Engineering a Design Method for Web Content Management Implementations

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ABSTRACT

The process of implementing a Web Content Management System (WCM) can be complex and time consuming. We argue that there is a need for a web engineering methods specifically addressing WCM implementations. In this paper we present the design phase of our Web Engineering Method (WEM). The design phase of WEM addresses fourteen identified key WCM concepts and consists of the main activities: Conceptual Design, Architecture Design, Presentation Design and Detailed Component Design. The proposed method is validated through an expert validation and a case study. Based on the outcome, we developed a prototype of a CASE-application supporting the Conceptual Design activity. Future research includes further development of the CASE-application including the abstract syntax and automation of the transition.

1. INTRODUCTION

Most public and private sector enterprises faced with challenges in satisfying evolving customer needs and meeting regulatory and compliance dictates, utilize Web Content Management (WCM) software. WCM software acts both as a controlling mechanism and an enabler: it controls the processes of managing the Web content with workflow, scheduling, authorization, reuse of content and archiving. WCM software enables organizations to operationalize their own content-delivery strategy with specific user interaction, personalization, and multi-channel delivery.

The implementation process of WCM systems within enterprises however can still be complex and time consuming. There are several reasons to substantiate this. First, WCM-supported Web applications often involve customizations and integration with back-office systems. Secondly, WCM has a collaborative aspect since multiple users from different departments of the enterprise work simultaneously on the same content and functionality. A third reason is that WCM presents information over multiple channels (web, mobile, e-mail, print) for different purposes (sales, marketing, e-business, services, questionnaires, etc.), often in a personalized context. And fourth, implementing WCM systems is not just about the technology, but also about people and processes and therefore involve change management [23], [24].

There is a need for a web engineering method for implementing WCM systems in particular to improve the implementation process (quality and user satisfaction) and speed up the development process [25]. Our resulting leading research question is: 'What is an appropriate method for designing web applications based on a WCM system'. In [25] and [24] we introduced the Web Engineering Method (WEM) as a Web Engineering approach for the implementation of Web Content Management Systems in particular to obtain high maintainability and give business owners the ability to manage and control Web applications. We call these type of Web applications CMS-based Web Applications. WEM is integrated in a traditional implementation method consisting of Orientation, Definition, Design, Realization and Implementation. This paper continues this research and elaborates on the Design phase. The contribution of this research consists of the development of the design phase to implement WCM systems. Secondly, we identified fourteen key WCM concepts which are based on a literature and market analysis. And finally the feasibility of integrating a CASE-application with a WCMS system is demonstrated.

To date, the research field of Web Engineering has resulted in several methods to support the complex task of designing and creating Web Applications [11], the research on the implementation of WCM however is scarce. There are several research groups working on related work. We briefly elaborate on four relevant research groups within the Web Engineering research field. Ceri et al. describe in [3] their Web Modeling Language (WebML), a notation for specifying complex web sites at a conceptual level. WebML and WEM are both focused on Web Engineering and the automated generation of Web Applications. Koch et al. describe the UML-based Web Engineering (UWE) approach in [13]. UWE is an object-oriented, iterative and incremental approach for the development of web applications. Pastor et al. describe different methods with the Object-Oriented Web-Solutions Modeling approach (OOWS). OOWS provides mechanisms to deal with the development of hypermedia information systems and e-commerce applications in web environments [19]. Similar to our framework: the OOWS approach is supported by a commercial software application called OlivaNova. Vdovjak and Houben address in their paper on the Hera project the integration of external content providers explicitly [33]. Hera is a methodology that supports the design

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and engineering of Web information systems. It is a model-driven methodology that distinguishes three parts in the design: integration, data retrieval, and presentation generation [32].

We address the research question by constructing a design method from related methods using assembly-based situational method engineering, we validate it with a case study and make a first prototype of a CASE application. The rest of the paper is organized as follows. Section 2 provides an overview of the construction of the design phase of WEM. Section 3 elaborates on the design phase of WEM itself based on four main activities. Section 4 summarizes the validation of the method based on an expert validation and a case study. In section 5 we present an application of the design phase. Section 6 contains concluding remarks.

