

# WEB INFORMATION SYSTEM: A FOUR LEVEL ARCHITECTURE

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**Abstract:** Business processes are playing a very important role in companies and the explicit introduction of them in Information System architecture is a must. According to the interest shown towards Web Application it is important to introduce a new web-oriented class of software, which is able to give to the manager the possibility to operate directly with the process (we will talk about process oriented WIS - Web Information System). It is necessary to replace the *three-level* logic of the traditional application development (Data, Business Logic, Presentation), that hides processes in the Business Logic, with a *four-level* logic that allows to separate the process level from the application level: definition and management of the processes will be not tied solely to business logic. Our research (work in progress) focus is on an innovative framework (software architecture and methodology) for Information System development that links together the know-how acquired in Web Application design and in the process definition concepts.

## 1 INTRODUCTION

Industries have made great efforts in the last years to improve their Information System which today is not only a tool for activities automation but also a powerful tool that enable managers to analyze their company's activities and to take timely decisions in order to correct possible management errors. To reach this goal, companies abandoned the vertical vision that locates business logic in functional areas and orients them toward a transversal vision that, following process logic, tries to improve the management exploiting as much as possible the existing resources (software, hardware, actors and so on). Process vision is a good way to guarantee to the manager a full business activity control and to increase flexibility degree in Information System management. The attention paid to processes brings to the necessity to integrate the existing applications inside the company with the goal to meet managers' goals. Although process vision is a good idea, today, processes are only in the mind of the business analyst and are not explicitly taken into consideration by IT experts: business experts define the process flow but, when the information system is implemented, processes are hard coded in the

application without well defined guidelines, so, developers are free to take decisions in order to reflect the process logic. These decisions often distort the original process logic in the final web application. In this way a change in the process flow means a change in the application code, so it is hard to obtain "on the fly" a change in the information system in order to meet the flexibility that the manager needs. To obtain a new vision of the process it is very important to separate the process logic from the business logic and to provide to the manager an horizontal view of the processes that take in consideration several people who belong to different division of the company. It is important to introduce a *new class of software* that allows the manager to define, to implement and to execute processes. In order to do this it is essential to have a tight cooperation between IT and Business sectors of the company so that business requirement can have in a brief time answers from the IT sector. Another important consideration is that an Information System must be addressed towards the horizontal management of the company and must be delivered on the web (we talk about WIS-Web Information System) in order to reach several users and to integrate services of other companies. Our research work, starting from a Web Application design

methodology and using methodologies of process analysis, design and representation already existing, propose to define a new methodology that by linking the know-how of both, drives the designer towards the design of a WIS. Our goal is to provide not only a methodology but also a set of tools that allow to pass from the representation of the process to the final Web Application where process can be executed.

In the next section we present the state of the art of the methodology that try to address the problem and of the tools actually on the market. In the section 3 we present the importance to introduce the fourth level in the overall information system architecture and in section 4 we explain the architecture proposed and a methodology that try to address the problem. We, then, apply the methodology to a case study. In section 5 we present conclusion and future works.

## 2 BACKGROUNDS

In order to design and to implement a Web Information System (WIS) it is important to address two different problems:

- The necessity to take under control the web application design and therefore the necessity to take in consideration, in the design phase, information, navigation, presentation and transactional aspects typical of Web Applications (Baresi, Garzotto, Paolini, 2005)(Baresi, Garzotto, Paolini, 2001).
- The necessity to represent and to manage business activities according to process logic.

Currently Web Information System design separates the problems related to Web Application from the problems related to the process management. Current attempts to consider process design in existing WA design methodology fail to explicit separate process design from typical Web Application design tasks. Moreover, processes implementation is in the mind of the developers which hides the process in the Web Application in some way difficult to understand and to modify. There are different approaches in the scientific community that take into consideration the process design explicitly in the Web Application design methodology. An example is in (Koch, N., Kraus, 2003) where the authors attempt to extend web application methodologies such as OO-H(Cachero,2003) (Gómez, Cachero, Pastor, 2001) and UWE (Koch, Kraus, 2003) with process design. The authors define a process model (made by UML

