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A UML EXTENSION FOR WEB DESIGN MODEL FOR INTERACTION PROCESS AND USER INTERFACE

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By

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Nowadays, the process of designing web application has become a challenge for many individuals. The designs should incorporate conceptual domain, interaction processes, navigation structures, and abstract presentation design. Unfortunately, many practitioners believe that most of the web design models have been developed in an ad hoc manner and there is less focus on the interaction processes. Thus, it can lead to a web design that is full of information, confusing navigation, and poor presentation layout.

Hence, as a solution to the mentioned problem, this study proposes a web design model called UML Extension Web Design Method (UEWDM) that comprises the conceptual design model, navigational model and user interface model which utilises Unified Modeling Language (UML) profile as the design modeling for the interaction processes and user interface. The extension stereotypes of UML design modeling is also proposed to complement the design modeling in the respective design stages. In order to verify and validate UEWDM, a case study has been developed and feedback from web experts are gathered as to ensure UEWDM is aligned with the developed case study. The results indicate positive feedback from the web experts as all web experts involved in this study agreed with the proposed design model.

In conclusion, UEWDM provides a web design model with enough expressivity in modeling interaction processes in web applications. In other words, it could assist web designers and developers in designing web applications that consist of interaction processes and user interface.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

MODEL REKA BENTUK WEB UML SAMBUNGAN UNTUK PROSES INTERAKSI DAN ANTARA MUKA PENGGUNA

Oleh

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Proses mereka bentuk aplikasi web merupakan salah satu cabaran besar pada masa kini. Reka bentuk perlu menggabungkan domain konseptual, proses interaksi, struktur navigasi, dan reka bentuk persembahan abstrak. Malangnya, ramai pengamal percaya bahawa kebanyakan model reka bentuk web telah dibangunkan secara ad hoc dan kurang tumpuan dalam proses interaksi. Oleh itu, ia boleh menyebabkan reka bentuk web yang penuh dengan maklumat, navigasi mengelirukan, dan susun atur persembahan yang lemah.

Oleh yang demikian, sebagai penyelesaian kepada masalah yang dinyatakan, kajian ini mencadangkan satu model reka bentuk web dipanggil Model Reka Bentuk Web UML Sambungan (UEWDM) yang terdiri daripada model reka bentuk konseptual, model navigasi, dan model antara muka pengguna yang menggunakan profil Unified Modeling Language (UML) sebagai pemodelan reka bentuk untuk proses interaksi dan antara muka pengguna. Stereotaip sambungan pemodelan reka bentuk UML juga dicadangkan sebagai pelengkap pemodelan reka bentuk pada peringkat reka bentuk masing-masing. Bagi menentusahkan dan mengesahkan UEWDM, satu kajian kes telah dibangunkan dan maklum balas daripada pakar-pakar web dikumpulkan untuk mematuhi UEWDM sejajar dengan kajian kes yang dibangunkan. Hasil kajian menunjukkan maklum balas positif daripada pakar-pakar web apabila semua pakar web yang terlibat dalam kajian ini bersetuju dengan model reka bentuk yang dicadangkan.

Kesimpulannya, UEWDM menyediakan model reka bentuk web dengan keekspresian yang cukup dalam proses interaksi pemodelan dalam aplikasi web. Dengan kata lain, ia dapat membantu pembangun web dalam mereka bentuk web yang terdiri daripada proses interaksi dan antara muka pengguna.

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LIST OF ABBREVIATIONS

A	Agree
AMS	Academic Management System
CASE	Computer Aided Software Engineering
COM^{+}HDM	Comprehensive Hypermedia Design Method for Complex Process Modeling
CSS	Cascading Style Sheets
D	Disagree
FCSIT	Faculty Computer Science Information Technology
GUI	Graphical User Interface
HTML	Hypertext Markup Language
IFML	Interaction Flow Modeling Language
JS	JavaScript
MDD	Model Driven Development
MDWE	Model Driven Web Engineering
MMU	Multimedia University
MOHE	Ministry of Higher Education
MySQL	Structured Query Language
NMMp	Navigation Maps Modeling Profile
OMG	Object Management Group
OO-H	Object-Oriented Hypermedia Method
OOHDM	Object-Oriented Hypermedia Design Method
OOWS	Object-Oriented Web Solutions

PHP	Hypertext Preprocessor
RUP	Rational Unified Process
SA	Strongly Agree
SD	Strong Disagree
TM	Telekom Malaysia
UEWDM	UML Extension Web Design Method
UML	Unified Modeling Language
USIM	Universiti Sains Islam Malaysia
UTAR	Universiti Tunku Abdul Rahman
UWA	Ubiquitous Web Application
UWE	UML Web Engineering
WebML	Web Modeling Language
WSDM	Web Site Design Method
WSDMDA	Web Site Design Model Driven Architecture

CHAPTER 1

INTRODUCTION

1.1 Motivation

Today, web applications are considered the most important platform used to gather information, deliver ideas and manage daily tasks such as banking transactions, knowledge searching, forum discussions and much more. All these applications are developed and integrated into web applications as to facilitate the users in order to access it online. Hence, it is very common to express the web-based system application development from the web engineering aspects (Murugesan & Ginige, 2005).

