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Web engineering in practice: a development case

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Abstract: - The development of large scale web systems requires a systematic and well-defined process to ensure quality and measurability - both in the process and in the product-, maintainability and reusability. Hypermedia/web engineering methods should provide mechanisms to deal with all the system features in a progressive, flexible and integrated way so that they can be put in practice without disturbing the project goals nor comprising its success. In this paper we describe how we did apply the ADM web engineering method in the ARCE project, why we decided to go for a web engineering approach and the main benefits of this approach.

Key-Words: Web engineering; e-government; web development; role-based access control; ADM method

1 Introduction

One of the most popular myths of web development is that applying systematic methods, or software engineering approaches, increases deployment time and even a hypermedia/web software crisis has been identified [1]. But myths are not supported by empirical or scientific facts. After more than a decade of web developments, it has become clear that it is not possible to face the development of large scale web systems without following a systematic and well-defined process [2] if we want to ensure quality, measurability, maintainability and reusability, both in the process as well as in the product. Indeed, empirical studies demonstrate that professional development is being addressed through some kind of formal method or approach [3].

Hypermedia/web engineering is gaining attention in the last years since the development of this kind of systems involves specific modeling problems [4, 5], such as the need for mechanisms to specify sophisticated navigational structures, interactive behaviors, interfaces with external applications, security constraints and multimedia compositions. Consequently, developers need specific mechanisms to analyze and design using abstractions and entities that belong to the hypermedia domain (such as nodes, links, anchors and space and time-based relationships) as well as design practices (such as the separation between nodes, contents and links or the definition of effective navigation tools). In addition, hypermedia or web engineering methods should provide mechanisms to deal with all the aforementioned features in a progressive, flexible and integrated way so that they can be put in practice without disturbing the project goals nor compromising its success.

In this paper we describe why we decided to go for a web engineering approach in the ARCE development project, how we did apply the ADM method [6] and the main benefits of this approach.

2 The ARCE project

One of the basic goals of the Latin-American Association of Governmental Organisms of Civil Defense and Protection (AIGO), an association representing 21 Latin-American countries, is to promote cooperation and mutual assistance in emergency situations. Obviously, international cooperation makes up the basis of disaster mitigation but, unfortunately, such cooperation process has some drawbacks that diminish efficiency. Currently, when an emergency occurs, the affected country asks for international aid in a unilateral way, that is, using a one-to-one communication channel like the phone or the fax, so that each potential cooperator has to be contacted directly. Moreover, as there is no information flow amongst cooperators, each one provides assistance on its own, without taking into account what the others can do or even have already done. Such absence of multi-lateral communication has more often than expected dramatic effects.

In this context, three years ago the Spanish Civil Protection Department along with the DEI research group at Carlos III University of Madrid started a project to develop ARCE [7], a web-based system oriented towards enhancing the management of

multinational cooperation in case of disaster by providing a multidirectional ring of communication and assistance amongst the AIGO associates. The ARCE system is aimed at becoming a platform to share updated and reliable in order to orchestrate an integrated and efficient response, respecting at the same time the peculiarities and autonomies of each member. With this purpose, ARCE provides mechanisms to notify an emergency, to ask for resources and to offer assistance. A number of reports can be created and the system can be used in routine mode as a communication channel amongst the associates and other related institutions and even external organizations (e.g. NGOs). Communication among users assumes a control flow policy that determines the kind of messages each user can send according to the role the user plays.

From the beginning of this project, the assumption of a systematic method emerged as a basic requirement for two basic reasons: first, the complexity of the system to be developed and, secondly, the complexity of the development process itself.

Concerning the system some issues were considered:

- The amount of information is huge and most nodes and contents are created dynamically.
- ARCE is accessed by different users with different responsibilities.
- Multilingual support is required.
- There are some multimedia presentations where different media are combined and synchronized.
- In order to increase the system usability, designers have to pay special attention to usability and consistency issues.

Concerning the development process some features that suggested the use of a systematic and disciplined approach, though flexible enough as to meet the needs of the project at each moment, were identified:

- ARCE team members have an heterogeneous background ranging from experts on civil defence issues to web designers and programmers. Consequently, design products and specifications that can be discussed by all the members of the development team are required.
- ARCE has to be adopted by a community with different organizational policies so design has to be flexible enough as to meet diverse needs.
- ARCE stakeholders have to be actively involved in the development process to engage them to use the system in emergency situations. The development team has to deal with a potential initial rejection of the system if associates feel not motivated to use it, particularly if they consider they are just being controlled without perceiving the need and opportunity of this kind of system.