2. CREATING THE DESIGN PHASE OF WEM

We apply concepts of assembly-based situational method engineering to find an appropriate method for implementing WCM systems. Situational method engineering is a useful way of approaching this type of research [2], [20]. We start with a description of assembly-based situational method engineering which we used to create an approach consisting of six steps. We elaborate on each of the six steps consecutively.

2.1 Assembly-based situational method engineering

Several approaches have been proposed in the field of situational method engineering. We adopted the assembly-based situational method engineering approach as proposed by Ralyté [21] since it was applied successfully in several cases for WCM systems [29]. We added two extra steps to refine the selection method for WCM systems: the first additional step is about decomposing the notion of WCM systems in order to get its key concepts. These key concepts are reflected in the developed model. The second step consists of a comparison matrix wherein selected method fragments and key concepts are compared to extract the relevant method fragments. The approach is summarized in the following steps:

1. Analyze implementation situations and identify needs
2. Select candidate methods that meet one or more aspects of the identified WCM implementation needs.
3. Store relevant method fragments in a method base.
4. Identify key concepts of WCM
5. Compare selected methods and key concepts.
6. Select useful method fragments and assemble them in a new method.

We illustrated this approach in Figure 1. We elaborate on these steps in the following sections.

2.2 Implementation situations and need identification

To make sure that the resulting method is consistent with business requirements we analyzed different implementation situations. A specification of an implementation situation can be established by means of categorizing unique project characteristics [31]. In total we gathered seven project characteristics by means of artifact analysis and semi-structured interviews with project managers which are organized within three areas of method configuration: Context, Organization and Technology. The project characteristics are summarized in the list below:

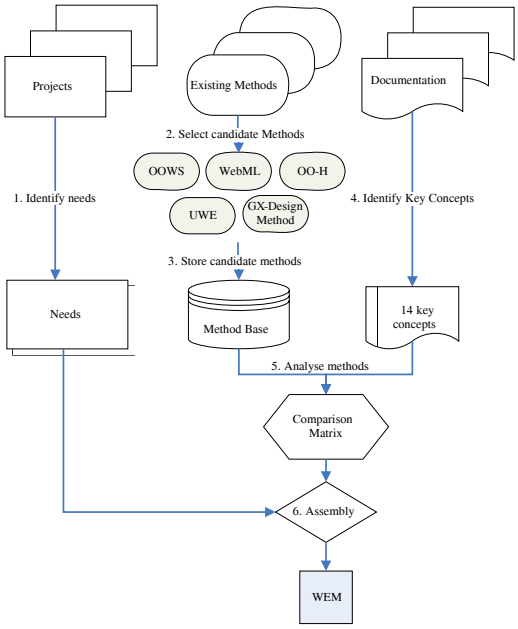

Figure 1: Research approach

1. **Context**
   (a) Dependency to external activities and conditions
   (b) Level of innovation of the applied technology, methods, tools and techniques
2. **Organization**
   (a) Number and diversity of stakeholders
   (b) Uncertainty of customer's expectations by management team
   (c) Uncertainty of development activities by customer
3. **Technology**
   (a) Complexity of functional components
   (b) Number of relationships to existing systems

Based on the project characteristics, we distinguished three types of projects: standard projects; complex projects and migration projects. In this research we focus on standard and complex projects since migration has a unique set of issues by itself and this research is focused on developing new web applications and not software migrations.

Constraints were gathered by analyzing architecture and requirement documents. Moreover, conducting semi-structured interviews with two software architects and two consultants provided additional needs. We abstracted the needs and organized them into overall needs, standard implementation needs and complex implementation needs. In total, eight needs were obtained.