Within this discipline, numerous web design models have been proposed to handle the systematic and efficient web-based system development applications. Additionally, all of the web design models have improved according to the necessities raised from the evolution of the web applications. However, the separation of concerns proposed to integrate interaction processes in each stage of design has not been fully achieved (Andrés, Londoño, & Duitama, 2012). Moreover, those web design models tend to incorporate interaction processes producing design models that are too complex to be handled and designed by designers.

Additionally, these solutions just dealt with the interaction processes of business processes definition. Due to this limitation, aspects such as the interrelated processes, consideration of activity navigation models, and physical layout presentations are out of the scope of the previous design models proposed solutions (Patel, Hande, & Meshram, 2013). Essentially, interactions web applications are defined as web applications that consist of dynamic information, complex navigational paths, and rich interfaces (Comai & Mazza, 2012). Additionally, interactions web applications require more behavioral modeling aspects as compared to structural aspects (Patel et al., 2013).

Therefore, interaction processes-driven web applications can be defined as systems that consist of processes with interrelated processes, time frame processes, and user dependent processes. Specifically, the features that characterise those web-based system applications are as follows:

- Interrelated Processes: Different categories of users processes are integrated and collaborate with other processes in order to achieve an objective. For example, a process for undergraduate supervision and process for postgraduate supervision by a lecturer. Hence, integrate these two processes in one process to simplify users' needs.

- Time Frame Processes: The execution of interaction processes involves time constraints. These extensions can be produced as a result of different purposes. For instance, promotion of a product that is valid for three days. Different content will be displayed to the respective users if the promotion is over and vice versa. Therefore, a design to simplify these time frame processes is needed in order to facilitate this kind of users activity.
- User Dependent Processes: In particular, a process flow depends exclusively on users activities and flows. For example, a graduation process of a graduate student where a user (student) needs to complete the graduation application from library clearance to an external process of Ministry of Education requirements. The whole process needs to be executed accordingly since a different input from users will direct the web-based system application to a different output.

Thus kind of processes can be categorised as interaction process in web-based system applications and practitioners believe more efforts are needed in the existing design models (Rossi et al., 2016).

Those interaction processes can provide better support for non-functional requirements in web applications. Those two non-functional requirements that were most addressed are usability and accessibility, because they express themselves during user interaction. Furthermore, the interaction processes permits communication of interface and interaction design to non-technical stakeholders. The design separates the stakeholder concerns by utilize the UML extension stereotypes (Brambilla & Fraternali, 2015). Hence, those defined interaction processes are required in the proposed design model.

Existing studies show involvement of Interaction Flow Modeling Language (IFML) in the development design as to solve interaction processes issues. However, IFML still need a supporting community due to the adoption is far from being mainstream (Rossi et al., 2016). Also, IFML cannot fully support the web development lifecycle (Karzan Wakil & Jawawi, 2017).

The proposed approach in this study is not developed from scratch. Alternatively, this study extends the UML Web Engineering (UWE) design models, formerly proposed by Koch (2001). The aim of this study is to extend the UWE design model with new features and structures. Hence, the new design model will result in an improved version of web design models for the designers.

Certainly, there are many design models that have been extended from UWE such as Com^{+}HDM (Jantan, 2012), UML-based Engineering Framework (Elminir, Elsoud, & Halawany, 2011), enhancement of UWE navigation model (Wakil, Safi, & Jawawi, 2014) and requirements models as first class entities in model-driven web engineering (Koch & Kozuruba, 2012b) .

However, external process concern, navigation activity particulars design and physical layout concern are very much lacking. Specifically, the proposed approach is more concerned on the stereotypes extension in order to cope with these interaction processes structures. The idea is to generate design pattern in those three different design concerns, conceptual domain, navigational and user interface model. Figure 1.1 illustrates the UWE design model developed by Koch (2001). More discussions will be provided in Chapter 2, Section 2.6.4.