3 The ADM method

The ADM proposes a systematic though flexible process to design and evaluate hypermedia and web systems. On the one hand, the method is **systematic** since it specifies a detailed process to be followed to design and evaluate all the features of the system concerning structure, navigation, presentation, interaction and access. The process is composed by three phases each of which faces development from a different but complementary abstraction perspective: Conceptual Design is focused on identifying abstract types of components, relationships and functions; Detailed Design is concerned with specifying the system features, processes and behaviors in a so detailed way that they might be semi-automatically generated; Evaluation proposes the use of prototypes and specifications to assess the system usability and improve the design, whether conceptual or detailed. Each ADM phase is decomposed into a number of activities each of which proposes a number of models to be developed (see Table 1).

ADM CONCEPTUAL DESIGN	
Activity	**Models**
Definition of the logical structure	Structural Diagram
Study of the system function	Navigation Diagram
	Functional Specifications
Specification of entities	Internal Diagrams
	Attributes Catalogue
	Events Catalogue
Users Modeling	Users Diagram
Definition of the security policy	Categorization Catalogue
	Authorization Rules
ADM DETAILED DESIGN	
Activity	**Models**
Identification of instances	Diagram of Nodes Instances
	Instanced Users Diagram
Specification of functions	Specifications of Access Structures
	Detailed Specification of Functions
Specification of instances	Detailed Internal Diagrams
	Access Table
	Users Allocation
Definition of the presentation features	Presentation Specifications
ADM EVALUATION	
Activity	**Models**
Prototype development	Prototype
Evaluation	Evaluation Document
	Conclusions Report

Table 1 ADM activities and models

On the other hand, the ADM process is **flexible** as it does not impose any kind of sequence or temporal dependency among the different activities to be carried out. Bottom-up, top-down or mixed approaches can be followed depending on the needs of the project. Indeed, section 4 shows the different process models that were adopted in the study case here described. In order to check completeness, consistency and integrity among the various models (diagrams, catalogues and specifications) produced in these three phases, a number of validation and verification rules are provided.
Finally, the method is supported by AriadneTool [8], a design toolkit that automates all the phases of the Conceptual Design and most phases of the Detailed Design. AriadneTool also supports fast-prototyping in HTML, XML, SMIL and RDF as well as automatic generation of documentation about the design process. Moreover, the tool incorporates the use of ontologies for checking completeness, consistency and correctness of the design.

4 Using the ADM in the ARCE project

Four reasons suggested the use of the ADM in the ARCE project: (1) its strong support for access policies specification; (2) its integration of different design views to deal with all the system features (structure, navigation, presentation, access, behavior and function) and different abstraction levels to work with different kinds of team members; (3) its systematic but flexible process model that fit the process needs; and (4) the existence of an automation tool that makes easier the specifications tasks. The method has been applied in several cycles, each of which has followed a different approach. The assumption of this iterative process has been considered useful both for developers, who can test their ideas and solutions in a realistic situation, and by stakeholders, who have adopted a quite positive attitude due to their active involvement in the development process. In particular, the project life cycle has gone through three different cycles where the ADM phases have been sequenced in a different way in order to meet the needs of the project at each stage as explained below.

4.1 First cycle: analysis through rapid prototyping

At the beginning of the project, the basic goal was to establish a set of feasible requirements as well as to engage stakeholders in the development process. In this case, the ADM evaluation phase, with prototyping and evaluation as main activities, played a central role. This first cycle (see figure 1) consists of an iterative process of analysis and evaluation.

