Guidance in Web Applications Design

Semia Sonia Selmi, Naoufel Kraiem, and Henda Hajjami Ben Ghezala

RIADI-GDL, National School of Computer Sciences, Campus Universitaire
Manouba, 2010, Tunisia
semiasonia.selmi@riadi.rnu.tn, naoufel.kraiem@ensi.rnu.tn, henda.BG@cck.rnu.tn

Abstract. *The paper introduces a new situational method for Web applications design. The purpose of the approach is to respond to the following limits of web development methods: they do not cover all design aspects and they lack of flexibility and guidance. The approach consists on the construction, on the fly, of new methods based on existing methods components, that are redefined and stored in method repository to be selected and assembled in a new method. The approach provides two types of guidance: (1) guidance in the selection of the most appropriate process-model, (2) guidance in the selection of the most appropriate method components.*

Key words: web application, web development method, method engineering, situational method

1 Introduction

The growth of the Internet and the world wide web has resulted in a large number of web applications. The development of these applications and the practices used to their development are different from traditional software development [21]. The essence of such discipline is to successfully manage the diversity and complexity of Web application development, and hence, to avoid potential failures that can have serious implications [12].
Although various methods have been proposed in literature, none of these aforementioned techniques and methodologies are used to any significant extent in practice [1].
The empirical study conducted in [1] revealed that web developers judge that existing methods are too cumbersome. They prescribe complex tasks rather than broad guidelines. In fact, for methods to be in use, they must be framed at a high level of granularity. Also, the empirical study conducted by [6] showed that a methodology must be suitable to the particular context of use [4] [35]. Due to the so broad range of web applications, no single methodology could possibly be relevant for designing them all [22]. There is a need to develop a better understanding of web development methods because of the large impact that has on web applications being developed.

Based on these observations, we have interested in the following research issue: How can we assist web designers to design web applications through the

use of existing and proposed methods ? When answering this question, we have study of near existing web development methods. Two sub-research issues have been, consequently, appeared turning around these following questions: **(1)** How can we structure design process without adding a new method to the already existing list of methods and avoiding, so, to fall in the YAM (Yet Another Model) syndrome? and **(2)** Could we propose a flexible solution rather than a prescriptive one?

First, we present our contribution. Second, we give an overview of the proposed approach. Finally, we describe how the approach provide guidance in the selection of the most appropriate design process and in the selection of the most appropriate method components.

1.1 Motivation and Contribution

To understand, deeply, the discipline of Web engineering, we have established a Web Engineering Framework [31]. To outline limits of existing methods we have proceed to the evaluation of seven methods among the most referenced ones in literature (RMM [8], UWE [17], WSDM [7], OOHDM [14], Takahashi Method [34], WebML [5] and HFPM [23]) according to the different views of the framework. This evaluation has revealed particularly three limits.

1. Informational aspect dominates the process design. We have noticed that the majority of methods do not consider all aspects having to be considered during design process.
2. All existing methods are prescriptive (except HFPM). In fact, they prescribe a list of tasks to be done without considering neither the development situation at hand nor designer experience.
3. Some methods lack guidance: they prescribe phases in their life cycle without detailing them or describing how to achieve them.

Considering all these issues, we propose to both relax the prescription of web design process model even further and cover all aspects that should be considered during web design. Situational Method Engineering responds to this need by offering techniques to construct methods by assembling reusable method components stored in a method repository. [3] has defined the Situational Method Engineering as "*the discipline to build project-specific methods, called situational methods, from parts of existing methods, called methods fragments*".
We talk, henceforth, about Web oriented Situational Method Engineering that proposes to support, on the fly, construction of web development methods based on a reuse strategy. By assembling reusable method components originating from different web development methods, a new method can be tailored to the project situation at hand. New methods can thus be constructed by selecting the set of components that are the most appropriate to a given situation from the method repository. As it can be seen, Web oriented Situational Methods discipline favors the construction of modular web development methods that can be modified and

augmented to meet the requirements of a given situation.