1. **Stakeholder documentation**: a set of understandable and easy-to-create conceptual models and design documents for stakeholders
2. **Requirements starting point**: the requirements document should be the starting point within all design activities

3. **Integration with WCM system**: integration of project lifecycle information with WCM in order to speed up the delivery process
4. **Support by CASE-application**: the design of complex and configurable user interaction components should be supported by means of a graphical application
5. **Structure navigation**: structuring the navigation should be improved to show the hierarchical structure of the website including relevant meta data
6. **Efficiency**: the design method should take the least effort as possible while maintaining high quality
7. **Reuse**: a minimum effort should be put in the creation of design deliverables by means of reusing knowledge of preceding projects where possible
8. **Use case alignment**: conceptual design models should be aligned with the use case descriptions

These eight needs are the defined constraints for the design phase.

2.3 Selecting candidate Methods

The second step is the selection of candidate methods who will become the foundation of our framework. As a result of a performed literature study, we selected the following approaches: Hypermedia Design Methodology [8], the Object Oriented Hypermedia Design Model [22], Website Design Method [27], Web Modeling Language [3], UML-based Web Engineering [12], Object Oriented Hypermedia [10] and Object Oriented Web Solutions [18].

We narrowed down the list of web application modeling approaches to a small comprehensible set of useful approaches based on the following criteria:

1. Acceptance by the community as a web application modeling approach;
2. Matured evolution of the approach; and
3. Advanced software application support.

The first criterion refers to the influence of the approach as well to the utilization of the approach as a web application modeling approach. This criterion also implies that the web modeling approach should be described in literature sufficiently. The second criterion is about the evolution and whether the approach matured over time. The last criterion is about advanced software application support since the development of web applications can be supported very well by software applications with the aim to speed up the design and implementation processes which is in line with one of our research goals.

Based on these criteria, we selected the following four approaches: WebML (WebRatio toolsupport), OO-H (VisualWADE), UWE (ArguUWE) and OOWS (Olivanova).

2.4 Method Base

The third step consists of the extraction and storage of method fragments in the method base. We used a meta-modeling technique called Process Deliverable Diagrams (PDDs) to analyze, select, store, and assemble the method fragments. The PDD technique is based on a UML activity diagram, reflecting the activity side, and a UML class diagram which reflects the deliverables side. The UML semantics are strictly applied, however, some primitives have been added in order to deal with composition issues. For detailed information about the meta-modeling technique, we refer to [29].

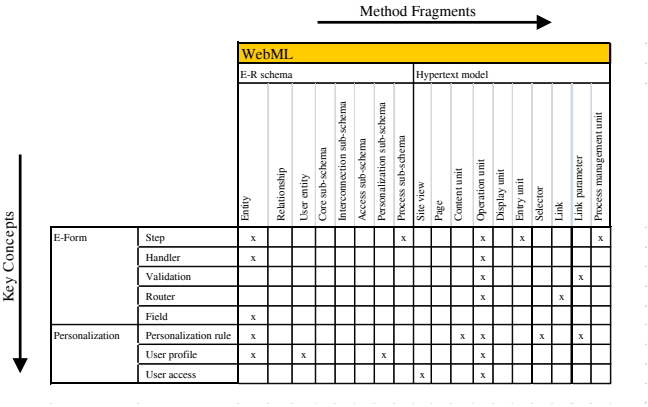

Figure 2: Excerpt of Comparison Matrix

Examples of method fragments are the Hypertext Model and E-R Schema from WebML. A total of 32 method fragments have been extracted and stored in a method based. Each method contains multiple concepts. In total, 92 concepts of the four web modeling methods are used for association and positioned against the key feature groupings and WCMS functionalities.

2.5 Identification of Key WCM Concepts

Step four is the identification of key WCM concepts. The purpose of identifying the key concepts of WCM is to enable the comparison, selection and analysis of method fragments with respect to WCM concepts. To identify key concepts of Web Content Management, we analyzed the available scientific papers [15], [34] and added market research reports.

All concepts were assessed by means of two expert validation interviews. One expert held a position as senior solution consultant and the other expert was a product manager. Based on the discussion and the comments given, the list of concepts has been refined and narrowed down to a list of 14 concepts. We distinguished the following 14 key concepts for Web Content Management:

Authoring Authoring deals with the production of web content (also known as the 'content life cycle'). According to the authors in [34] the content lifecycle covers creation to archiving and destruction of content components.