activity diagram) that allows to design process flow. After the process model definition, the navigation model, designed without take into consideration the process, is integrated with process model in order to allow the final user both to navigate in the general information and to execute process steps. The Navigation model defines a process entry and exit points between tasks. In this interesting approach the design start from the navigation model without taking into consideration, in a separate way, the information involved in the Web Application and in the process too. Another approach is proposed in WebML (Brambilla,2003); this approach extends its data model to define the process but the approach is limited to very simple process without a complex logic and the authors say that this approach is not valid when the logic complexity is high. As it regards the technological point of view, currently there are on the market a lot of frameworks that allow to define processes and to develop applications that implements them: these frameworks are both complex and expensive. As an example, Filenet P8 (<http://www.filenet.com>), W4, iLog, PopkinSoftware and Fuego (<http://www.Fuego.com>,<http://www.ilog.com>,<http://www.popkin.com>, <http://www.w4global.com>.) The main problem related to these frameworks is that they are difficult to apply in a small-to-medium sized companies (target of our research work) because they are very complex and therefore they require high investments both to purchase hardware and to training people in the company that will adopt these frameworks. These frameworks, also, does not consider any design methodology or guidelines in order to design the final web application.

## 3 THREE LEVELS VS. FOUR LEVELS APPLICATION ARCHITECTURE

The introduction of a new class of software that allows to take under control in an explicit way the definition and management of processes imposes to modify the current application architecture. Today, applications are usually structured in a three level architecture: there is a Data level made up of centralized or distributed databases where information are stored; Application level where there is the company business logic that exploit and manage data of the underlying level; finally Presentation level that allow the end user to interact with business logic. Since the '90s, process logic

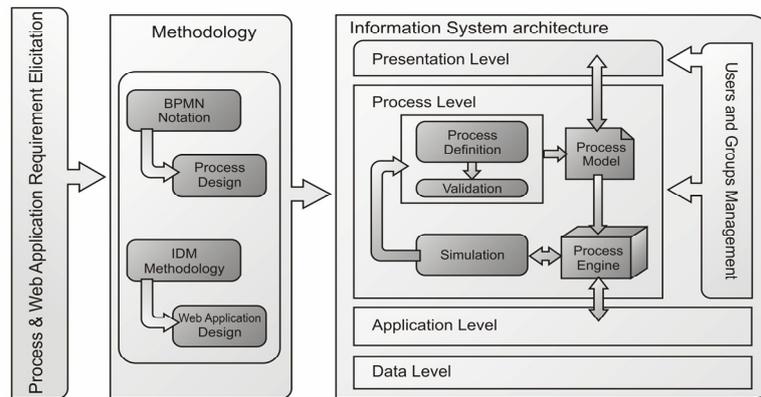


Figure 1: The architecture of our research.

began to affirm with the BPR theory (Business Process Reengineering) (Hammer, 1990) which introduced the process as the way to improve the company's management. Nevertheless analysis and re-engineering of processes is a preliminary phase of the Information System realization or change, the processes are, today, not explicit in company's management and thus it is very difficult to monitor and to manage them. We think that it is very helpful to *separate the application level from process level* and, to do so, we introduce the process level that allow to define and implements process in explicit way (eventually re-using existing business logic) and to monitor them. Process level will be the contact point between business experts and IT experts each of them with a specific goal:

- *Business experts* will focus on the processes and in the direct process management in order to modify the company's work: a change to the process will directly reflect on the application that implements it without a full re-design and re-implementation; to change process means to change *the management* of the business logic and not the business logic. In this way the application obtained will be *more flexible* and will be focus on the process logic and not on the business logic.
- From the *IT experts* point of view the code maintenance is simplified: a change in the business logic means a change in the application level code without any (or with few) changes in the Presentation and Process level; a change in the process will directly reflect a change in the process level without modify the business logic and with some changes in presentation level. In the company, very often, there is the necessity to change (or re-define) processes and not the underlying business logic, for this reason the introduction of a process level is very helpful. In

the process level processes may be defined; it is possible to simulate its behavior and to change, if needed, the design, The difference between process level and application level is that in the process level it is possible to define actors, process flow, tasks, while in the application level there is the implementation of each task (or groups of task), the implementation of the access right to each actor and so on.