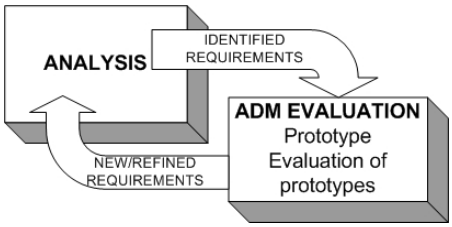

Fig 1. ARCE project 1st cycle

Since analysis is not yet included in the ADM, a typical working group technique was applied [9]. A group of web engineers and people with technical knowledge in civil defence was created to discuss the system services. Rapid throw-it-away prototypes supported requirements elicitation and validation.
Evaluation is primarily aimed at providing information about the potential usability of a system and it can be applied at different phases. According to the ADM, the first step in the Evaluation is to prepare an *Evaluation Document* including sections such as the objective, the method to be used, the evaluators profile, the data to be collected, the tasks to be performed to be sure that evaluators analyze all the features and tools of the system, the recording mechanisms and the evaluation planning. In this first cycle the objective of the evaluations was to gather and refine requirements and the method was an empirical evaluation of interface mock-ups. As said before, evaluators were experts in civil defence. Data gathered concerned the completeness of the functions with a view to detect new functions.
Once evaluation has been performed, the results are analyzed to derive conclusions to improve the system. These conclusions are summarized in the *Conclusions Report* and they can imply modifications in the products generated throughout the design, whether Conceptual or Detailed, or just in the prototype itself. In this first cycle of development, where no designs are performed, the conclusions of the evaluation process were used to refine existing requirements or to identify new ones.
The outcomes of this cycle were a set of requirements and a throw-it-away prototype gathering the main features of the ARCE web system.

4.2 Second cycle: producing a common design

The next step was to put more emphasis on technical solutions in order to ensure a quality implementation process, as well as to continuing refining requirements and involving users in this process. The idea was to deepen on the basic features and services of the system producing a generic design that could

be adapted later to the needs of each associate. In this second cycle, the Analysis phase lost relevance in favour of the Conceptual Design (see figure 2) and Evaluation maintained its central role to assess prototypes as well as design models. At the Conceptual Design phase design solutions are expressed in terms of expected types of elements that will be translated into concrete entities in the Detailed Design. In the ARCE project, the ADM Conceptual Design offered a most useful choice to establish a coherent structure and function, since it provides a number of models readable enough to be discussed with user representatives after a short explanation on the notation. Moreover, compared to the use of prototypes, Conceptual Design models hide details that can deviate the users attention to issues, such as colors, backgrounds and so on, which are not relevant when trying to define generic and abstract features of the system. This second cycle was again an iterative process devoted to refining designs and requirements.
A bottom-up process was followed to build some of the ADM Conceptual Design models from the prototypes developed in the previous cycle. In particular, design was focused on the system structure (*Structural Diagram*), the services offered to the users (*Functional Specifications*) and the access policy (*Users Diagram* and *Authorization Rules*).

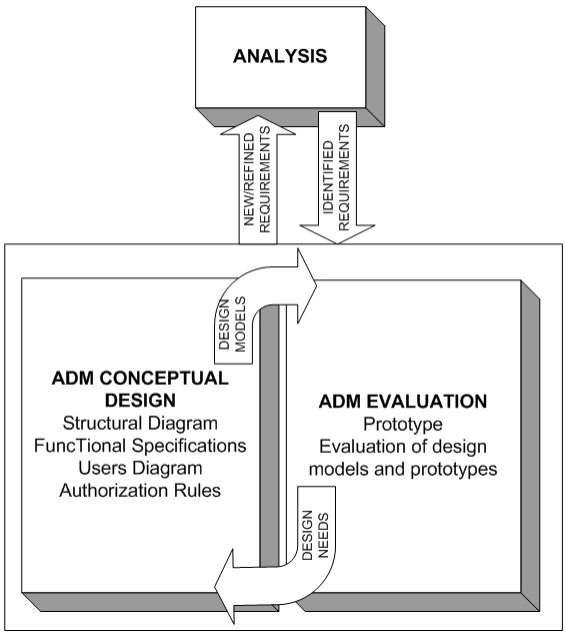

Fig 2. ARCE project 2nd cycle

The *Structural Diagram* includes the abstract nodes of the system as well as their structural relationships. Figure 3 shows the current structure of the ARCE system obtained through a number of iterations in this cycle. Abstract nodes can be simple (see nodes with a single border like ”Message”) or composite (see nodes with the double border like ”ARCE-web site”). Composite nodes gather one of two possible structural relationships: aggregation and generalization, the latter involving inheritance of contents, links, attributes and events.