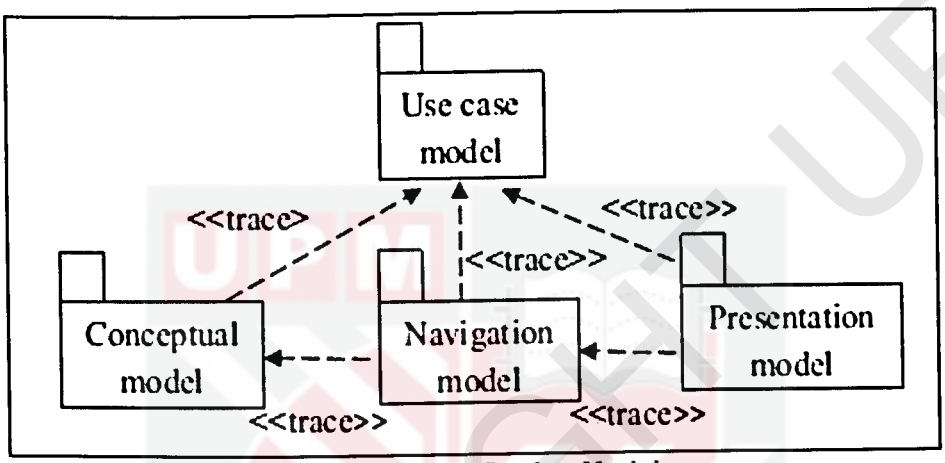

Figure 1.1: UWE Design Model
(Adapted from N. P. De Koch, 2001)

1.2 Problem Statements

Existing web design models in web-based system applications are not specific and have been developed in a general way (Patel et al., 2013). As a result, it has led to several issues such as lack of functional requirements (Jantan, 2012), complex navigational process (Jantan, 2012) and lack of user interface features (Elminir et al., 2011). Therefore, many practitioners believe more design efforts are required to support different ways of dealing with interactions web application (Kumar & Sangwan, 2011; Rossi et al., 2016) as to provide a comprehensive and systematic design process of web applications.

The main shortcomings to be addressed are comprised of:

1. Most existing web modeling structures are still solely focused on the conventional websites, with little regard for user interaction or common web-specific concepts. In many cases, the interaction process flow is not designed to interact with other interaction processes from different websites. Hence, there are limited solutions which allow interaction process flow between different web applications (Patel et al., 2013; Rossi et al., 2016).
2. Many different possibilities of navigation may have to be considered in the interactions of web applications. The navigation flow and interaction in interaction processes might lead to confusion to the user

if the navigation structures are not well-designed (Wakil et al., 2014). Moreover, the navigational structure model that has been built until now is not sufficient to describe how nodes can be reached by navigation (Patel et al., 2013).

3. Most of the existing user interface design model emphasised on the logical structure design of the web page. Additionally, the physical outlook is still being created in an ad hoc manner in the web design processes. There is no standard model that is concerned on GUI design in the user interface design phase (Patel et al., 2013).
4. Lack of complete web design models that allow interrelated process flow, time frame process, and user dependent process in web applications (Patel et al., 2013; Wakil et al., 2014).
5. Lack of case study examples and implementations especially those that are comprised of interrelated process, time frame process, and user dependent process in this research field (Andrés et al., 2012).

1.3 Research Questions

As extracted from Section 1.1, the available web design models proposed by previous researchers are unable to fulfill the requirements to some extent which are exposed by web-based system applications. None of them handles interaction processes according to this study's designation, which is usually found in different categories of web applications. Hence, to overcome the issue of development design process, the following research questions are formulated:

1. What are the roles of interaction processes in web-based system application? How do we define interaction processes in web-based system applications design context?
2. How do the interaction processes adapt with different possibilities in navigation and presentable to the designers in the design model?
3. How does the Graphical User Interface (GUI) design cooperate with the interaction processes and users?
4. How can we ensure that the proposed design models fulfill and resolve issues of interaction processes in web-based system application?
5. How can we confirm that the proposed design model is practical and is implementable in the web application development?

These research questions are analysed and answered in the following sections.

1.4 Research Objectives

The objective of the study is to obtain a clear picture of the web application design process from a designer's perspective and how the proposed design model is able to solve interaction processes flow involved in the development of web application. This study proposes an extension to the UWE design model and provides the design model with enough expressivity as to model web

applications that provide support towards interactions processes. In this study, expressivity is defined as clarity and simplicity of the design model.

Specifically, the objectives of this study are:

1. To design a conceptual design pattern that is able to solve user interaction activities which comprise of time frame, interrelated, and user dependent processes. The design model provides an extensive approach towards the interaction processes in order to ensure the interaction processes are well-integrated into the design model.
2. To develop a navigational design pattern that is able to provide detailed navigation activities. The design model utilises UML stereotypes and the features of the extensions in the navigation design stage as to depict the interaction processes structures in the design model.
3. To design user interface mapping pattern that provides a physical layout for Graphical User Interface (GUI) elements. The design model integrates physical design layout in the user interface design stage in order to position the GUI features in the design model.
4. To construct an expressivity web design model that comprises a conceptual design, navigational design, and user interface design. The design model utilises UML stereotypes for modeling the interaction processes.
5. To evaluate the correctness of the web design model through a case study example, Academic Management System (AMS) which comprises of interaction processes.