2 Overview of the Approach

At the beginning of the web design process, the designer is invited to characterize the current situation of the web application being developed by a set of situational factors. Based on introduced situational factors, the most appropriate design process is selected at different levels of abstraction.
The selected path is constituted of successive steps allowing each one the definition of a product model. We have adopted this principle conformingly to existing methodologies which often advocate a model-driven approach, inspired by the separation-of-concerns principle. In order to tackle the complexity of the problem, each model in the system focuses on a different aspect of the design and often also a different level of abstraction. The different steps which constitute the selected path are achieved by method components. These latter are defined accordingly to the COMET meta-model [24] and stored in a method repository in order to be selected. To be able to select the most appropriate method components, we have fixed a set of selection criteria for each product model involved. We have used the multi-criteria analysis approach to select most appropriate method components.
Selected components are, then, assembled and transformations from instances of one model into instances of the next model are taken place to, ultimately, reaching the final result in the form of a web situational method.
In this sense, our solution is based on the following aspects which were be further detailed in this paper: **(1)** a list of classified product models [29], **(2)** a set of situational factors characterizing the current situation [32], **(3)** a web applications design process meta-model providing required guidance during design [30], **(4)** a set of selection criteria which lie to product models [33].

We propose a multi-process method offering panoply of design processes for web applications. Every activity addresses a particular concern and is accomplished separately since it covers existing approaches transparently.
First, we base our process meta-model on a set of product models concerning each one a particular aspect of design. Second, to model associated design process models, we need to adopt a process model formalism. As our solution provides many alternatives and paths, strategic oriented process models seems to be the solution. In particular, the MAP formalism belonging to this class can be employed to model the design process as we intend to do; that is why we keep it for our solution.

In the following, we present first, product models and their classification, and second, we give a brief description of the MAP formalism. Finally, we describe the different situational factors in which navigation in process meta-model is based on.

2.1 The Product Models

Web development methods consider design phase as a phase of product models delivery, addressing each one a particular concern of design.
A typical web design approach deliver the following product models [12] [29] [9]:

- Conceptual model: describes the organization of the information managed by the application in terms of pieces of content that constitute its information base and their semantic relationships.
- Navigation model: concerns the facilities for accessing information and for moving across the application content.
- Presentation model: affects the way in which the application content and the navigation commands are presented to the user.
- Requirements analysis model: gathering and forming the specification of users and/or stakeholders requirements.
- Adaptation modelling: presents the objects that participate in the adaptive functionality and describes how this adaptation is performed [17].
- User model: aims to construct a user model which contains information that represents the view the system has of the knowledge, goals and/or individual features of user.
- Services model: describes the operational level, that is the set of the services (tasks) offered by web application. This model called also process model [18] or task model aims to representing and organizing the different tasks user can execute in application.
- Business model: It is important for the e-business applications design. It helps designers and developers, for instance, in identifying and understanding the relevant elements in a specific domain and their relationships.

Although existing web development methods recommend to deliver aforementioned models, we have noted that they do not consider them with the same degree of importance. In fact, they focus on the informational aspect by delivering: conceptual model, navigation model and presentation model. This is can be justified by two reasons: (1) at the early beginning of the web, web applications have primarily the role of disseminating information to users. This made methods privilege information dimension and derived aspects such as navigation and presentation; (2) informational dimension is recognized as fondamental in the design of any web application type [11], [9],[15], [25], etc. However, web applications are evolving from simple web sites to more and more complex and sophisticated applications.

Consequently, others aspects besides the informational dimension should be considered during their design.
Based on this analysis, we have classified aforementioned product models in two classes: *Commun models* class and *Features models* class. The first class comprises conceptual model, navigation model and presentation model. The second class contains requirements analysis model, adaptation model, user model, business model and services model.

The proposed approach covers all aforementioned design product models and adopt the process meta-model MAP as modelling formalism. In the following, we present an overview of the MAP and its associated guidelines.