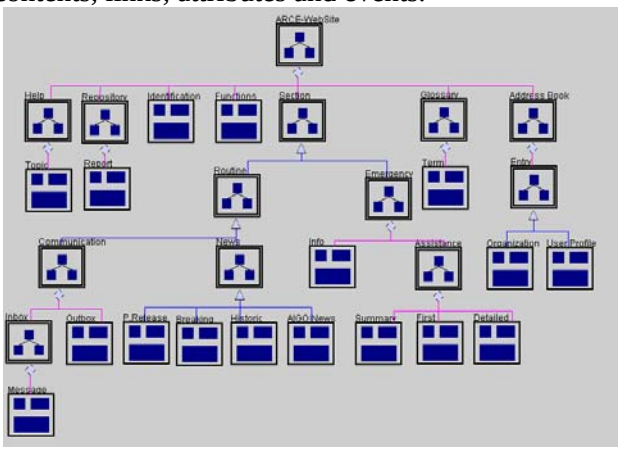
Fig 3. ARCE Structural Diagram

The *Functional Specifications* define services not strictly related with navigation including processes such as: accessing the database to create nodes, providing communication mechanisms among users or updating the database with the information included in the nodes. Examples of ARCE functions include "Manage Emergency Situation", a function that is decomposed into sub-functions such as "Open Emergency", "Update Emergency", "See Emergency Negotiation process", "Request Assistance", "Offer Assistance" and so on.
The users structure is represented by means of the *Users Diagram* a model that sets the basis of the security policy (see below) and that makes possible to define user-dependent presentations as well as personalized environments. This was a key product in ARCE, where a structure general and flexible enough to fit within organizations that have a different needs and requirements was proposed (see figure 4). The Users Diagram represents the users structure using roles and teams [6]. For instance, the ”National” role was introduced to provide some autonomy to each associate while maintaining certain services at a centralized level. Thus, each country within the Association can decide which number of users will assume each role under the ”National” structure as well as which roles can be assumed by the same user.
The actions permitted for each subject, that is, for each role or team, are established through the *Authorization Rules*, a model that makes possible to assign access rights at the function level (see Figure 5) adopting an RBAC mechanism [10]. Fine-grained policies, where users holding different roles can have different manipulation abilities for the components of a node, can be defined. Thus, when retrieving a node,

information is hidden, reordered or presented using a different form component depending on the user role.

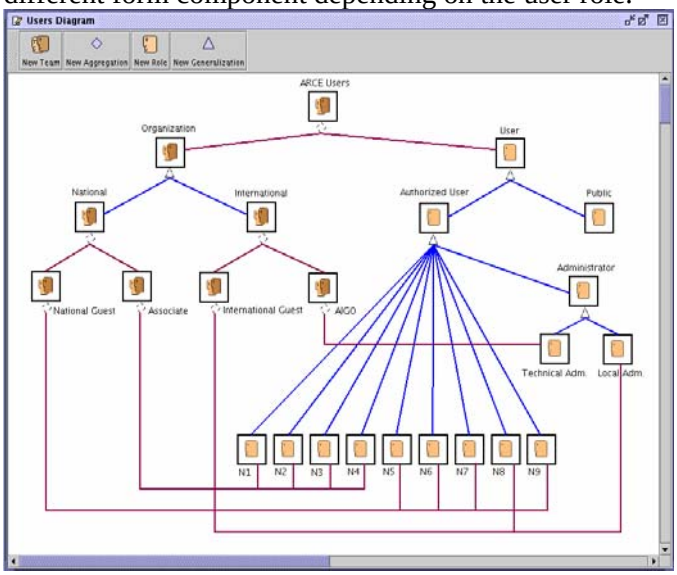

Fig 4. ARCE Users Diagram

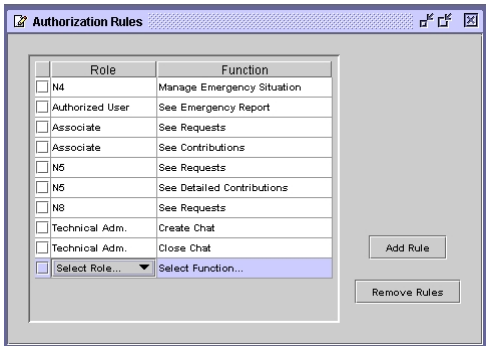

Fig 5. Example of Authorization Rules

All these design models were assessed with the stakeholders to refine them. Sometimes such analytical evaluation gave place to changes in the prototypes and even in the requirements.

Empirical evaluations of the prototypes were also performed in a number of ARCE courses with a view to refine the interface and assess the validity of the services offered to the users. The first evaluation in this cycle was carried out in the meeting of the Latin-American Association held in Cartagena de Indias (Colombia) in February 2002. In this meeting representatives of 13 countries took part in a disaster simulation exercise and they used ARCE to coordinate a multinational response. Results of this evaluation are reported in [7]. Similar exercises are performed periodically to test the system requirements and the design decisions.

