User-Centered reverse engineering: Genesis-D project

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ABSTRACT

In the last years, the requirements of the end-users are notably evolved. A good software must not have only a good functionality cover but it also must have good usability features. From this point of view, the most recent design methodologies focus on the interaction between the end-user and its user experience; in this way, the design focus there is not on the data element (represented as objects or relational entity) but on the end-user and its perception of the information anymore. According to growing needs, it is more and more frequent the requests of reengineering of existing products that, developed in many years, have a good coverage of the application domain; these existing products result completely unsuitable to the modern paradigms of interaction. In this paper, we introduce an experience of reengineering (in web perspective) of a legacy application on the environment monitoring. This experience has been performed into the industrial research project (funded by Italian Government) called "Genesis-D"[1] (Global Environmental Network System of Information for Sustainable Development) that understanding the importance of the new user-centred approach wants to reengineering its own products.

Categories and Subject Descriptors

D.2.0 [**Software**]: Software engineering – *General.*

General Terms

Management, Documentation, Design, Standardization, Languages, Theory, Legal Aspects.

Keywords

User experience, Web application design, Environmental domain, reverse engineering process

1. INTRODUCTION AND BACKGROUND

The rapid growth of the web and the on-line services has made the complexity of the design and the following development manageable only through structured and engineered approaches. In order to improve the web application (WA) quality, the designer must not only manage the information and navigation aspects but, also all the multi-user and multi-device requirements combined with the customization needs; although, these aspects have been subject of study [6][3], their cohesion and mutual implications have brought to the birth of new methodological approaches.

In the last years, several design solutions have been proposed; their main goal is to adapt the well know methodology to the new WA requirements; thus, these methodology would be able to introduce complex contents and to manage the requirements of user-accessibility.

The methodologies so adapted are founded on the idea that to model any page type (and so to describe a WA), is enough to represent its fundamental elements (pages, form and link) and to relate themselves through the classical object-oriented relationships.

Starting from this perspective, we have to take in consideration Jim Conallen approach [4]: WAE (Web Application Extension), an UML profile that adding new stereotypes, simplifies the Web page representation. WAE is strongly confirmed in the industrial environment and UML community. WAE is very useful and powerful when is used to describe the logical design of the software modules that composes a Web system; but, on the contrary, it has some weakness (due to the lack expressive ability and the inadequacy) to represent the User Experience aspect.

These considerations are helpful both when the designer is planning an application ex-novo and when he/she is making an application reengineering; rather, in a phase of reengineering the semantics of the user experience must drive the designer: the designer must not be influenced by the object-oriented paradigm. After all, supposing to have a pure object-oriented design, if WAE was applied the result would be only the same application translated in the web domain but with the same politics of interaction of the first one getting a "porting" and not a reengineering in the user-centred point of view. Starting from these considerations, we introduce a reengineering experience in which different design techniques, both traditional and user-centred, are combined.

[1] The leading company is Edinform SpA and is located in Lecce

2. THE APPLICATION DOMAIN AND THE APPLICATION

The approach to the environmental protection (understood as habitat of all the organisms and as organic structures of systems and subsystems), is evolved considerably. If, in the sixties, the public administration attitude was finalized to control to the law prescription, today great importance is given to the knowledge acquisition of the factors that heavily affect the environment quality; this choice is determined by the high growth rate of the population and by the evolution of the productive system that make pressure on the environment.

Today the monitoring activity and environmental control are made not only by the public administrations such as Municipality, Provinces, Regions but also by several associations and organizations and by protection environment agencies in the national and international territory.

The number of involved actors and the need to acquire the quality status of the environment and territory, lead to create a consistent, coherent and reliable informative exchange. To achieve this goal organization and institution nets (with the target to improve the collaboration for a common environmental politics) were born. The efforts to collect and to delivery the environmental knowledge in Italian and European area does not match in regional institutional level, because the technological infrastructures does not support informative exchange. In this context take places the research project GENESIS-D[1] sponsored by Edinform S.p.A in collaboration with the University of Lecce and Polytechnic of Milan. The project goal is the creation of a "framework" for the modelling and the development of software systems about the environmental management at regional or sub-regional institutional level. The Web applications, obtained starting from the framework Genesis-D, have to improve the interface and the interchange of environmental information among different institutional subjects such as Regions, Provinces, Municipality, ARPA (Regional Agencies for the environmental protection), etc.

