# A VIEW ON THE WEB ENGINEERING NATURE OF WEB BASED EXPERT SYSTEMS

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Abstract: The Web has become the ubiquitous platform for distributing information and computer services. The tough Web competition, the way people and organizations rely on Web applications, and the increasing user requirements for better services have raised their complexity. Expert systems can be accessed via the Web, forming a set of Web applications known as Web based expert systems. This paper supports that the Web engineering and expert systems principals should be combined when developing Web based expert systems. A development process model will be presented that illustrates, in brief, how these principals can be combined. Based on this model, a publicly available Web based expert system called Landfill Operation Management Advisor (LOMA) was developed. In addition, the results of an accessibility evaluation on LOMA – the first ever reported on Web based expert systems – will be presented. Based on this evaluation some thoughts on accessibility guidelines specific to Web based expert systems will be reported.

## 1 INTRODUCTION

In many real-world problems, expert knowledge is scarce and yet in high demand. Computer programs that simulate the thought process of human experts can propagate domain expertise and can provide a solution to these problems. These programs are known as expert systems. In brief, expert systems have a knowledge base and an inference engine. The acquired knowledge of a specific domain is stored in the knowledge base. The inference engine is where the processing of the stored knowledge and the reasoning of the expert system take place.

The Internet – and the World Wide Web in particular – has become the ubiquitous platform for distributing data and information. The rapid growth of the Web and the evolution of the corresponding technologies "forced" Web applications to evolve as complex, challenging and multidimensional projects. That gave birth to a new engineering approach known as Web engineering (Deshpande et al., 2002).

Expert systems can be accessed via the Web, forming a set of Web applications known as Web based expert systems. Recently, has been mentioned that Web based expert systems can be considered as Web engineering projects that can be developed by merging an expert system and a Web site/application subprojects (Dokas, 2005). In essence, Web based expert systems can be formed by the combination of at least two components; namely an expert system and a Web site.

There has been a lack of research and of general methodology for developing Web based expert systems (Duan, et al. 2005) and a basic question that requires an answer is the following: Though which phases a Web based expert system development project is progressing, starting from its conceptualisation and ending when it is released? This paper is an attempt to answer this question. In addition, this paper aims to demonstrate the need for collaborative work among expert systems and Web engineering practitioners and researchers, on the development and operation of Web based expert systems. A development process model will be



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presented that reveals the Web engineering nature of such projects. Based on the presented model, a publicly available Web based expert system called Landfill Operation Management Advisor (LOMA) was developed. Additionally, the results of an accessibility evaluation on LOMA; the first ever made on a Web based expert system, will be presented and some thoughts on accessibility guidelines specific to Web based expert systems will be reported.

## 2 THE PROPOSED DEVELOPMENT PROCESS MODEL

Development process models are used for the description, coordination and management of necessary activities towards the development, implementation and release of computer systems. The proposed development process model is schematically displayed in Figure 1. It can be used to help Web based expert system developers to organize and manage effectively the necessary activities towards their project completion. Bellow, each phase of the proposed model will be explained in detail.

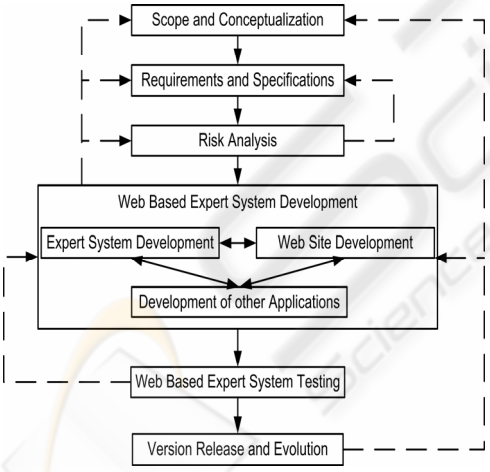


Figure 1: The development process model.

**Scope and conceptualization:**
Web based expert systems are developed to satisfy a need that has to do with the delivery of a domain expertise over the Web. The scope of a Web based expert system is to satisfy the above-mentioned need. The general concepts, the necessary components, the basic working principles and tasks can be briefly described, forming a conceptual model.