#### 4 THE PROPOSED INFORMATION SYSTEM ARCHITECTURE

The architecture that we propose in our research work is in Fig. 1. Our work is at an initial stage, so we would like to explain here our idea without provide too many technical details. First of all there are three different parts: requirement analysis, design methodology and the four-level application architecture. After the requirements analysis, the next step is to design the Web Application that allows to take in consideration also the process analysis. Our idea, explained in the next section, is to define an innovative methodology that integrates in an opportune way the IDM (Perrone, Bolchini, Paolini, 2005) design methodology with the process definition finding the contacts points between this methodology and the process definition. Starting from this new methodology will be possible, *with an effort that, we foresee, will be hard*, to obtain a final Web Application, automatically or manually produced, that goes over the simple definition of information contents and navigation between them but includes also a process and the instruction of its execution. In the process level it is possible to represents the process (Process Definition) using

BPMN (Business Process Management Notation) (OMG, 2006). The designer has ad-hoc tools, the process editor (Guido, Paiano, 2006), that allow to obtain as output the process model (Model) in a formal language (OWL language (W3C, 2004)). The editor, thanks to BPMN notation and to the efforts made to provide a tool simply to use and to understand both by business and by IT experts, is *independent* from any analysis methodology we think to use. After process definition it is possible to validate the design (process validation) in order to verify if the design follows the BPMN constraints (as an example the process design infinite loop are not accepted or each fork will be followed by a join and so on). The output of the process editor will be a *formal representation* of the process, the process model, where it is possible to find all the information about process. Process model will be the input for the process engine tool (not yet implemented) that manages the process execution that is the process flow and the assignment of each task to the right actor. The process engine will interact with the application level and allow to include in the process management also business logic not yet implemented in the company. It is clear that the methodology will help in the interaction between different levels. In the architecture show we refer also to the *process simulation* block (we think to complete this tool within 6 months) that allows to define Key Performance Indicator (KPI) and to verify if the process meets the performance

requirements.

### 4.1 Web Information System Design Methodology

The web application design methodology reflecting the IDM methodology aspects is *transversal* to the Data level, the Application level and the Presentation Level. The methodology proposed links both the know how obtained by the IDM design methodology (so will solve the information, navigation and transactional aspects typical of web application) and the know how coming from the process design knowledge. First of all we think that *two different experts* will design, independently from each other, the information system processes (using BPMN notation) and the information and navigation aspects (using IDM design methodology). In fact process design will explain *how* companies work; while information and navigation design will explain *what* the information system provide to the final user from the communicative point of view (in a few word design the design of the *user experience*). In our study we first evaluate the possibility to provide a direct mapping between process task and IDM design. We observe that it is *impossible* to provide a general strategy to do so because the user experience design is made up not only by information related to the process (expressed as input and output of the task) but it is often important to add other information not directly connected to the process

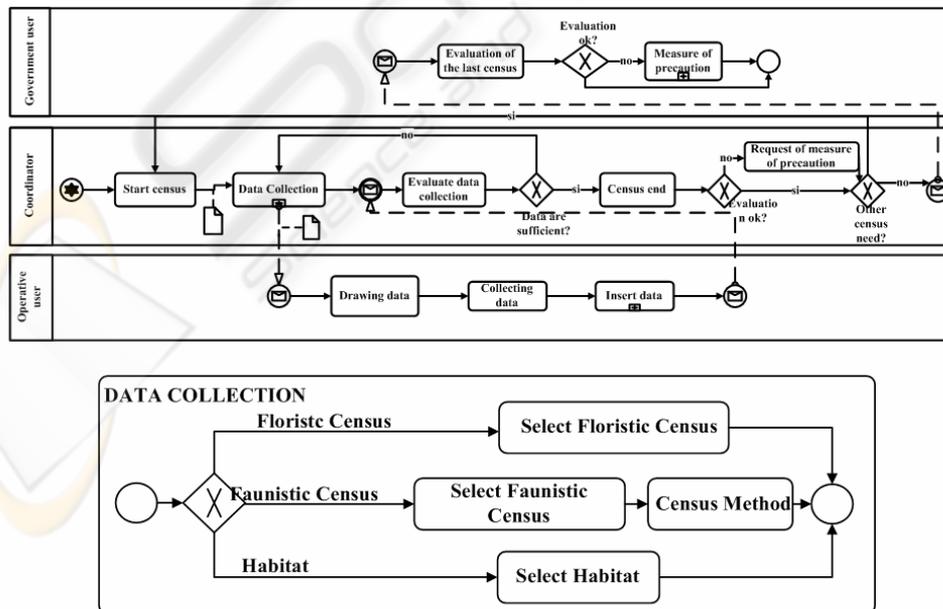


Figure 2: BPMN design of the management of the flora-faun census process.