Authorization Management Authorization is used to infer which privileges authenticated users are granted [35]. Additionally, the authorizations have to be checked when a particular users accesses data which is relevant because of the collaborative aspects of WCM.

Connectivity Management Connectivity management covers the notions of application integration, interaction, database pages and portal integration.

Content Repository Content repositories provide services which allow for storage of content objects within the database associated with meta-data.

Deployment and Replication The deployment process potentially contains the delivery, assembly, and maintenance of a particular installed software system at a website [30]. Note that the deployment aspect could be outsourced when for instance using a WCM based on 'Software as a Service' (known as SAAS).

Digital Asset Management Digital Asset Management (DAM) can be defined as the management of digital content so that it can be cataloged, searched and customized [17]. Enterprises can achieve strategic advantage by implementing a DAM because of the need to incorporate a growing quantity of graphics and rich media into corporate Web sites.

E-Forms / Transaction Management E-forms are the means which allows a user to interact with a web application and so its services and data. Moreover, e-forms enable companies to provide self-services or other services in an easy way.

Layout and Presentation Management WCM systems separate content, structure and presentation. Based on templates and style sheets the layout and presentation are generated. The main goal of templates is to provide a web application the same look and feel, but it also makes web applications easy to update.

Multi-channel delivery and syndication Customers make use of several channels (e.g. internet, SMS, print) in order to gather information or to interact with companies. However, it is for companies a challenge to synchronize these channels to gain advantage from a multi-channel strategy. One of the best known syndication standards is RSS (Really Simple Syndication).

Personalization Personalization is about tailoring of content, presentation or navigation based on user preferences or user behavior ([3], [7], [11]).

Website Management Website management can be defined as the organization of the structure of a WCM system in terms of effective navigation and content.

Community Technologies Community technologies or web 2.0 concepts are probably still too intangible for a solid classification, however it can be said that the Web 2.0 approach emphasizes interaction, community and openness [16]. Two community technologies concepts namely blogs and wikis. Both concepts have in common that it is mainly about users who can generate and publish content, while another can edit or reply on it.

Web Analytics Web analytics, similar to the notion of web usage mining can be defined as the application of data mining techniques to discover usage patterns from Web data, in order to understand and better serve the needs of Web-based applications. Also McKeever identified reporting tools as in integral part of the Web Content Management [15].

Workflow The concept workflow can be defined as a collection of tasks organized to accomplish some business process ([9]). A more complete definition of the concept workflow is 'the automation of a business process, in whole or part, during which documents, information or tasks are passed form one participant to another for action, according to a set of procedural rules' [4].

In the next step we make a comparison based on these key WCM concepts.

2.6 Comparison and selection of method fragments

The fifth step consists of analyzes of the method fragments by comparing functionalities and concepts with meta-model concepts.

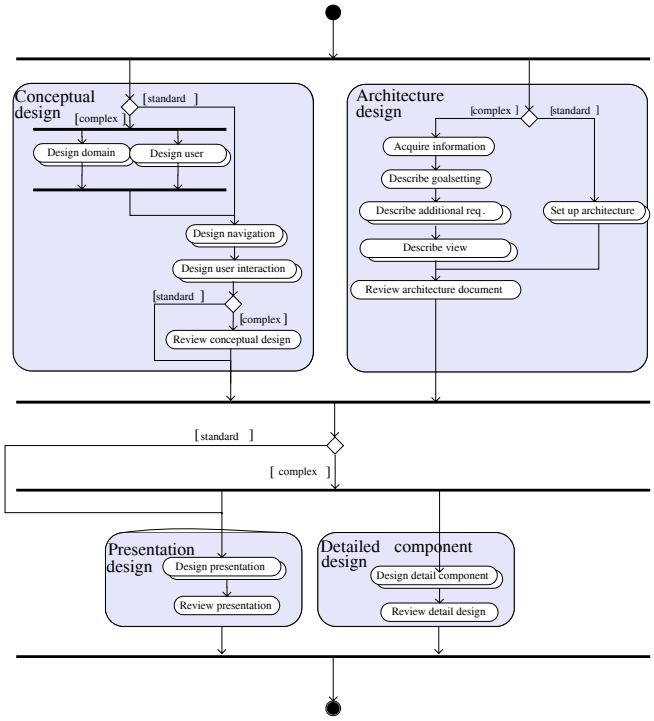

Figure 3: WEM Design Phase Overview

The purpose is to select relevant method fragments based on the functional criteria and results in a comparison matrix including the design rationale. Figure 2 gives an excerpt of the comparison matrix that in total consists of 31 rows and 92 columns