The application domain is characterized by a considerable number of actors (public administrations, authorities, corporate bodies, local health services, experts of domain, etc), of administrative documents (norms and national laws, regional, directives of the European Community, etc.), of studies (international standard, studies of sector, models, etc.). It is clear that the creation of a framework based on the reverse reengineering of existing product (developed in about ten years), that considers many laws, studies, is a good starting point. In accord with Edinform S.p.a., it was established to perform the reverse engineering of the application SIRA (Environmental Regional Information System).

2.1 SIRA

SIRA supports the environment management and control activities in a regional context.

In accord with the standard SINAnet (Cognitive National System and of the Environmental Controls), SIRA split the environmental subject in the thematic area base of the National Thematic Centres: Waters inside and sea coastlines (EKB-AIM), Wastes (EKB-RIF), Soil and contaminated sites (EKB-SSC), Nature Preservation (EKB-CON), Air climate and emissions in atmosphere (EKB-ACE), Physical Agents (EKB-AGF). This segmentation strategy is the base of EKB (Environmental Knowledge Base). Its reality is the Environmental Reality composed by environmental facts and phenomena.

Starting from this point of view, SIRA is structured in the following subsystems:

- *General registry*: it manages all the registry data of the firms, of the subjects and of the operational structures with an impact on the environment or that they have involved in the control and in the environmental prevention.
- *Management procedures*: it allows the administrative management of the documents produced by the activity of environment monitoring.
- *Soil*: it allows the management of data coming from the monitoring of the environment risk areas (polluted sites and plants at risk of accidents with dangerous substances) present on the regional territory.
- *Water*: it allows the management of data coming from the monitoring of hydrographical basins, the water bodies, the waterworks, the withdrawal work, the unloading and presence of mud on the regional territory.
- *Nature*: it allows the management of data coming from the monitoring of the protected areas, and of the relative areas of protection, on the regional territory.
- *Wastes*: it allows the administrative management of the unique form of environmental declaration, annually introduced by the firms and by the municipalities that they participate in the cycle of waste management.
- *Security*: it allows the definition of the access profiles of the system.

3. THE REVERSE ENGGINEERING PROCESS

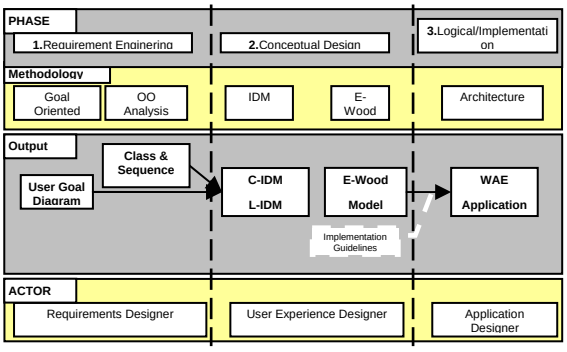
As written above, in the first project phase the main goal is the reengineering (with user centred approach) of SIRA. In order to manage the complexity of the application domain and taking into consideration the kind of application, the creation of a process in order to correctly drive the designer is needed. The main process is divided in three macro-phases:

1. *Requirements elicitation and analysis*. This phase can be divided in two parts: the first one uses the "user centred" approach focused on the stakeholders and on their goals; the second one aims to represent the application domain knowledge. In the first sub phase, we recommend the use of requirement engineering approach based on "goal oriented" techniques; in our case study, we used the methodology AWARE based on the KAOS theory of Lamsweerde [5]. This technique traces the meaning of each requirement that is related to its specific goal. The "stakeholder" is whoever (end-user, developer, manager, buyer, financier, etc.) has a specific interest in the system and so it is able to express his goals. The goals of a specific stakeholder can eventually be shared with other one. A single goal not related to a specific stakeholder, it is not a goal for the web system and it must be therefore deleted. The output of the analysis is a user-centred vision of the application requirements and will be the base for the following process phases. The second sub phase, instead, uses object-oriented technique to perform the

application reverse engineering. Output of this sub phase is the complete diagrams (class diagram and sequence diagram) that could be defined still part of the requirement engineering because they aim to describe the application domain. Our case study describes the application SIRA using OO paradigm and this is a good starting point for the informative object study of the domain and the relationships among them.