definition but strictly related to the user-experience design. We think that, probably, it is possible to see some *contact points* between information needed in the process definition and information needed from the user experience point of view. It is important to cover also the navigational aspect typical of Web Application taken in consideration in the IDM methodology. When we consider processes, it is important to think not only to the navigational link related to the user experience (semantic relationships) but also to the navigational link that allow the final user to follow the process flow. In our experience with several case studies, a mismatch between process link and semantic link has been covered by a process re-design and/or a user experience redesign. Thus, this mismatch could be a signal that there are some problems in the process design and/or in the user experience design. These aspects bring us to think that *process links are a subset of semantic links*. The main difference between process link and semantic link is that the user is free to navigate between semantic links but he/she is not free to navigate between process links because there is an underlying process flow that he/she must follow. Another important aspect is related to the access structure: it is important to define *ad hoc access structures* that, depending on the state of the process, provide to the final user the access to the process in the exact point where he/she leaves from it in a previous session. Access structure

strictly related to the process flow would be added to the access structure related to the user experience design, so we may see in the methodology two types of access structures: the access structure coming from the user experience design and the access structures coming from the process design.

#### 4.1.1 A Case Study: Environmental Monitoring

We apply our consideration about the four layer application and about the methodology to a research industrial project founded by the Italian Government about environmental monitoring. In this project business experts and IT experts teams design, in separate way, both the user experience (through IDM) and the business process (through BPMN) of the overall information system. We present here, due to space limitations, a fragment of the overall Information System: the management flora-faun census. The BPMN design of this process is in fig. 2. The sub-process “data collection” considers three type of census but we are interested only to “faunistic census”. The integrated design, made up by the observation made in previous section, is shown in fig. 3; it refers only to the coordinator user. We observe that in the integrated design *we can recognize the four level architecture* presented above: the *data level* is the definition of the information content and their relationship while the

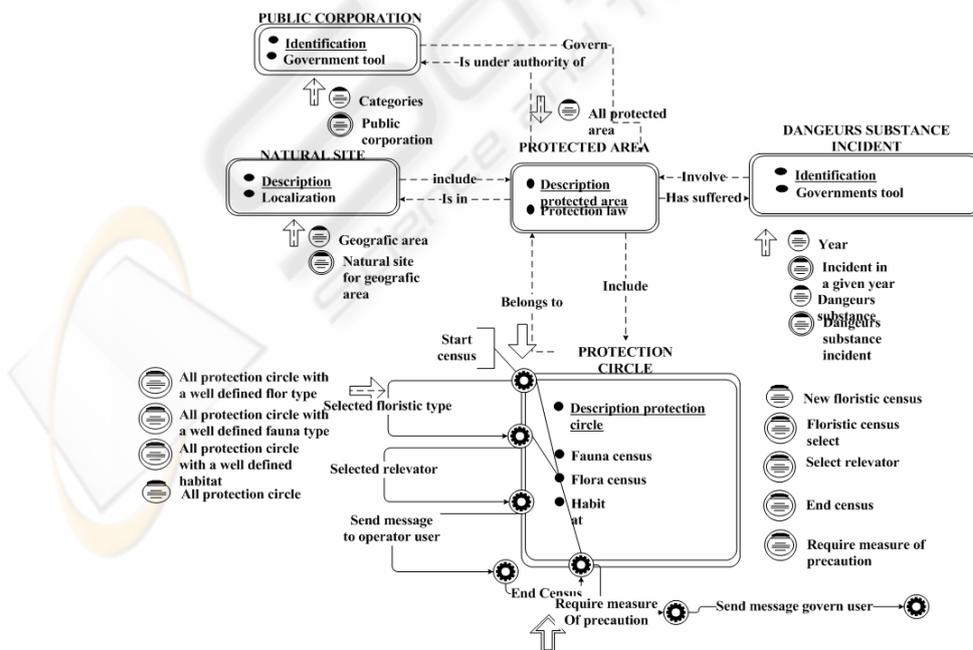


Figure 3: The integrated design.