By analyzing the comparison table we determined the applicability of each of the models. Additionally, the comparison table provides a functional overview for the selection of models and is the basis for the assembly of the situational method. Furthermore it shows the coverage of WCM functionalities by several web application modeling approaches. Based on the comparison table, we selected the relevant method fragments and constructed the Design phase of WEM.

3. THE DESIGN PHASE OF WEM

Similar to our earlier research in [25] we made two routes: one for standard projects and one for complex projects. The design phase of WEM consists of the following four activities:

1. **Conceptual Design**: providing a general design of the domain, the users and the interaction of the user with the system.
2. **Architectural Design**: The architecture design describes the system in a 4+1 view, providing the process and deployment of the system.
3. **Presentation Design**: detailing the visual presentation of the website.
4. **Detailed Component Design**: providing the technical details of customized components.

An integrated overview of the design phase of WEM is presented in Figure 3. The following sections elaborate on each of the four main activities.

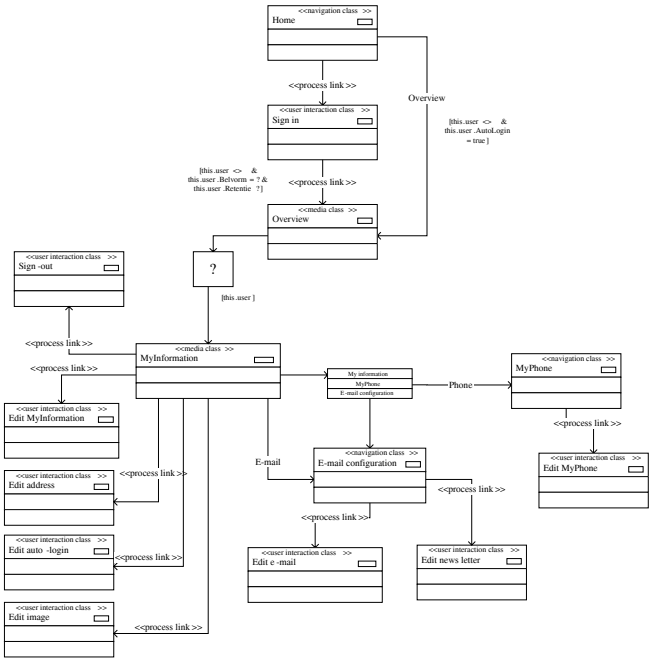

Figure 4: Navigational Model

3.1 Conceptual Design

As visualized in Figure 3, the conceptual design starts with domain modeling within the complex route. In this sub-activity, a domain model is created which represents the main concepts and relationships of the problem domain derived from the requirements document. Concurrently to this step, users of the WCM system can be modeled similar to a domain model.

After that, a navigation model is created (Figure 4). The navigation model originates from the navigation model (UWE) but is extended with several WCM specific navigation nodes such as: media class, database class and user interaction class. The first step in navigation design is identifying the navigation view. The navigation nodes are then constructed based on the navigation. An example of a navigation node is a navigation class which is a stereotyped class which can be visited by webusers. Access primitives are then added which are nodes that specify the way a navigation node is accessed (e.g. by query). Last, conditions can be added to links wherein personalization rules are specified. An example of a personalization rule is for example: "this page can only be accessed by registered users".