2. *User experience design*. This is the first phase of the reengineering and must have performed using WA design methodologies based on user centred approach. In the case study, we used two methodologies IDM [2] (used to describe the interactive and navigational essential aspects of multi-channel applications, focusing on the dynamics of dialogue end-user / application) and E-Wood (Edinform Web Object-oriented Design) that, refining the IDM analysis, uses the object-oriented techniques integrated with the necessary semantics for the web applications. Both the two designs have kept in mind of the informative objects derived by the SIRA reverse engineering combined with the goal-oriented analysis; in other words, the two methodologies allow to filter the OO analysis with the goal-oriented vision of the domain for the specific stakeholder. The E-Wood design methodology has been created by the Polytechnic of Milan, and inherits the notation from UML. E-Wood allows the conceptual design of the application with the WAE profile. Thus, its output could be adapted to the specific implementation technology.
3. *Implementation design*. The output of the phase is intended to the developer and provides the implementation model of the system; in other words, it describes through WAE the pages and the software components that the developer must implement using a specific implementation technology such as Micorsoft .Net, J2EE model 1, J2EE model 2 etc. It is called also "logical design" and it allows adding the implementation details directly connected with the system and the selected architecture.

In figure 1, it is possible to see the process scheme of reverse engineering. The transition from the conceptual modelling E-Wood to the implementation design is made easier thank to the guidelines provided. The guidelines provide several advantages to create the final product; in fact, applied in a systematic way after having established the architecture type to use, they allow to conform the implementation of specific E-Wood structures and accordingly to get an uniformity in the code; in other words, the guidelines limit the freedom of the developer to translate the methodology objects in code.



Figures 1: Scheme of the process of reverse engineering

3.1 The E-Wood methodology

Following UML community approach, in order to model the page features such as layout, contained, navigation in E-wood several views are used. The goal is to separate the different aspects into different design in order to improve the quality of the analysis of the aspects that are correlated each other. The required views are:

- *Structural navigation view:* it specifies the pages used to represent the information content related to a conceptual entity. In this view the navigation among these pages is defined too.
- *Association view*: it allows to specify how create the navigation between pages that describe different entity linked by a semantic association.
- *Navigation Path view*: it allows to specify as the navigation among pages created for supporting the end-user interaction with driven path of navigation.
- *Operation Views*: it allows to specify the pages that support the execution of operations.

The E-Wood methodology provides also these general views:

- *Page Template View*: it defines the general structure of the pages and the aspects of layout specifying general contents and links of landmark shared with various pages.
- *Navigational Map View*: it provides a view of whole application, or related to the screens belonging to a single package of pages, showing the main Screens and the possible navigation among them.

4. REVERSE ENGINEERING OF THE SIRA APPLICATION

According to the process described above, the SIRA application reverse engineering was performed. In the stakeholder analysis, it must be highlighted that different authorities and corporate bodies share the responsibilities for protecting and preserving the environment, that operate at different institutional levels (municipality, intercity, provincial, inter-provincial, regional, inter-regional, national, EU, etc). Among these subjects, at national level we remember the APAT (Agency for the Protection of the environment and Technical services), the Minister of the environment, the Forest Body of the State, the Italian Red Cross, the Civil Protection, etc. At regional level it is opportune to mention the various ARPA (Regional Agencies for the Protection of the environment), the Basin Authorities and the Park Authorities, the Provinces, the Regions. At provincial level we remember the APPA (Provincial Agencies for the Protection of the environment), the metropolitan cities, the prefectures, the provinces, the offices responsible for police force and public order, while at town level there are the municipalities. Studying the competences of these corporate bodies, it is possible to identify not detailed professional figures (that would be hundreds considering that each organization has an inside structure and own rules) therefore we focused on the roles that the figures assume in an environmental monitoring system; in detail, three different typologies of roles are been founded:

- *Government role*: who adopts the opportune tools of government for the protection and preservation of the environment and cooperating with the government end-users