In particular, the solution proposed in this thesis has been applied to a design model named UML-based Web Engineering (UWE) (N. P. De Koch, 2001). This approach has already been extended to cope with conceptual (Jantan, 2012), navigationality (Wakil et al., 2014) and presentation layout (Karzan Wakil & Jawawi, 2014). In this thesis, an extension is proposed to provide the design models with enough expressivity to model web applications that involve support to the execution of interaction processes.

1.5 Research Scope

This study is focused in designing interaction processes mentioned in Section 1.1, which are time frame, user dependent, and interrelated processes. In other words, the study emphasises the design modeling of interaction processes which occur in the development of web applications. Hence, the case study is developed by the author to demonstrate the interaction processes design modeling. The case study is not developed as a complete web application with full modules of academic management process. The database issues, server platforms, aesthetic value of the design, and user satisfactions are not covered in this study (Durán & Eduardo, 2008; Jantan, 2012; N. P. De Koch, 2001).

1.6 Research Contributions

Nowadays, web applications are getting increasingly complex and are fully packed with information and interactions that need to be carefully designed. This study could provide information on design modeling of web applications and highlight the design issues among the web designers and developers. The conceptual design model could assist web designers and developers in designing the conceptual domain of the web applications. Subsequently, the navigational design model can enhance designers' navigation information structures and access elements. Additionally, a user interface design model with a well-planned creation of GUI model will give a standard presentation model of web applications in terms of the physical and logical view of the model. The proposed design model utilises UML as the design notation diagrams for the interaction processes. In other words, this study contributes UML extension stereotypes and also designs patterns in the designing structures.

The findings in this study will benefit web designers and developers, especially in designing web applications which are comprised of interaction processes. Nevertheless, the design structures can be treated as a guideline in web designing process for novice web designers and developers.

1.7 Structure of the Thesis

The thesis has been structured in seven chapters as follows:

- **Chapter 2. Literature Review.** This chapter provides an analysis of the literature work found in the web design modeling area. Specifically, this chapter emphasises the solutions proposed by each of the original and revised design models regarding the integration of interaction processes. The preliminary survey is also included as an additional support for the literature.
- **Chapter 3. Research Methodology.** This chapter outlines the research methodology employed in this study. Specific details on how the research has been conducted and the step-by-step research approach are explained in this chapter.
- **Chapter 4. UEWDM Design Processes.** This chapter discusses the set of the proposed design models, the interactions between all models, the elements consumed and generated in each step of the development process. Specifically, this chapter presents the complete research work on design processes and development in web application.
- **Chapter 5. UEWDM Implementation.** This chapter presents the UEWDM implementation in a case study called Academic Management System. This study demonstrates how the proposed UML stereotypes and the extensions cope with the interaction processes occurred in AMS.

- **Chapter 6. Results and Discussion.** This chapter provides discussions on the findings and justification of the research work. This chapter will then specifically focus on the interpretations of the results obtained from the implementation of UEWDM in the case study. Design verification and validation results from experts are also included in this chapter.
- **Chapter 7. Conclusions and Future Works.** This chapter summarises the main contribution of the proposed design models and provides recommendations for future research work.

REFERENCES

Al-Fedaghi, S. (2011). Developing web applications. *International Journal of Software Engineering and Its Applications*, *5*(2), 57–68. http://doi.org/10.1007/978-1-4302-0439-8_13

Andrés, J., Londoño, H., & Duitama, J. F. (2012). Model-Driven Web Engineering Methods : A Literature Review. *Revista Facultad de Ingeniería Universidad de Antioquia*, *63*, 69–81.

Aragón, G., Escalona, M. J., Lang, M., & Hilera, J. R. (2013). An analysis of model-driven web engineering methodologies. *International Journal of Innovative Computing, Information and Control*.

Azlan, W., Hassan, W., Teridi, N. A., Abdullah, K. A., & Hamid, A. (2010). An Assessment Study On Usability Of Academic Management System, 199–202.

Baresi, L., Colazzo, S., Mainetti, L., & Morasca, S. (2006). W2000 : A Modeling Notation for Complex Web Applications. In *Web Engineering. Springer Berlin Heidelberg* (pp. 335–364). http://doi.org/10.1007/3-540-28218-1_11

Brambilla, M., & Fraternali, P. (2013). Large-scale Model-Driven Engineering of web user interaction: The WebML and WebRatio experience. *Science of Computer Programming*, *89*, 71–87. http://doi.org/10.1016/j.scico.2013.03.010

Brambilla, M., & Fraternali, P. (2015). *Interaction Flow Modeling Language. Interaction Flow Modeling Language*. http://doi.org/10.1016/B978-0-12-800108-0.00010-2

Brambilla, M., & Mauri, A. (2012). Model-driven Development of Social Network enabled Applications with WebML and Social Primitives. In *Current Trends in Web Engineering* (pp. 41–55). Springer Berlin Heidelberg.