Following, the user interaction design is created by using a business process model (BPM) (Figure 5). The business process model is developed by a set of activities performed by a web visitor interacting with the WCM system in separate swimming lanes. We adopt the Business Process Management Notation (BPMN) similar to [1]. Complex implementation often involve new business process models in contrast to the standard route where reusable subsets are available. The conceptual design activity is finalized by a review on all conceptual design models with the objective to raise the quality of the conceptual design deliverables.

3.2 Architecture Design

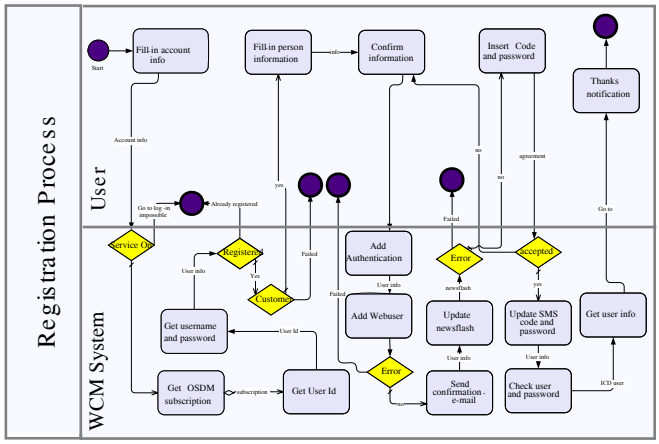

Figure 5: Business Process Model

The software architecture of the Web Content Management System is described by means of the 4+1 view model developed by Kruchten [14]. The 4+1 model describes a software architecture using five concurrent views: logical view, process view, implementation view, deployment view and requirements view.

In the architecture design activity an architecture document is delivered based on the specified requirements. The architecture consists of the foundation of the WCM system itself and the customizations for the project at hand. Moreover, project specific non-functional requirements are taken into account (e.g. performance, security, availability). The non-functional requirements are described and categorized.

3.3 Presentation Design

Part of a WCM implementation is the construction of the visual presentation of the website which usually is developed by an external graphical designer consisting of static (X)HTML prototype. The implementation of the presentation consists of making the graphical design dynamic that the content can be managed from within the WCMS. The XHTML prototype typically consists of XHTML pages including a CSS, javascript and other frontend file files (e.g. Flash, Shockwave, Silverlight), possibly supported by AJAX libraries (such as BackBase, Echo2, Rico). The XHTML prototype will be assessed for suitability and the content management part is determined. Based on presentation types described in the document the static XHTML files will be implemented to dynamically generated XHTML.

3.4 Detailed Component Design

The detailed component design activity covers the process of designing customizations of the WCM system to meet the functional requirements. The customization could be adjustments on the existing components or the development of new components within a WCM implementation project. The main result of this activity is the detailed design document.

The detailed component design activity starts with setting a goal of the component. Then requirements document and architecture document are analyzed and a conceptual description of the component is written. Such a description contains a textual description, a presentation (e.g. table or diagram) and rationale. The description is related to functionality part of one or more (future) components which are described within the implementation view, part of the architecture document. During the final step, the detail design doc-

ument is reviewed by an architect. Customizations can have a large impact on the system and its stability. A proper way to cope with customizations as described in [26].

4. VALIDATION

According to [6] and [36] we validated the Design phase of WEM through an expert review and a case study. An expert review can be conducted for confirming the relevance of a theory [6]. With the case study we experimented with the method in a real life context.

4.1 Expert validation

WEM has been evaluated in collaboration with four experts: two functional consultants and two technical architects. The validation has been performed to evaluate the correctness and completeness of the situational method, and to improve the design.

The research and the validation was performed within GX, a Web Content Management vendor. GX develops and implements a proprietary Web Content Management System called GX WebManager based on open standards, which is described in [28] and [26].

The selected experts held the positions consultant or software architect within GX who are responsible for the functional and the technical solution respectively. During the interviews both route maps (standard and complex) were validated. Before validation we gave an introduction to the meta-modeling technique. Following to that, we walked through all relevant method fragments, including the high-level overviews of the different route maps. Next to that, we tried to reveal their perception concerning the usage of PDDs for the employment of route maps.