2.2 The Process Meta-Model Formalized with MAP

A MAP is a meta-process model which allows designing several processes under a single representation. It is a labelled directed graph with intentions as nodes and strategies as edges between intentions.
The directed nature of the graph shows which intentions can follow which ones. A MAP is composed of one or more sections. A section is a triplet <source intention I, target intention J, strategy Sij> that captures the specific manner to achieve the intention J starting from the intention I with the strategy Sij. An intention is expressed in natural language and is composed of a verb followed by parameters. Each MAP has two special intentions "Start" and "Stop" to respectively begin and end the navigation in the MAP. Each intention can only appear once in a given MAP. To each section, is associated a guideline that can be one of the following three types: Simple, Tactic or Strategic. There are three guidelines associated with a MAP: IAG, ISG and SSG. IAG can be one of the aforementioned types namely tactic or simple or strategic while SSG and ISG are always tactic guidelines. For more details see [2].

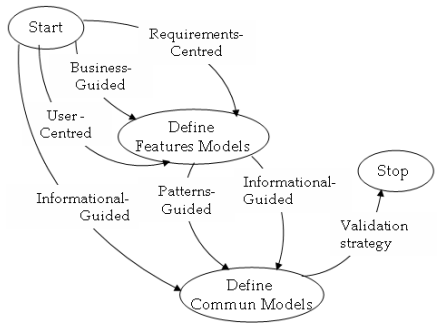

Fig. 1. The Web design process meta-model.

The process meta-model for the web applications design formalized using MAP is shown in figure 1. It contains two core intentions "Define Commun models" and "Define Features models" in addition to "Start" and "Stop" intentions.
To allow designer going through the different intentions of the map, the approach provides a set of factors called Situational Factors.

2.3 Situational Factors

The first step is to analyze the projects, categorize them in situations, and identify their specific requirements. The categorization of situations is based on their distinguishing characteristics. [3] and [19] stress the importance of distinguishing development situations.
[16] defines a characteristic of a development situation as: *a delimited part of a development situation, focusing on a certain problem or aspect which the method configuration aims to solve or handle*.

By analogy, we have proposed a list of situational factors characterizing current development situation. They help designer to choose the appropriate strategy among those presented in the map. We have identified the following factors:

Application type: {kiosque application, Web Information System, Adaptive application, e-commerce application}
All aforementioned types are obviously web applications; however they are different in term of deliverable models during design process.

Service complexity: {Low, Medium, High}
Application complexity is measured through the complexity of services offered by application. Being more complex than kiosque applications, WIS should be designed differently, by giving more attention to services modelling dimension.

Similarity with others applications: {Low, Medium, High}
The similarity with others applications factor specifies if the designer has already participated in the development of similar applications belonging to the same domain. It is to notice that web applications belonging to a same domain have similar structures and provide similar services. Thus, during design process, approach considers designer profile by offering to him the possibility to reuse their past experiences.

User-application adaptation: {Low, Medium, High}
This factor determines the adaptation degree of the application to users. A user-application adaptation having a high degree is specific to adaptive applications. when designer consider user aspect during design process a user-centered approach, this factor will take Medium value. In other cases, this factor will be of a low degree.

Problem clarification: {Low, Medium, High}
This factor reveals either the problem description of the current project is well defined and clarified or not.

Designer Experience: {Low, Medium, High}
The approach considers the different profiles of designers such whose having long experiences. In fact, they can exploit the different design patterns collected and stored to be employed.

Situational factors guide designer during navigation through the design process meta-model. We continue, in the following section, with showing how the proposed approach employ these aforementioned factors during the design process.

3 Guidance in Design Process Model Selection

The choice of a particular path among those of the meta-model of figure 1 depends largely on purpose of designer in term of web application type to be designed. A more in-depth analysis of the process MAP shows that designer is guided in very deep and flexible ways. Associated sections are refined to a lower level of abstraction proposing various techniques available to achieve the corresponding intentions.
From the "Start" intention, designer is faced to a choice of two alternatives. He can either progress to achieve "Define Features Model" intention or "Define Commun Model" intention.
When designing a simple web site (kiosk application) which problem description is well identified and requirements are well defined, designer should progress to "Define Commun Model" intention. In others cases, designer should progress to "Define Features Model" intention.
When progressing to "Define Commun Model" intention, designer can perform only one strategy named *Informational-guided* strategy. However, if he intends to progress to "Define Features Model" intention, he is faced to three alternatives. These strategies can be performed in parallel or alternatively depending on given situation:

Business-guided strategy is followed when designer intends to develop an e-commerce application. In this case, he needs to conceptualize both Business Model and Services Model. We provide designer with the ability to design a Services Model in particular for WIS which are characterized by a high complexity of service. This strategy will be refined with a strategic guideline: a MAP at a lower level of abstraction. This latter contains two intentions: "Define Business Model" and "Define Services Model".