Ceri, S., Fraternali, P., Bongio, A., & Milano, P. (2000). Web Modeling Language (WebML): a modeling language for designing Web sites. *Computer Networks*, *33*(1), 137–157.

Cestra, G., Liguori, G., & Clementini, E. (2013). An extended uml metamodel for efficient application design and development. *International Journal of Software Engineering and Its Applications*, *7*(4), 359–378. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84884576882&partnerID=40&md5=1d34de47be8bee99dd7435ce0546d4b1

Comai, S., & Mazza, D. (2012). A model-driven methodology to the content layout problem in web applications. *{ACM} Transactions on the Web*, *6*(3), 10:1–10:38. http://doi.org/10.1145/2344416.2344417

Cortés, H., & Navarro, A. (2014). NMMp: A Model-Driven UML Extension for the Description of Navigation Maps for Web Applications. *International Journal of Software Engineering & Knowledge Engineering*, *24*(3), 391–417. http://doi.org/10.1142/S0218194014500156

Creswell, J. (2013). Qualitative, quantitative, and mixed methods approaches. *Research Design*, 1–26. http://doi.org/10.2307/3152153

De Troyer, O. M. F., & Leune, C. J. (1998). WSDM: a user centered design method for Web sites. *Computer Networks and ISDN Systems*, *30*(1-7), 85–94. http://doi.org/10.1016/S0169-7552(98)00042-7

Distante, D., Tilley, S., & Canfora, G. (2006). Towards a holistic approach to redesigning legacy applications for the Web with UWAT+. *2011 15th European Conference on Software Maintenance and Reengineering*, *0*, 295–299. http://doi.org/10.1109/CSMR.2006.55

Durán, R., & Eduardo, G. (2008). Modelling adaptive web applications in OOWS., (March). Retrieved from http://dspace.upv.es/xmlui/handle/10251/2000

Elminir, H. K., Elsoud, M. A., & Halawany, A. M. E.-. (2011a). UML based engineering framework for modeling web application. *Journal of Software Engineering*, *5*(2), 49–63.

Elminir, H. K., Elsoud, M. A., & Halawany, A. M. E.-. (2011b). Uml-based Web Engineering Framework for Modeling Web Application. *Journal of Software Engineering*, *5*(2), 49–63. http://doi.org/10.3923/jse.2011.49.63

Garzotto, F. (2001). Ubiquitous Web Applications. In *Advances in Databases and Information Systems* (p. 1). Springer Berlin Heidelberg. http://doi.org/10.1007/3-540-44803-9_1

Garzotto, F., Schwabe, D., & Paolini, P. (1993). HDM — A Model-Based Approach to Hypertext Application Design. In *ACM Transactions on Information Systems (TOIS) 11* (Vol. 11, pp. 1–26). http://doi.org/10.1145/151480.151483

Gómez, J., & Cachero, C. (2003). OO-H Method : Extending UML to Model Web Interfaces. *Information Modeling for Internet Applications*, 144–173. Retrieved from http://www.dlsi.ua.es/~ccachero/papers/igp.pdf

Gómez, J., Cachero, C., & Pastor, O. (2000). Extending a conceptual modelling approach to web application design. *Advanced Information Systems Engineering*, 79–93. Retrieved from http://www.springerlink.com/index/Q3F6AXRQ9JMCWGD5.pdf

Grigera, J., Rivero, J. M., Robles Luna, E., Giacosa, F., Rossi, G., & Luna, E. R. (2012). From Requirements to Web Applications in an Agile Model-Driven Approach. In *Web Engineering* (Vol. 7387, pp. 200–214). http://doi.org/10.1007/978-3-642-31753-8_15

Grillo, F. D. N., & Fortes, R. P. de M. (2014). Accessible Modeling on the Web: A Case Study. *Procedia Computer Science*, *27*, 460–470. http://doi.org/10.1016/j.procs.2014.02.050

Harrison, R., Flood, D., & Duce, D. (2013). Usability of mobile applications: literature review and rationale for a new usability model. *Journal of Interaction Science*, *1*(1), 1. http://doi.org/10.1186/2194-0827-1-1

Herrero Agustin, J. L., & del Barco, P. C. (2013). A model-driven approach to

develop high performance web applications. *Journal of Systems and Software*, *86*(12), 3013–3023. http://doi.org/10.1016/j.jss.2013.07.028

Hoisl, B., & Strembeck, M. (2012). A UML Extension for the Model-Driven Specification of Audit Rules. In *Advanced Information Systems Engineering Workshops, CAiSE 2012 International Workshops* (pp. 16–30). http://doi.org/10.1007/978-3-642-31069-0_2

Huang, Y., Wu, C., & Chu, C. (2011). A New Approach for Web Engineering Based on Model Driven Architecture. In *International Conference on Management Learning and Business Technology Education*.