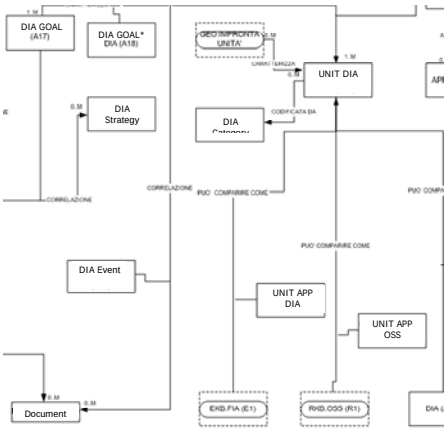
of other corporate body and authorities in order to perform an integrated territory management. The first level goal are: Optimal management of the territory, Reduction of the level of acoustic pollution, reduction of the level of atmospheric pollution, the waters' preservation, reduction of the wastes and reclamation of the polluted sites, preservation of the human health.

- *Coordination role:* supervise the job of the operational end-user; it provides all the necessary information to the government end-user to adopt the opportune measures. Its goals are the same of high-level government role but with different assignments and functionality; for instance, in order to perform an optimal management of the territory, the coordination end-user takes in care the promotion and planning of the use services of the local areas and parks (as the creation of cycle routes); thus, it performs studies and projects preparatory to the environmental activities and territorial planning, it finds the development opportunities of the territory compatible with the environment, it promotes initiatives to enhance the naturalistic patrimony and to protect the biodiversity and the environmental quality, and it deals with the management of the censuses of the wildlife and of the surveys of the habitats in the natural reserves.
- *Operational role* deals with to perform the surveys for the environmental monitoring and to point out to the coordination end-user about particular anomalous values emerged by the analyses performed so that to be able to adopt the opportune measures, effect the plans of management of the reserves, deals with to perform the inquiry of environmental impact evaluation for the realization of new works, and to perform the environment monitoring, that is to periodically perform the censuses of wildlife and the survey of the habitat in the parks, in the reserves and in the other areas of interest.

At the end of the AWARE analysis, the reverse engineering of the application SIRA was performed with Object-oriented paradigm. The application SIRA from the end-user point of view is very bind to the information managed; in fact, the user interface in its structure and navigability mirrors the relational model and, therefore, it is limited to a set of forms of insert/view.

The environment business logic is directly contained instead in a set of objects related to the insert forms. The application allows the end-user profiling preventing the access to particular information to the end-users not authorized.

The OO analysis identified about 190 classes with the relative methods and objects (in figure 2 a part of the class diagram is showed).

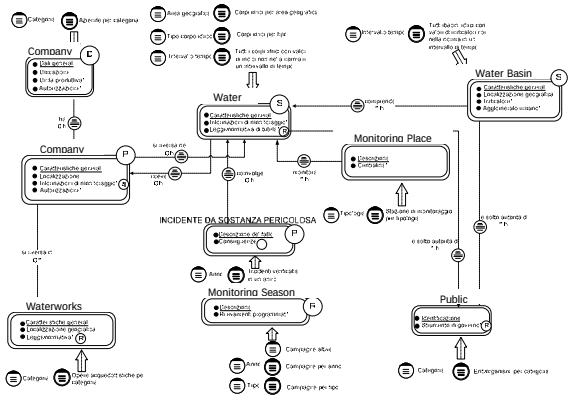


Figures 2: Part of the class diagram of SIRA

In the figure 2, the identified objects are tightly bind to the information that represent and cannot directly be used in a user-centric application, since they mirror the data and do not keep in mind as they are perceived by the end-user. Using the goal analysis and the detailed information (attributes and methods) derived from the OO analysis, the IDM methodology is applied.

