The former has the objective to identify and define the user classes within their roles and activities performed, while the latter is to present the navigation capabilities of each user class depending on its information needs.

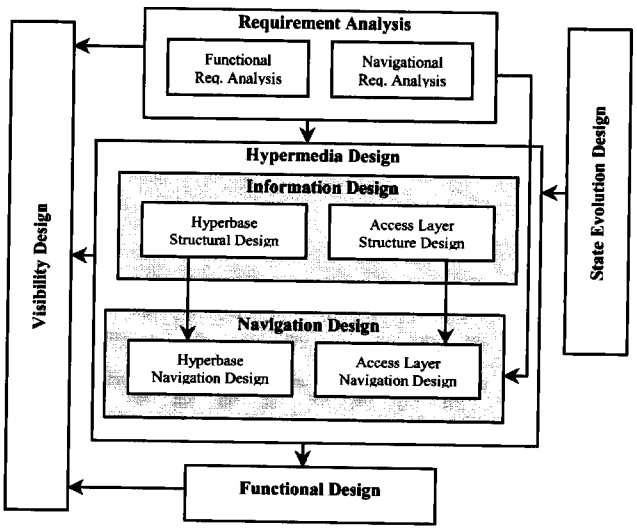

Figure 3. W2000 Design Framework [2].

W2000 implements its conceptual design in *hypermedia information design*. The idea is to organize the contents of information provided by separating them into different levels of information, namely hyperbase layer and access layer. The *hyperbase structural design* deals with the core information objects that will be viewed to users, while *access structure design* deals with the higher-level structures of information to support access paths to the core information. *Access structure design* also defines collection or group members of the core information elements. Navigation design can be divided into *hyperbase navigation design* and *access structure navigation design*. The main objective is to provide the way how users will access information contents in the application within its access structures. *Hyperbase navigation design* defines the information units or nodes including their links of the application, while *access structure navigation design* defines the links for each collection of information called *collection links*.

2.4 Object-Oriented Hypermedia (OO-H)

Object oriented hypermedia method or OO-H [9] is yet another hypermedia design method to provide facilities on the navigation paths and interface layout of application contents. OO-H is a generic UML-based model that covers on the authoring process with two main models, called *navigation model* and *presentation model*. The first two processes, called *requirement analysis* and *conceptual design* are implemented by conforming the exclusively UML [5] standard notation and represented by *use case models* and *business class diagrams*, respectively.

Navigation model is constructed by a single or collection of navigation diagrams called *navigation access diagrams (NAD)*. Each NAD represents a view of information contents by a single user of the application. The idea is to differentiate the views of users and thus, navigation paths can be defined much clearly. The construction of each NAD is based on four types of constructs; *navigation classes*, *navigation targets*, *navigation links*, and *collections*. Presentation design is done to provide refinement mechanisms of the user interface at a lower level of abstraction. OO-H proposes two types of user interface diagrams. *Abstract presentation diagrams (APD)* can be automatically generated from the NAD and provides a functional but yet a simple view of the presentation layout where some refine works might be necessary to be conducted for a deeper and detail view of the application. The second diagram, called *composite layout diagram (CLD)* is to identify the visual impact of the constructed interface. In CLD, objects location, visual styles, and widgets can be edited or added to improve the visual impact of the application.

3. DISCUSSIONS: A SUPPORT FOR COMPLEX BUSINESS PROCESS

One of the factors that make web-based hypermedia application as a complex example is the needs for them to support business processes for their evolution [21]. Generally, there are two main features to differentiate business process from a general process. First, a business process takes the users of the application through its flow of activities, depending on user's actions; and at the same time it defines the set of activities to be executed among them [18]. Secondly, a business process has its own state where changes can be made only by the input or actions taken by the users [19]. As been described in previous sections, hypermedia design consists of four major processes, namely requirement analysis, conceptual design, navigation design, and user interface design. Ongoing research has shows that business processes must be considered and relied on each of the design process. According to [17], business processes are inadequately supported by the means of normal navigations mechanisms but they should have to integrate some process flow in order to avoid usability problems and erroneous results from being generated. Thus, this will required designers to consider designing business processes from the earlier design stage.

All design methods discussed in previous section have a little concern on this issue and they are incomplete or inadequate to answer this new functionality of processes; they are lack of aspects on how business processes can be modeled effectively in the hypermedia design nature. A comparative study has been made by [20], that shows most of current hypermedia design methods are unable to address the modeling functionality of a business process. Therefore, further close-up studies of hypermedia applications design and development practices are needed for a deeper view in this issue.