Jantan, A. H. (2012). An Extension of UML Modeling for Web Hypermedia Design : A Case Study. *International Journal of Information*, *2*(1), 69–78.

Knapp, A., Koch, N., Moser, F., & Zhang, G. (2003). ArgoUWE : A CASE Tool for Web Applications. In *1st International Workshop Engineering Methods to Support Information Systems Evolution (EMSISE'03)* (pp. 1–14).

Koch, N. P. De. (2001). *Software Engineering for Adaptive Hypermedia Systems and Development Process*. Verlag Uni-Druck, Munich.

Koch, N., & Kozuruba, S. (2012a). *Current Trends in Web Engineering. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 7703). http://doi.org/10.1007/978-3-642-35623-0

Koch, N., & Kozuruba, S. (2012b). Requirements Models as First Class Entities in Model-Driven Web Engineering. In *Current Trends in Web Engineering. Springer Berlin Heidelberg* (pp. 158–169). http://doi.org/10.1007/978-3-642-35623-0_16

Koch, N., & Kraus, A. (2001). The Expressive Power of UML-based Web Engineering.

Koch, N., Kraus, A., & Hennicker, R. (2001). The Authoring Process of the UML-based Web Engineering Approach. *First International Workshop on Web-Oriented Software Technology*, 1–29.

Kruchten, P. (2004). *The Rational Unified Process: An Introduction. Addison-Wesley Professional.* Addison-Wesley Professional. http://doi.org/10.1.1.27.4399

Kumar, S., & Sangwan, S. (2011). Adapting the Software Engineering Process To Web Engineering Process. *International Journal of Computing and Business Research (IJCBR)*, *2*(1).

Lin, J., Sulaman, S. M., & Martin, H. (2015). Guidelines for Conducting Surveys in Software Engineering, *08*.

Liu, G. Z., Liu, Z. H., & Hwang, G. J. (2011). Developing multi-dimensional evaluation criteria for English learning websites with university students and professors. *Computers and Education*, *56*(1), 65–79. http://doi.org/10.1016/j.compedu.2010.08.019

Mason, M. (2010). Sample Size and Saturation in PhD Studies Using

Qualitative Interviews. *Forum: Qualitative Social Research*, *11*(3), 1–19. http://doi.org/http://nbn-resolving.de/urn:nbn:de:0114-fqs100387

Milicic, D. (2005). *Software Quality Models and Philosophies*. Blekinge Institute of Technology: Software quality attribute and trade-offs.

Mohagheghi, P., Dehlen, V., & Neple, T. (2009). Definitions and approaches to model quality in model-based software development - A review of literature. *Information and Software Technology*, *51*(12), 1646–1669. http://doi.org/10.1016/j.infsof.2009.04.004

Mukhtar, M. A. O., Fadzil, M. H., Jaafar, J., & Rahim, L. A. (2014). WSDMDA: An Enhanced Model Driven Web Engineering Methodology. In *International Conference on Control System, Computing and Engineering (ICCSCE), 2014 IEEE* (pp. 484–489). Retrieved from http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7072767

Murugesan, S., Deshpande, Y., Hansen, S., & Ginige, A. (2001). Web Engineering: A New Discipline for Development of Web-based Systems. In *Web Engineering* (pp. 3–13). Springer Berlin Heidelberg.

Murugesan, S., & Ginige, A. (2005). *Web Engineering: Introduction and Perspectives*. Idea Group Inc.

Nugroho, A. (2009). Level of detail in UML models and its impact on model comprehension: A controlled experiment. *Information and Software Technology*, *51*(12), 1670–1685. http://doi.org/10.1016/j.infsof.2009.04.007

OMG Unified Modeling Language. (2007). OMG Unified Modeling Language (OMG UML). http://doi.org/10.1007/s002870050092

OMG Unified Modeling Language Specification. (1999). Retrieved from http://www.omg.org/spec/UML/1.3/PDF

Pastor, O., Fons, J., & Pelechano, V. (2003). OOWS: A Method to Develop Web Applications from Web-Oriented Conceptual Models. *International Workshop on Web Oriented Software Technology (IWWOST)*, 65–70. Retrieved from http://ceit.aut.ac.ir/~sa_hashemi/My Research/0-Selected Papers/2-ECommerce Systems/OOWS A Method to Develop Web Applications from Web-Oriented Conceptual _ 6.pdf

Pastor, O., Insfrán, E., Merseguer, J., Romero, J., & Pelechano, V. (1997). OO-METHOD: An OO Software Production Environment Combining Conventional and Formal Methods. In *Proceedings of CAISE'97* (Vol. 1250, pp. 145–159). http://doi.org/10.1007/3-540-63107-0_11

Patel, P., Hande, A., & Meshram, B. B. (2013). Survey of Existing Web Models Techniques to Design Web Application. *International Journal of Computer Technology and Applications*, *4*(June), 514–521.