User-centered strategy can be performed when designing an adaptive application. In this case, designer needs to consider users aspects and/or adaptation techniques through a user model and/or an adaptation model.

Requirements-centered strategy helps to gather and form specification of users and stakeholder requirements.

All aforementioned guidelines associated to these strategies are refined through a MAP at lower level of abstraction. We have to stress that these three strategies can be performed alternatively or together. Let's taken the example of an e-commerce application where requirements are all the time different and several. In fact, such application is characterized by both a high complexity of services and heterogeneity of clients to who we should satisfy requirements. Consequently, all strategies *Requirements-centered*, *User-centered* and *Business-guided* strategy must be followed and achieved in this case.
Once "Define Features Model" intention is achieved, designer should progress to "Define Commun Model" intention either following *informational-guided* strategy or *patterns-based* strategy. We should recall that he can design a kiosk application and in this case, he follows also *informational-guided* strategy from

"Start" intention. Being in one or other situation and at a lower level of granularity, refinement of this strategy is done through a MAP providing panoply of paths and strategies from "Start" and "Stop" intentions. It contains three core intentions: "Define Conceptual Model", "Define Navigation Model" and "Define Presentation Model".

Beginning from the "Start" intention, designer is faced to two strategies to achieve "Define Conceptual Model" intention. The *modelling techniques-based* strategy is applied when designer decides to start from scratch and to adopt a well known conceptual data-model like ER model or any Object-Oriented technique [27] to define conceptual model. By applying *web design framework-guided* strategy, designer has experience in current domain and has, already, designed similar applications in similar domain. Designer can reuse conceptual schemas already elaborated during similar past projects. He should only personalize and adapt hot-spots according to specificities of the project at hand. While defining the conceptual model, *Service-guided* strategy and/or *Content adaptation-based* strategy can be followed respectively when designer intends to enrich model with concepts associated to business process modelling and/or application being designed is an adaptive one.
Once the "Define Conceptual model" intention is achieved, designer progresses to achieve "Define navigation model" intention either by following *web design framework-guided* strategy or *process-guided* strategy. The first consists on the same one as the previous step but navigation oriented at this level. The *process-guided* strategy allows to be guided by a particular method selected as the most appropriate one from method components repository. The same strategies are, also, proposed to achieve "Define Presentation Model" intention oriented, here, presentation dimension. Navigation in the Map is stopped by the *validation* strategy aiming to validate the different product models defined.

Once the most appropriate design process is selected, we proceed to the selection of method components based on a list of criteria by employing a multi-criteria method.

4 Guidance in Method Components Selection

We describe in this section how the approach allows selection of the most appropriate method components given a selected design process. The selection step is realized based on a set of selection criteria associated to each defined product model. Designer is invited to attribute values to these criteria every time the *process-guided* strategy is selected.
We have fixed a set of selection criteria characterizing product models; we refer readers to [33] for more details about selection criteria. We limit ourselves to present only those specific to Navigation Model.

- Notation (NOT) indicates the standardization degree of the notation. It can be Standard, Mix or Proper.
- Evolved Dimensions (DIM) indicates dimensions that are considered during design. It can be Statique, Dynamique or Mixte.

- Access Structures (StrAc) indicates wether method integrates additional navigation nodes. They allow acceding to navigation objects. It is a boolean criteria.
- Adopted approach(APP) indicates the approach adopted to define the navigation model. It can be Button-up, Top-down or Mix.

4.1 The Analytic Hierarchy Process Method

To achieve selection of most appropriate components we propose to employ a multi-criteria method such as the Analytic Hierarchy Process (AHP) method [28]. AHP allows both quantitative and qualitative criteria to be compared using informed judgements to derive weights and priorities.
The first step of AHP consists in determining analysis criteria, in our case, selection criteria associated to product models. Next step aims to elaborate binary comparison, in order, in one hand, to identify importance of one criterium relatively to others, and in the other hand, evaluate method components relatively to every criterium. Introduced values during evaluation should be conform to the AHP table [28].