Our research concern is to capture the global view of critical business processes in the design phase, which starts since the earlier stage of design processes. Therefore, we conclude and propose the following requirement analysis stage and the four main design processes (including the new proposed *business process design)* as regard to consider how business process can be systematically modeled in a design method.

- **User Requirement Analysis:** Gather all information needs from the potential users in terms of their functional / business requirements and navigation preference requirements (for web-based hypermedia application). Models are constructed via UML *use case* models.
- **Conceptual Design:** The idea of this process is to capture all classes and objects that relies in the application, and to give a clear view of application domain to the designer. Involve defining classes, attributes and their relationships (i.e. inheritance, aggregation, and composition). Results are developed as *conceptual (class) diagrams* – UML standards.
- **Business Process Design:** A new feature added to the current four main processes as stated in Section 2. From the class diagram constructed in previous process, designer should be capable to identify any classes (or creating new classes) that involve business process. From this effort, all business classes should be treated in a different way if compared to other classes. Business classes have to be expanded into a much deeper view so that the flow of activities and the state of the classes can be determined in an effective way (in UML, we can do this by constructing sequence diagram and activity diagram). For representing business classes in the *conceptual (class) diagrams*, we introduce a new UML's stereotype profile called *<<business class>>*. Results are shown by extending the previous *conceptual (class) diagrams*, to a new one, called *conceptual-business model,* which presenting the integration of classes between conceptual classes and business classes.
- **Navigation Design:** This design stage defines the directions or links for every class (including business class), which are determined in the previous *business process design* stage. For all classes in the *conceptual-business model*, designer defines the appropriate navigation path for users to navigate all classes in the real situation. Then, access structures are also being applied for each link to describe how those classes in *conceptual-business model* can be reached by the users. This will involve with introducing a number of access elements for navigation purposes such as *index*, *guided tours*, *query*, etc. This can be done also by declaring a number of new UML's stereotype profiles.
- **User Interface Design:** Those classes and navigation links that have been described are getting into further details on how to present the classes in the real appearance including the navigation structures. In the other words, it represents the appearance of the designed application as it will be seen by the users.

For the sake of simplicity, we have only covered the definition of each design process and hide other possible refinements such as the graphical notations of the new UML profiles' stereotypes defined. We strongly believe that by adding the new design process called *business process design*, the effort for modeling a complex business process are lessen and easier.

4. CONCLUSIONS AND FUTURE WORKS

This paper has overview a number of web-based hypermedia design methods that consist of four main processes. Four design methods called WSDM [6,7], UWE [11,12], W2000 [2], and OO-H [9] has been chosen for reviewing purpose since they are model driven with similar aspects of design processes and using different graphical notation for presentation. No matter whether they are structured-based or object-oriented approach, the art of model driven has given them the great facilities to present the design product in terms of simplicity and clarity for the web application. Some methods such as UWE and OO-H use a well known UML notation, while some (e.g. WSDM and W2000) only use their own notation. Limiting to the use of well known notation instead of using new introduced notation has the advantage of compatibility and easy-to-use features. Notation such as UML also has been greatly used by many case tools [12]. Using a new establish graphical notation however, has its own strengths. They are not limited to any platform, moreover they has their own mechanisms on how design effort could be getting much better than using any given standard notation.

The issue however, arises when most of the hypermedia design methods do not emphasize on complex business processes environment into the design aspect. According to our review, it has been agreed that the involvement of complex business processes to hypermedia applications increase the challenges and risks; and thus we require a flexible and systematic design method in order to cope with the process needs. Further refinement works might be necessarily conducted to improve the usability and functionality, thus avoiding undesired results and errors. Our future works will be focus onwards to the extension of reviewed design methods in order to offer more systematic and yet, powerful facilities in the business process design. Our research will cover five main processes including the new proposed process, called *business process design*. All these processes are relied on the object oriented approach that is based on Unified Modeling Language (UML), and the facilities provided in the UML's profiles (by proposing a number of new stereotypes for designing purposes). Through the notations provided and these new modeling stereotypes, our proposed design approach will be used to design a case study of a web and business-based hypermedia application to prove users' satisfactions and implementations. Through this case study, we anticipate that our design approach which is performed and being done in incremental and iterative styles of development will be able to successfully capture the complete view of a complex business process modeling.