Per Runeson, Martin Host, Austen Rainer, B. R. (2012). *Case Study Research in Software Engineering*. New Jersey: John Wlley & Sons, Inc.

Petre, M. (2013). UML in practice. *Proceedings - International Conference on Software Engineering*, 722–731.

http://doi.org/10.1109/ICSE.2013.6606618

Reich, S., Kappel, G., & Pr, B. (2006). *Web Engineering: The Discipline of Systematic Development of Web Applications. International Journal of Information Technology and Web Engineering* (Vol. 4). http://doi.org/10.4018/jitwe.2009100606

Rosenberg, D., & Stephens, M. (2007). *Use case driven object modeling with UML: Theory and Practice. Use Case Driven Object Modeling with UML: Theory and Practice*. http://doi.org/10.1007/978-1-4302-0369-8_1

Rossi, G. (2008). *Web Engineering: Modelling and Implementing Web Applications. Web Engineering Modelling and Implementing Web Applications* (Vol. 12). http://doi.org/10.1007/978-1-84628-923-1

Rossi, G., Urbieta, M., Distante, D., Rivero, J. M., & Firmenich, S. (2016). 25 Years of Model-Driven Web Engineering: What we achieved, What is missing. *CLEI Electronic Journal*, *19*(3), 1:1–1:29. http://doi.org/10.19153/cleiej.19.3.1

Schnall, R., Bakken, S., Iii, W. B., Carballo-Dieguez, A., & Iribarren, S. (2016). Usabilty evaluation of a prototype mobile app for health management for persons living with HIV. In *Studies in Health Technology and Informatics* (Vol. 225, pp. 481–485). http://doi.org/10.3233/978-1-61499-658-3-481

Schwabe, D., & Rossi, G. (1998). Developing Hypermedia Applications using OOHDM. *Workshop on Hypermedia Development Processes Methods and Models Hypertext98*, *98*, 1–20. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.40.4780

Serrano, N., Hernantes, J., & Gallardo, G. (2013). Mobile web apps. *IEEE Software*, *30*(5), 22–27. http://doi.org/10.1109/MS.2013.111

Sim, S., & Ratanotayanon, S. (2006). An initial study to develop an empirical test for software engineering expertise. *Institute for Software Research*, University of California (January), 10. Retrieved from http://www.researchgate.net/profile/Susan_Sim2/publication/228971739_An_Initial_Study_to_Develop_an_Empirical_Test_for_Software_Engineering_Expertise/links/0a85e533984258a95a000000.pdf

Troyer, O. De. (2015). Revising Web Design to Deal with Current Development Practices. In *Proceedings of the 11th Asia-Pacific Conference on Conceptual Modelling (APCCM 2015)* (pp. 27–30).

Troyer, O. De, Casteleyn, S., & Plessers, P. (2008). Wsdm : Web Semantics Design Method. In *Web Engineering: Modeling and Implementing Web Applications* (Vol. 30, pp. 303–351). http://doi.org/10.1007/978-1-84628-923-1_11

Urbieta, M., Rossi, G., Distante, D., & Ginzburg, J. (2012). Modeling, Deploying and Controlling Volatile Functionalities in Web Applications. *International Journal of Software Engineering and Knowledge Engineering*. http://doi.org/10.1142/S0218194012500064

Valderas, P., Pelechano, V., & Pastor, O. (2007). Introducing Graphic

Designers in a Web Development Process. In *Advanced Information Systems Engineering* (Vol. 4495, pp. 395–408). Retrieved from http://dx.doi.org/10.1007/978-3-540-72988-4_28

Valderas, P., Pelechano, V., & Polit, U. (2011). A Survey of Requirements Specification in Model-Driven. In *ACM Transactions on the Web (TWEB)* (Vol. 5, p. 10). http://doi.org/10.1145/1961659.1961664

Vera, P., Giulianelli, D., Rodriguez, R., & Pons, C. (2012). User interface and navigation modeling methodology for mobile hypermedia systems. In *2012 7th Colombian Computing Congress (CCC)* (pp. 1–6). http://doi.org/10.1109/ColombianCC.2012.6398041

Wakil, K., & Jawawi, D. N. A. (2014). Metamodels evaluation of web engineering methodologies to develop. *International Journal of Software Engineering & Applications (IJSEA)*, *5*(5). http://doi.org/10.5121/ijsea.2014.5504