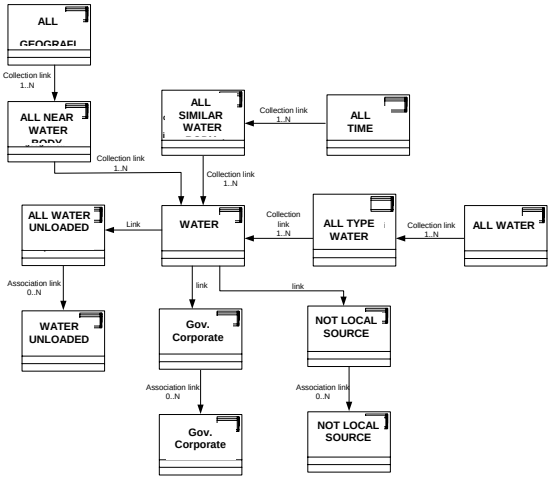
The conceptual model of the new system of environmental monitoring has been realized keeping in mind the thematic of the environmental domain: Water, Soil, Air, Nature, and Waste. Keeping in mind therefore the aforesaid thematic environmental and the typologies of stakeholders, have been realized for each end-user five IDM views, one for each thematic. In figure 3 the IDM scheme of the thematic Water for the Government is showed.

The founded topics contain all the information derived by the objects (OO analysis) modified with the end-user perception of them: for instance, the topic "waterworks" contains inside the dialogs act: General Features (Description, Type of work, Type of waterworks net, Manager, Year of realization, flow in, flow out, Pressure in, Pressure out, K, Quota), Geographical Location (imprint, geo-code, geo-references), Law / normative (Denomination, Text, Category tool, Absorbed Tool). It is clear that all the dialogs acts derives from different objects; in fact, in the class diagram there is the object RKB.OSS of which the waterworks is an instance that is related with the class "DIA unit of application" to which the geo-references (GeoImprint Unit) is related.



Figures 3: View of Government End-user for the thematic Water

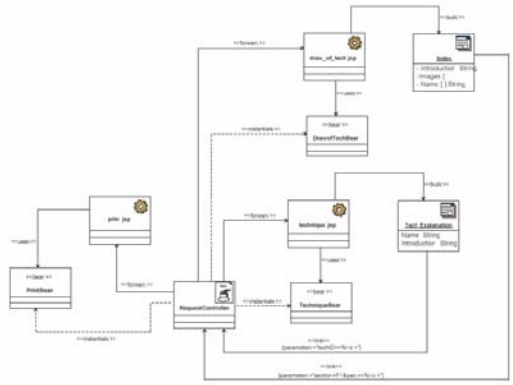
At the end of the IDM design (in which the information is modified in terms of user experience), the E-Wood analysis is performed; thus, all the E-Wood views for specific end-user and environmental thematic are produced: Structural Navigation View, Association View, Navigation Paths View, Operations View, Page Template View, Navigational Map View.



Figures 4: View of the navigational map of the water Body for the government end-user

The figure 4 shows the navigational map of the "water body" object.

At the end of the E-Wood modelling, established the software architecture, the implementation view could be produced. This task is not excessively complex because E-Wood uses a similar notation of implementation views and thus, it is possible to establish a mapping between the objects of the conceptual modelling and those of the "implementation view"; furthermore, Polytechnic of Milan has established the guidelines that allow an easy translation of the E-wood diagrams in the specific architecture.



Figures 5: "implementation View" of the navigational map of the water Body for the government end-user

The Figure 5 shows the implementation view of the navigational map of the water Body for the government end-user in the case was chosen as implementation architecture MVC model 2: the request controller is present and each JSP page invokes the bean of the corresponding entity.

5. CONCLUSIONS

The growing demand of new services and the continuous interest for the web is forcing a lot of company to evolve their applications. This transition is heavy: all the application logic has to change from a system vision to user centric vision. The information is not fundamental while the perception and the interaction that the user has with it is the design core. It is clear that whether to resolve the problem of the reengineering is not enough a methodology but it is necessary a *process* that leads the designer to understand the domain, the stakeholders and the following phase of analysis and design. This paper presents a reengineering process that, integrate well known methodologies as Aware, Object-oriented, IDM and E-wood, applied to a real case. The output is good: a logical model effectiveness and uniform ready to be implemented. The effort to perform the complete design with user centred approach has required just 4 months of a designer (a very small effort for a domain very extended). It is sure, that the introduction of the guidelines for the implementation level, constitutes a great facilities for the designer and it allows to get a design more uniform and correct. Since the guidelines are tightly connected with the selected implementation architecture, a very interesting future development is to create new guidelines toward new technologies.

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