Three experts agreed upon the decision to use a PDD instead of a decision table for decision-making within project situations.One expert stated that "the visual aspect of the PDD provides more overview and is easier to use than a decision table." However, one expert stated that a distinction between standard and complex projects is debatable. The expert prefers to reason from a complex implementation situation. When some deliverables are not needed, he leaves them out. When discussing the PDD's, all fragments were positively validated in terms of completeness and correctness: the process steps were perceived as logical precedents and the relationships between the concepts and process steps were seen as correct and useful. Last, the concepts were perceived as nicely related to the concepts of the requirements phase.

In total, approximately 30 changes have been proposed by the experts differing from a cosmetic level to a serious request with a high impact on the initial design. These results have led to adjustments of the situational design method which we used in the case study. An example of a change request which was given when evaluating the 'presentation design' method fragment is: "A presentation variant [concept] is not the same as a presentation, but rather a sub-type; some presentational parameters are changed within the presentation, which accomplishes a new presentation variant."

4.2 Case Study

After refinement of the models we applied the design phase of WEM in two real life cases. We describe one of them: the case organization is a large Dutch telecommunications provider which provides telephone, internet and television services to individuals and organizations within the Netherlands. In this case study the complex route map of the 'conceptual design activity' was put to practice based on a recently completed project. The case project provides customers a personal environment with special services: online phone bill, composing Short Message Services (SMS) and Multimedia Messaging Services (MMS) and the ability to change personal information. In total, 16 selected use cases have been designed.

The project had an estimated effort of 1500 man hours. During this phase, the functionalities were restyled and the design took approximately 40 man hours. The case study started with a thorough analysis of the use cases within the requirements document and the implemented WCM system. In total, 29 diagrams have been created, whereof one domain model, one user model, three navigation models and 24 business process diagrams. After the first design, in total two involved software developers and two consultant validated the produced models and filled-out a survey. In this survey, for each deliverable, five questions were asked with regard to the readability, abstraction level, correctness, software application supportability and applicability of the conceptual design deliverables. After filling-out the survey, informal interview were held in order to discuss the usefulness of the deliverables and the situational web design method.

4.2.1 Results

We observed that the respondents were positive concerning the method by itself, although the results diverged depending on the role and the diagrams discussed. First, software developers were more positive about using domain models than consultants, since the latter considered the models too complex for customers. Both architect and consultant agreed that the domain model could be useful to define customizations. This corresponds to our method where we positioned the domain model in the complex route. Some remarks made by the architect concerns the separation of domain and user model which was perceived as an unnecessary separation.The navigational model was found useful by the software developers since it could provide a good alternative for the current description of navigation (usually a spreadsheet). The consultants had contradicting opinions about this navigational model especially concerning the ability to communicate it with all stakeholders.

The Business Process Diagram (BPD) was found the most useful by both software developers and consultants as it visualizes complex user interaction flows and it improves the communication with customers. Moreover, it provides an overview of the interaction as well as the integration aspects. "When requirements for complex flows are written down textually by a consultant, it is hard to interpret the requirements and transform them into configured functionalities without any ambiguity, but this diagram could filter out misinterpretations" concluded the architect. One software developer stated that the BPD is the clearest model of all conceptual models. The architecture design and the detailed component design was not changed in this method.

5. CASE APPLICATION SUPPORT

Based on the results of the validation and to further support the Design Phase of WEM we developed a prototype of a Computer-aided Software Engineering (CASE) application. The purpose of the CASE application is to improve the efficiency of the application development. We focus with the CASE-application on the Conceptual Design of WEM and more specific on the Business Process Diagram for the following reasons: (1) the Conceptual Design defines standard components in a WCMS and is suitable for automation. Moreover, interviews with experts showed that defining the user interaction and configuring the WCMS is a time consuming task. (2) the Architecture Design results in a description of the physical server setup and the application architecture which is very hard to automate. (3) the Presentation Design is an interpretation of static XHTML files which will then be made dynamic. There are more then one (commercial and free) visual software applications

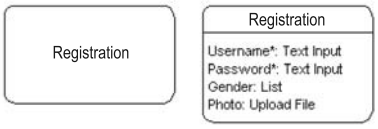

Figure 6: Notation of a Step and Formelements

available to create dynamic Web pages. 4) the Detailed Component Design is about detailing the customizations of the Web application. This customization could be just about anything which makes it hard to formalize it in a CASE-application.