During LOMA's conceptualisation phase, the lack of expertise on landfill operations was realized. A decision was made to acquire the available expertise on landfill operational problems and to propagate it worldwide via a Web based expert system. High-level restrictions on time and on expenditures were set. Abstract descriptions of the system's components and of the user-system interactions were made.

**Requirements and specifications:**
Based on the conceptualization model, a more detail description of the desired functions of the Web based expert system should be made leading to a set of functional requirements. In addition, some desired characteristics and/or constraints could be revealed. These are defining the non-functional requirements of the system. The functional and non-functional requirements together are defining the Web based expert system specifications.

In LOMA's case the initial specifications included: the overall scope and goal of the Web based expert system, the target group of users, use cases describing the Web based expert system behaviour under various scenarios of user requests,

**Risk analysis:**
The reason of performing the risk analysis is to assess the factors that may jeopardize the Web based expert system development, and to define control measures and procedures that must be activated whenever anticipated problems occur during the development process.

Some of the assessed factors that could jeopardize LOMA project were the selection of: improper tools like expert system shells, server applications, Web editors etc., ineffective knowledge acquisition techniques, unproductive development strategy for the Web based expert system software components. Therefore, additional specifications were established, which were related to these issues.

**Web Based Expert System Development:**
When the preliminary phases reach an acceptable level of completeness, the development of the Web based expert systems subcomponents can begin. These components will include at least an expert system and a Web site. Based on the specifications, other computer applications, such as GIS and database systems, can be developed to enrich the Web system capabilities. The new challenge behind Web based expert systems development is to discover methods and techniques to combine, coordinate and manage the subcomponents development in order to save resources and time.

That is why the subcomponents development phases are interconnected with two-way arrows in Figure 1.

Each subcomponent development team can perform the requirements analysis, specifications, and risk analysis processes again, but this time at a low level, among other necessary development processes such as design, coding implementation and testing. When all subcomponents reach an acceptable operation level, they can be combined to form a prototype Web based expert system. Using the prototype system it is possible to check the degree to which the specifications are fulfilled.

**Web Based Expert System Testing:**

Before launching the Web based expert system on the Web, it is necessary to apply testing procedures to identify the degree to which the entire Web based expert system is correct and complete, based on the specifications. Moreover, the knowledge base and the reasoning mechanism of the expert system component must be tested and validated for errors.

The testing of LOMA was conducted in three phases. The first was to evaluate to which degree the specifications have been achieved. The second was to invite the collaborative domain experts to use LOMA and to point out problems, bugs, errors or improvement suggestions. The third was to send e-mail invitation to landfill experts from different countries to evaluate LOMA.

**Version Release and Evolution:**

During this phase, it is important to make sure that the system can be used properly and some non-functional requirements can be fulfilled. Since the domain knowledge, the used tools and the corresponding technologies are evolving, the Web based expert system must evolve with time, because progressively it will be less satisfactory to use.

Recently, the need to improve LOMA Web based expert system in a way that will make it more accessible to people with disabilities, expert users under time pressure and to mobile devises has been identified. Bellow, the accessibility evaluation of LOMA will be presented; as far as the authors know, this is the first ever reported for Web based expert systems. Through LOMA's accessibility evaluation process, some thoughts on accessibility guidelines, specifically for Web based expert systems, have been raised and will be presented.

# 3 WEB ACCESSIBILITY

The Web accessibility concept refers to a combined set of measures, namely, how easily and how efficiently different types of users may make use of a given service. Developers can extend the portability and longevity of their Web based expert system by using standard formats and accessibility rules. Additional improvements are expected, such as on speed and usability. Accessible Web pages should indeed be faster to navigate and minimize the mental load. These factors have in turn an indirect impact on safety.

## 3.1 LOMA Accessibility Evaluation

The system has been tested on desktop computer, running various Web browsers, and on a PDA with a screen of 230×320px (IE 4.01). Accessibility, HTML and CSS automatic validation tools were first used to spot some flaws. Then, the conformance evaluation of LOMA has been made by following the W3C WAI methodology and its "Checklist of Checkpoints for Web Content Accessibility Guidelines 1.0" [http://www.w3.org/TR/WAI-WEBCONTENT/full-checklist.html]. On 65 checkpoints, 17 were successful, 27 failed and 21 were not applicable.