4.2 The Components Selection Process

To achieve intentions included in selected design process, designer is invited to introduce his preferences by giving priorities between selection criteria as illustrated in figure 2.

$$\mathbf{MC} = \begin{pmatrix} & \mathbf{NOT} & \mathbf{DIM} & \mathbf{StrAc} & \mathbf{APP} \\ \mathbf{NOT} & 1/1 & 3/1 & 3/1 & 7/1 \\ \mathbf{DIM} & 1/3 & 1/1 & 5/1 & 5/1 \\ \mathbf{StrAc} & 1/3 & 1/5 & 1/1 & 3/1 \\ \mathbf{APP} & 1/7 & 1/5 & 1/3 & 1/1 \end{pmatrix} V_{PC} = \begin{pmatrix} 0.5111 \\ 0.3154 \\ 0.1198 \\ 0.0535 \end{pmatrix}$$

Fig. 2. Evaluation Matrix of selection criteria corresponding to Navigation Model and its eigen vector

For instance, the value 7/1 evaluated between notation (NOT) and Adopted Approach (APP) indicates that designer judges that the first criterium (NOT) is much more important than the second criterium (APP). In another side, methods such as OOHDM, WebML, WSDM and UWE, examples of web development methods allowing the production of navigation model are evaluated in method repository. The method expert has the responsibility to compare methods according to every criterium of all product models as illustrated by figure 3.
It is to recall that existing methods do not support product models definition with the same degree of importance. For employed notation, most of methods except UWE method based on UML standard employ mix notation. OOHDM, for example, combines OO technique with its proper notation (context, etc.) and

WebML integrates content units with XML. Evaluation matrix and associated eigen vector are shown in figure 3. For instance, the value 7/1 between UWE and WSDM means that the component of UWE method associated to the navigation model definition is much more important that WSDM component relatively to Notation criterium. This is due to the fact that UWE is entirely based on the standard UML language.

$$MM1 = \begin{pmatrix} & \textbf{OOHDM} & \textbf{WSDM} & \textbf{UWE} & \textbf{WebML} \\ \textbf{OOHDM} & 1/1 & 5/1 & 1/5 & 2/1 \\ \textbf{WSDM} & 1/5 & 1/1 & 1/7 & 1/3 \\ \textbf{UWE} & 5/1 & 7/1 & 1/1 & 7/1 \\ \textbf{WebML} & 1/2 & 3/1 & 1/7 & 1/1 \end{pmatrix}$$

$$V_{PM1} = \begin{pmatrix} 0.2057 \\ 0.0718 \\ 0.5791 \\ 0.1109 \end{pmatrix}$$

Fig. 3. Methods Evaluation matrix / Notation (NOT) Criterium and its eigen vector

The same principle of evaluation is taken for all criteria of a particular product model. All eigen vectors obtained from evaluation matrix (in this case 4 vectors) form a matrix which will be multiplied by the eigen vector obtained from designer comparison matrix. The highest value in the AHP vector corresponds to the most adequate method that is UWE in this example.
At this level, proposed approach continues to guide designer during application and employment of the selected components as they are stored in a method repository and redefined according to COMET meta-model.

5 Conclusion

The paper has presented our proposed approach subscribing in the context of Web oriented Situational Method Engineering discipline. We have begun by describing the process meta-model which is formalized with MAP formalism and allows designer guidance in the selection of the most appropriate design process at different levels of abstraction. We have focused, after that, in describing how the approach guides during selection of most appropriate components through fixed criteria. The approach provides, also, guidance in the application of selected method components. This part is not presented in this paper.

Remark 1. In the printed volumes, illustrations are generally black and white (halftones), and only in exceptional cases, and if the author is prepared to cover the extra cost for color reproduction, are colored pictures accepted. Colored pictures are welcome in the electronic version free of charge. If you send colored figures that are to be printed in black and white, please make sure that they

really are legible in black and white. Some colors as well as the contrast of converted colors show up very poorly when printed in black and white.

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