For the development of the CASE-application we need to formalize the models we want to support and develop a graphical notation which corresponds with the formalized models. We use concrete and abstract syntax similar to [5] to define our modeling language. In this paper we elaborate on the graphical notation.

Based on interviews, we gathered input how the different elements of a form should be represented graphically. The interviewees had consensus on how a step should look like: a step was drawn as a square. Form fields, which are related to a single step, are properties of a step. We represented the form fields similar to UML Class-Attributes. The user should be able to choose wether he would like to view the form fields or not (different abstraction layers). An example of a step and a step with form fields is shown in image Figure 6

For each form element, we made a representation in the CASE application. We modeled the Business Process Diagram as presented in 5 with our CASE-application. The result is presented in Figure 7.

The application generates XML which can be imported by the WCM. An excerpt of the generated XML is shown below in

Listing 1: XML Excerpt from Application

```
<form id="_3_3902">
  <name>Registration Process</name>
  <steps>
    <step id="_3_3924">
      <name>Account Info</name>
      <field ref="_3_4825" />
    </step>
  <fields>
    <field id="_3_4825">
      <name>Username</name>
      <type>TextField</type>
      <validator ref="_3_4821" />
    </field>
  <validators>
    <validator id="_3_4821">
      <name>Minimum Length</name>
      <parameter ref="_3_4823" />
  </validators>
</form>
```

All elements in the XML have a unique identifiers. The elements have internal references to other elements using these identifiers. A single step for instance will normally have multiple formfields. The XML is then transformed to an XML format which can be imported into the WCMS GX WebManager. We successfully imported the example shown in Figure 7 in GX WebManager and proved thereby that the application could be used to define Business Process Models during requirements phase and implement it into the WCMS.

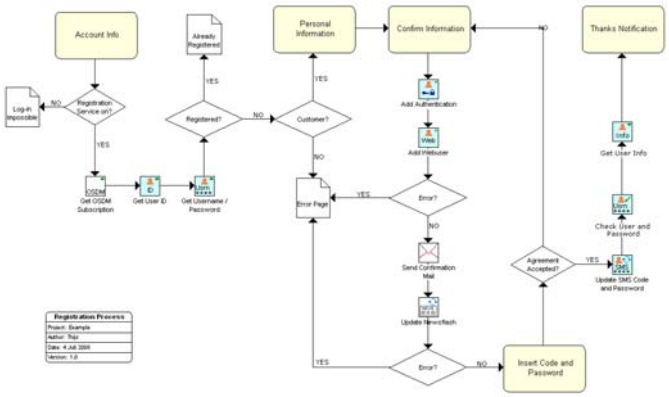

Figure 7: BPD within the WEM application

6. CONCLUSIONS

In this paper we elaborated on the research question 'What is an appropriate method for designing web applications based on a WCM system'. To answer this question we constructed the design phase of WEM: an implementation method specifically addressing WCM systems. The design phase has a standard and a complex track and contains of four main activities: Conceptual Design, Architecture Design, Presentation Design and Detailed Component Design. We validated the designs through an expert validation and a case study. The overall response on the validation was positive although only the Business Process Diagrams was unanimously supported. Based on the outcome of the validation, we made an application which supports the Design phase of WEM. For the application, we formalized the conceptual design diagrams and developed a graphical notation. The application generates XML which can be imported into the WCMS.

We believe that we have made a step forwards in developing a method for the implementation of WCM systems although the results show that not all diagrams are as useful. Furthermore, we think that the approach through the identification of key concepts and the application of situational method engineering is useful beyond the scope of Web Engineering. Future research consists of completion of the WEM framework: construction of the implementation phase. Part of the WEM framework is the sophistication of the described CASE-application in order to support the implementation processes and speed up development.

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