The basic outcomes of this second cycle were a more complete requirements definition, a prototype and some design models.

4.3 Third cycle: adapting designs to each organization

Next step was to keep on refining design and validating if it suits the specific organizational features of each associate taking part in the project. In this third cycle (see Figure 6), which is the current one, Analysis activities were practically anecdotic and the ADM Detailed Design came into the scene to define concrete instances of some conceptual models. All the models of the Conceptual Design were developed and refined and Evaluation continued as a basic activity to assess both design models and prototypes.

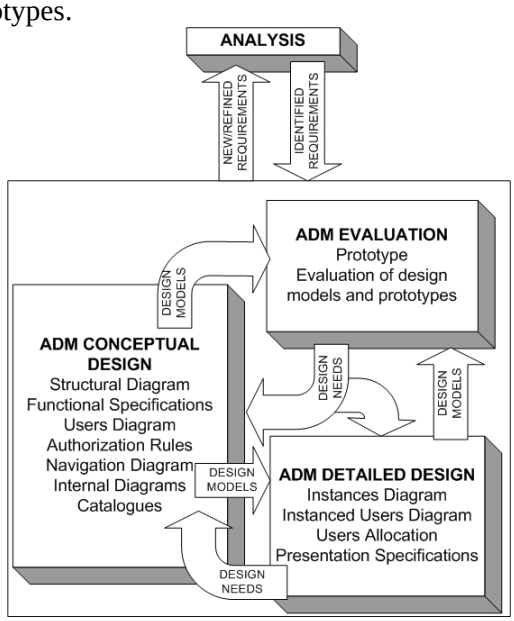

Fig 6. ARCE project 3rd cycle

Concerning Conceptual Design, the models of the previous cycles are refined and new ones are developed following a top-down approach to go deeper into the conceptual features of the system (see figure 6). For example, the navigation paths and tools are defined in the *Navigation Diagram* and the *Internal Diagrams* are created to define the appearance, semantics and behavior of each node.

During the Detailed Design phase entities and services are fully specified. Such specific elements can be identified in a declarative way (e.g. using an identifier, url o uri) or in a procedural one (e.g. by means of scripts or database queries). Indeed, most instances of nodes and contents in ARCE were defined in a procedural way. For example, all items concerning an emergency are created at runtime accessing a PostgreSQL database. The *Instances Diagram* and the *Instanced Users Diagram* include concretes instances of the Structural Diagram and the Users Diagram respectively in order to reuse the

common design in different contexts adapting it to specific organizational needs. It's worth noting that users instances are not specific users of the hypermedia system but concrete roles and teams that appear in the domain of the application. Specific users are associated roles through the *Users Allocation* model. Thus, users will be able to exercise the abilities specified for the roles they belong to according to the principles of RBAC models [10]. A user can be associated to more than one role to increase flexibility. In this case the most permissive authorization is assigned during a session since currently no separation of duties is considered in the ADM. Finally, *Presentation Specifications* include details on how to convey information to the user. Different Presentation Specifications can be defined for the same node or content, so that the most appropriate one can be selected for each user. This feature was used to provide multilingual support, specifying that all contents are presented in two languages (Portuguese and Spanish) and selecting the language according to a user attribute: the nationality. Models from the Conceptual and Detailed Design as well as implementations are evaluated to assess their utility and usability.

In this third cycle, Evaluation is a more exhaustive process based on the criteria proposed in [11]. Such criteria include: richness, completeness, motivation, hypertext structure, autonomy, competence, flexibility, aesthetic, consistency, self-evidence, naturalness of metaphors and predictability.

5 Conclusion

In this paper we have discussed why and how we are applying a hypermedia/web engineering approach to improve the development process in a real project. The main lessons we learned from this experience can be summarized as follows:

- A systematic approach does not delay but speed up the delivery time, as activities can be planned on a more realistic way, knowing in advance what has to be done and who must be involved.
- Flexible model processes are required to fit different project needs at different development stages.
- Stakeholders have to be actively involved in all the stages to get a positive attitude as well as a more usable product.
- The use of conceptual models improves the communication with non-technical members who are able to discuss not only prototypes but also abstract design solutions.

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