Some general flaws were identified in various categories, such as invalid HTML and CSS code, character encoding issues, non user-friendly and non permanent addresses (URLs) and client side programming (JavaScript) problems.

Accessibility specific issues were for instance important pictures without alternative text, insufficient colour contrast, pop-up windows, form fields without explicit labels, undefined acronyms or abbreviations, etc.

## 3.2 Accessibility Considerations for Web Based Expert Systems

Based on the experience of evaluating of LOMA, some thoughts on accessibility recommendations specific to Web based expert systems are reported.

The system should inform the user of the number of steps already done, and an averaged estimation of the remaining steps. Furthermore, listing the questions already dealt with can help users in establishing a good mental model. Even for expert users, it is important to have self-explanatory questions: pictures can greatly improve text descriptions and are quickly understood. Similarly, a glossary of the words used in the context of the current expertise is an interesting resource.

Some Web based expert systems can be used for time critical decisions, for which there should be a possibility to go directly to the possible solutions

ranked by probability. Similarly, a mechanism to mark them as “not applicable” or “unknown” should be investigated.

In safety critical environments, even more efforts should be put to ensure robustness. On Image 1, a list of two advises was designed for large screens and use a simple carriage return <BR> instead of a standard list. On a smaller screen, this is rendered as 3 lines, making difficult to isolate the 2 advises. Using meaningful mark-up helps browsers to ensure the semantics of the page, even under unexpected situations. Another robustness issue is due to the behaviour of some widgets, which are more likely to show their limitations on small screens. This is for instance the case with the <SELECT> element in our tests, which crops the text when it is too long to fit into the screen, as seen on Image 2. It can be replaced by a set of radio buttons, or checkboxes.

Finally, some Web based expert systems use time limited sessions. Users shall be given sufficient time, but in safety critical applications, sessions should be avoided.

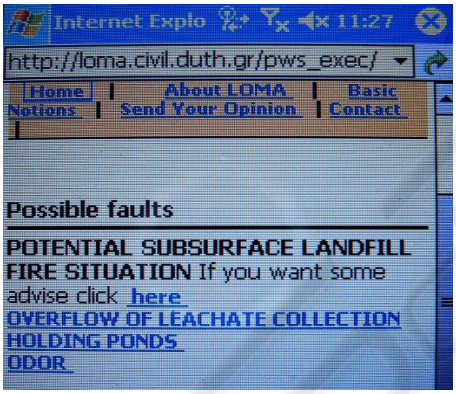


Image 1: List of items.

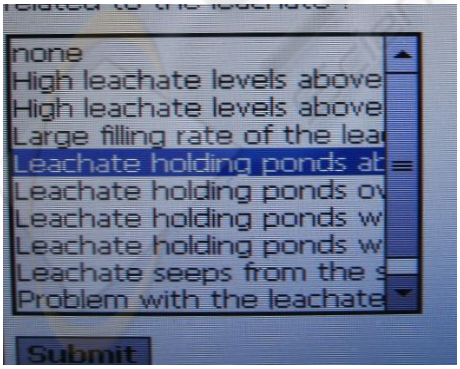


Image 2: Content overflow.

# 4 CONCLUSIONS

In many real life and safety critical circumstances, there is a need for rapid and effective distribution of expert knowledge and guidance. Web based expert systems can be an alternative solution to satisfy that need. This paper introduced a development process model for Web based expert systems that shows the phases through which a Web based expert system development project is progressing. In addition, this paper pointed out that the collaborative work of expert system, Web engineering practitioners and researchers is essential in such projects.

In an attempt to underline the Web engineering nature of Web based expert system, an accessibility evaluation on LOMA has been presented. Based on LOMA’s accessibility evaluation, some thoughts on accessibility guidelines specific to Web based expert systems have been reported. Further work is needed to validate and test them in different publicly available Web based expert systems.

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