Wakil, K., & Jawawi, D. N. A. (2015). Model driven web engineering: A systematic mapping study. *E-Informatica Software Engineering Journal*, *9*(1), 87–122. http://doi.org/10.5277/E-INF150106

Wakil, K., & Jawawi, D. N. A. (2017). Analyzing Interaction Flow Modeling Language in Web Development Lifecycle. *IJACSA) International Journal of Advanced Computer Science and Applications*, *8*(1). http://doi.org/10.14569/IJACSA.2017.080137

Wakil, K., Safi, A., & Jawawi, D. N. A. (2014). Enhancement of UWE navigation model: Homepage development case study. *International Journal of Software Engineering and Its Applications*, *8*(4), 197–212. http://doi.org/10.14257/ijseia.2014.8.4.21

Yin, R. K. (2009). Case Study Research - Design and Methods. *United States: Library of Congress Cataloguing-in-Publication Data*, *2*, 8–13. http://doi.org/10.1016/j.jada.2010.09.005

Zaiontz, C. (2015). Real Statistics Using Excel. Retrieved from www.real-statistics.com

BIODATA OF STUDENT

Siti Azreena was born in 1981 in Negeri Sembilan, Malaysia. She received her Bachelor degree (hons.) in Information Technology majoring in Multimedia Systems at the University of Multimedia in 2003. From 2003 to 2005, she worked at the Multimedia Synergy Sdn. Bhd as Multimedia Programmer. From 2006 to 2008, she worked as a tuition teacher. She started her Master degree in Computer Science at University of Putra Malaysia (UPM), Selangor in 2010 during her work as senior lecturer at KFCH International College (KFCIC), Selangor (2008 – 2014). She commenced with her PhD just after she graduated her Master in 2012. Currently, she works as a lecturer at Kolej Yayasan Saad Business School, Malacca. At the same time she is a freelance Swift Developer (iOS Apps) at Brainstorm Technologies Sdn. Bhd. Her research interests are Web Design and Development, Human Computer Interaction, Pattern Recognition and Multimedia Technology and Application. As one of the finalists in UPM 3 Minute Thesis Competition, she believed in order to success, she needs to walk out from her comfort zone and always challenge herself.

LIST OF PUBLICATIONS

Siti Azreena Mubin, Azrul Hazri Jantan, Rusli Abdullah, Azrina Kamaruddin, "UEWDM User Interface Design: A Case Study of i-GIMS", *International Conference on Computational Science and Technology (ICCST), 2016 on*. Advanced Science Letters (ASL), Nov 2016.

Siti Azreena Mubin, Azrul Hazri Jantan, Rusli Abdullah, Azrina Kamaruddin, "UML-based Conceptual Design Approach for Modeling Complex Processes in Web Application", International Journal of Applied Engineering Research (IJAER), Vol. 11, No. 6, pp. 4579-4585, 2016.

Siti Azreena Mubin and Azrul Hazri Jantan. "A Modeling Approach for the Development of Process Driven Web Applications", International Journal of Engineering Research and Technology (IJERT), Vol. 3, Issue 10, pp. 785-792, October 2014.

Siti Azreena Mubin, Azrul Hazri Jantan, Rusli Abdullah and Azrina Kamaruddin. "UML Stereotypes for the Development of Process Interaction-Driven Web Applications." *International Human-Computer Interaction and User Experience Conference (CHIuXiD), 2016 on*. ACM, April 2016.

Siti Azreena Mubin, Azrul Hazri Jantan, Rusli Abdullah and Azrina Kamaruddin. "UML-based Navigational Design Approach for Modeling Complex Interactions in Web Applications." *Malaysian Software Engineering Conference (MySEC), 2015 on*. IEEE, December 2015.

Siti Azreena Mubin and Azrul Hazri Jantan, "A Preliminary Study on Design Concept of Academic Management System", Postgraduate Information Technology Colloquium (INTEC 2015), UPM, 7 - 8 April 2015.

Siti Azreena Mubin and Azrul Hazri Jantan. "A UML 2.0 profile web design framework for modeling complex web application." *Information Technology and Multimedia (ICIMU), 2014 International Conference on*. IEEE, November 2014.

Siti Azreena Mubin and Azrul Hazri Jantan. "A Review on Web Design Processes: How They Incorporated in a Complex System", Proceeding of The Software Engineering Postrgraduate Workshop (SEPoW 2013), UTeM Malacca, 19 November 2013.

Siti Azreena Mubin and Azrul Hazri Jantan. "A Review on Web Engineering Application Designs: A Case Study on Academic Management System", Proceeding of The International Research Conference on Information Technology and Computer Sciences (IRCITCS 2013), Kuala Lumpur, 28-30 September 2013.