*application level* is represented with the property of each operation act (we does not show these property for the space limitation but in each operation act()) is well defined how it is implemented). We can see the *process level* inside the integrated design in the start process() in the intermediate event () and in the process links (that links together operation act with the name of the destination task). Note that gateways are not presented in the integrated design because they are defined in the attributes of the operation act. It is very important to observe that in Fig. 3 only the “protection circle” has its own operation act but it is possible, in other case study, to have operation act in several topic so the process involve different topics but the mapping between BPMN and IDM design is also valid. Another observation is that there are several access structure (near to the protection circle topic) in order to take in consideration the entry point to the application coming from the process design, these are obviously not taken in consideration in the IDM design before integration. It is important to highlight that the process flow can be followed directly in the integrated design, so a change in the process flow will be immediately followed by a change in the integrated design, and, thus to the final web application that take in consideration both the process and the user experience issues. This allows to obtain the right flexibility required by modern Information System.

Finally, the *presentation level* is not show in this integrated design because we define this level through another methodology (named E-WOOD) more suitable for the presentation design.

## 5 CONCLUSIONS AND FUTURE WORK

Modern Information Systems will be more flexible and able to answer “on the fly” to the manager innovation requirements. The only process analysis and re-definition is not too much to meet the Information System flexibility and, as consequence, it is necessary to make explicit the process in the WIS architecture. We add a fourth level in the traditional three level Information System architecture in order to explicitly manage processes. We provide not only tools to manage process but also a methodology that links together the know how coming from process design and the know how coming from the user experience design. A case

study is shown and we highlight where the four level proposed are in the application design. Our research work is not yet concluded, we work to refine the methodology proposed and to complete the development of tools in the process layer.

## REFERENCES

- Baresi, L., Garzotto, F., Paolini, P. (2001). Extending UML for Modeling Web Applications. Proc. of *34th Annual Hawaii International Conference on System Sciences IEEE Computer Society*. Island of Maui, Hawaii.
- Baresi, L., Garzotto, F., Paolini, P. (2001). From Web Sites to Web Applications: New Issues for Conceptual Modeling. Proc. *WWW Conceptual Modeling Conference*, Salt Lake City.
- Brambilla, M. (2003). Extending hypertext conceptual models with process-oriented primitives. *International Conference on Conceptual Modeling (ER)*, Chicago, Illinois USA
- Cachero, C. (2003). OO-H: Una extensión a los métodos OO para el modelado y generación automática de interfaces hipermediales. Retrieved October, 2005 from <http://www.dlsi.ua.es/~ccachero/pTesis.htm>
- Gómez, J., Cachero, C., Pastor, O. (2001). On Conceptual Modeling of Device Independent Web Applications: Towards a Web Engineering Approach. *IEEE Multimedia Special Issue on Web Engineering*. Vol. 8(2) pp. 20-32
- Guido, A.L., Paiano, R. (2006). BPM:Overall Architecture and Business Process Design Tool *WebIst 2006 Setubal, Portugal* ISBN978-972-8865-46-7
- Hammer, M.(1990). Reengineering Work: Don't Automate, Obliterate. *Harvard Business Review*. Vol. 68 pp. 104-112
- Koch, N., Kraus, A. (2003). Modeling Web Business Processes with OO-H and UWE. *Third International Workshop on Web-Oriented Software Technologies*, Oviedo, Asturias
- Koch, N., Kraus, A.(2003). Towards a Common Metamodel for the Development of Web Applications. *International Conference of Web Engineering*, LNCS, Springer Verlag Oviedo Spain 497-506
- OMG, BPMN 1.0, (2006). Final Adopted Specification, February 6, 2006 Retrieved April, 2006, from [www.bpmn.org](http://www.bpmn.org)
- Perrone V., Bolchini D., Paolini P. (2005). A stakeholders centered approach for conceptual modeling of communication-intensive applications. Proc. of the *23rd annual international conference on Design of communication: documenting & designing for pervasive information* pp: 25 – 33, ISBN:1-59593-175-9
- W3C, OWL Web Ontology Language Overview, (2003): retrieved on <http://www.w3.org/TR/2003/CR-owl-features-20030818/>