5. REFERENCES

[1] P. Avgeriou and S. Retalis, "CRITON: A Hypermedia Design Tool", *Multimedia Tools & Applications*, 27, 5-21 Springer, 2005.

[2] L. Baresi, F. Garzotto, and P. Paolini, "Extending UML for Modeling Web Applications", *Proceedings of the 34th Hawaii International Conference on System Sciences*, 2001.

[3] P. Barna, F. Frasincar, G.J Houben, R. Vdovjak, "Methodologies for Web Information System Design", *Proceedings Information Technology: Coding and Computing [Computers and Communications]* pp. 420 – 424, 2003.

[4] C. Barry and M. Lang, "A Comparison of traditional and multimedia information systems development practices", *Information and Software Technology*, 45(4) pp. 217-227, 2003.

[5] G. Booch, I. Jacobson, J. Rumbaugh, "The Unified Modeling Language User Guide", *The Addison-Wesley Object Technology Series*, 1998.

[6] De Troyer, "Audience Driven Web Design", *In Information modelling in the new millennium, Eds. Matt Rossi & Keng Siau, Publ.*, IDEA GroupPublishing, 2001.

[7] De Troyer and C.J Leune, "WSDM: A user-centered design method for web sites", *Computer Networks and ISDN Systems, Proceedings of the 7th international WWW conference*, Elsevier pp. 85-94, 1998.

[8] F. Garzotto, P. Paolini, D. Schwabe, "HDM: A Model Based Approach to Hypertext Application Design", *ACM Transactions on Information Systems*, Vol. 11,No 1, pp. 1-26, 1993.

[9] J. Gomez and C. Cachero, "OO-H Method: extending UML to model web interfaces", *Information modeling for internet applications*, pp. 144-173, 2003.

[10] T. Isakowitz, A.S Edward, P. Balasubramaniam, "RMM: A Methodology for Structured Hypermedia Design", *Communications of the ACM*, Vol. 38 Issue 8 pp. 34-44, 1995.

[11] N. Koch, A. Kraus, and R. Hennicker, "The Authoring Process of the UML-based Web Engineering Approach", *In Daniel Schwabe, 1st International Workshop on Web-oriented Software Technology (IWWOST01)*, online publication, June 2001.

[12] N. Koch and A. Kraus, "The Expressive Power of UML-based Web Engineering", *2nd International Workshop on Web-oriented Software Technology (IWWOST02),* D. Schwabe, O. Pastor, G. Rossi, and L. Olsina, editors, CYTED, pp. 105-119, June 2002.

[13] M. Lang, "Issues and Challenges in the development of hypermedia information systems", *Proceedings of 11th Annual Business Information Technology Conference (BIT 2001),* Manchester, England, October 30-31 2001.

[14] M. Lang and B. Fitzgerald, "Hypermedia Systems Development Practices: A Survey", *IEEE Software* Vol. 22, Issue 2, pp. 68 – 75, Mar-Apr 2005.

[15] D. Schwabe and G. Rossi, "Developing Hypermedia Application using OOHDM", *Proceedings of Workshop on Hypermedia Development Process, Methods, and* Model, 1998.

[16] L. Uden, "Design process for Web applications", *IEEE Multimedia*, Vol. 9, Issue 4, pp. 47-55, Oct.-Dec.2002.

[17] H.A. Schmid and G Rossi, "Modeling and Designing Processes in E-Commerce Applications", *IEEE Internet Computing*, Vol. 8, Issue 1, pp. 19 – 27, Jan-Feb 2004.

[18] H.A. Schmid, "Business Entity Components and Business Process Components", *Journal of Object-oriented Programming*, Vol. 12, no. 6, 1999.

[19] H.A. Schmid, F. Falkenstein, and G. Rossi, "Components for the Reuse of Activities in Web Applications", *Proceedings of 7th International Conference on Object Oriented Information Systems (OOIS 01)*, Springer, pp. 191-200, 2001.

[20] S.S. Selmi, N. Kraiem, and H.B Ghezala, "Toward a Comprehension View of Web Engineering", In *International Conference on Web Engineering (ICWE2005)*, Sydney Australia, pp. 19-29, 25-29 July 2005.

[21] D.Distante, G.Rossi, G.Canfora, S.Tilley, "A Comprehensive Design Model for Integrating Business Processes in Web Applications", *International Journal on Web Engineering and Technology*, Vol. 3, No. 1, pp. 43-72, 2007.