Business Process Management – A Traditional Approach versus a Knowledge Based Approach

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Abstract

The enterprise management represents a heterogeneous aggregate of both resources and assets that need to be coordinated and orchestrated in order to reach the goals related to the business mission. Influences and forces that may influence this process, and also for that they should be considered, are not concentrated in the business environment, but they are related to the entire operational context of a company. For this reason, business processes must be the most versatile and flexible with respect to the changes that occur within the whole operational context of a company.

Considering the supportive role that information systems play in favour of Business Process Management - BPM, it is also essential to implement a constant, continuous and quick mechanism for the information system alignment with respect to the evolution followed by business processes. In particular, such mechanism must intervene on BPM systems in order to keep them aligned and compliant with respect to both the context changes and the regulations. In order to facilitate this alignment mechanism, companies are already referring to the support offered by specific solutions, such as knowledge bases.

In this context, a possible solution might be the approach we propose, which is based on a specific framework called *Process Management System*. Our methodology implements a knowledge base support for business experts, which is not limited to the BPM operating phases, but includes also the engineering and prototyping activities of the corresponding information system.

This paper aims to compare and evaluate a traditional BPM approach with respect to the approach we propose. In effect, such analysis aims to emphasize the lack of traditional methodology especially with respect to the alignment between business processes and information systems, along with their compliance with context domain and regulations.

Keywords: Business Process Management, Compliance, Knowledge Base, User Experience, Business - IS Alignment

1. Introduction

The enterprise management represents a heterogeneous aggregate of both resources and assets that the enterpriser has to coordinate and orchestrate in order to achieve the goals related to the business mission. This coordination and orchestration process must be properly designed and

implemented, mainly referring to the definition of the relevant business processes, and trying to fully exploit the support offered by the ICT technologies.
The Workflow Management Coalition (*www.wfmc.org*) defines a process as a "set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships".

Centrality of business processes is focused in (Rikhardsson et al., 2006) and (Zoet et al., 2011), and in particular in (Zoet et al., 2011) is reported "Business processes are used to manage and execute an organizations' coordinated, value-adding activities and are thereby among their most important assets or capabilities".

In order to achieve an efficient and effective process management, it is necessary that the same management is the most versatile and flexible with respect to the changes that occur within the operational context of a company. For sure, these changes can represent a chance for the companies to improve their competitive position, but for this purpose it is also essential to ensure the business process compliance with respect to the reference regulations for the organizations.

With regard to the business process compliance, in (Sadiq and Governatori, 2015) authors report "The ever-increasing obligations of regulatory compliance are presenting a new breed of challenges for organizations across several industry sectors. Aligning control objectives that stem from regulations and legislation with business objectives devised for improved business performance is a foremost challenge. Compliance is defined as ensuring that business processes, operations, and practice are in accordance with a prescribed and/or agreed set of norms. Compliance requirements may stem from legislature and regulatory bodies (e.g., Sarbanes-Oxley, Basel II, HIPAA), standards and codes of practice (e.g., SCOR, ISO9000), and also business partner contracts".

In effect, the regulation rules inevitably provide impact on all the business process phases, and consequently even on the knowledge amount a business actor must know about technical know-how and legislative information.
The correlation between regulation compliance and business process management is also highlighted in (Governatori & Sadiq, 2008), in which it is emphasized that "The key point is that compliance is a relationship between two sets of specifications: the specifications for executing a business process and the specifications regulating a business".

Among the more traditional BPM approaches, *Enterprise Architecture* – EA – provides to organize and undertake a series of both studies and activities aimed to the company representation in the form of AS-IS and TO-BE. With regard to *Enterprise Architecture*, authors in (Wegmann, 2002) state that it represents "the discipline whose purpose is to align more effectively the strategies of enterprises together with their processes and their resources (business and IT). Enterprise architecture is complex because it involves different types of practitioners with different goals and practices during the lifecycle of the required changes".

Therefore, according to the *Enterprise Architecture* approach, it is essential to organize a multi-disciplinary team in order to produce such company representations. Such team is made up of both domain and information technology experts and aims at solving the information gap problem, using an appropriate knowledge exchange. While domain experts contribute to the knowledge exchange trying to share their know-how regarding the company operational context, IT experts aspire to interpret, translate and wire this know-how in both the BPM solution and the related information systems. As already mentioned in (Wegmann, 2002), the results produced by this knowledge exchange greatly depends on the experience of both parties in being able to appropriately identify and dissect each focal point of the business context analysis.

In this regard, several authors have already pointed out the importance of organizational modelling before requirements elicitation (Kavakli & Loucopoulos, 2004; Regev & Wegmann, 2004; Eric, 1995). In particular, the authors in (De la Vara González and Diaz, 2007) state that "The development of an information system (IS) is a complex process that not only requires the

resolution of technical problems, but that also requires the organizational environment related to the application domain to be taken into account. In business contexts the application domain is constituted by the organization where the system will be deployed. Therefore, a good knowledge of the application domain is critical to be able to succeed in requirements elicitation". Moreover, also referring to (Alexander, 2003) and (Dumas et al., 2005), the authors in (De la Vara González and Diaz, 2007) assert "Nowadays, it is widely acknowledged that any IS must be a business process support system (or process-aware information system) that manages and executes operational processes involving people, applications, and/or information sources on the basis of process models".

In this context, misconduct or little careful analysis can cause heavy deficiencies within the corporate information systems, primarily in those related to the Business Process Management. In addition, it is also possible that part of the knowledge exchanged between the multi-disciplinary team members can be misinterpreted and/or lost, if not properly formalized, handled and stored.
Taking into account the supportive role information systems play in the business process management, it is essential to implement a constant, continuous and quick mechanism for the information system alignment with respect to the evolution followed by business processes.

As documented in (Luftman et al., 1993; McKeen & Smith, 2003), alignment concept firstly appears in the early 70s, even if a specific definition can be found in (Ullah & Lai, 2011), where it is defined as "the optimized synchronization between dynamic business objectives and technological support by respective IS".

The importance and the necessity to keep constantly aligned business processes and information systems of a company is also underlined in (Wang et al., 2008), where the authors verbatim quote "misalignment between business and IT is one of the critical reasons why enterprises fail to get the full potential of their IT investments. Meanwhile, which enterprises have accomplished a high degree of alignment usually you are associated with better business efficiency and effectiveness performance".

On the contrary, a slow or non-alignment information system process can cause poor or misleading support to the business actors. In effect, during the fulfilment of their activities, business actors must be able to be fully aware of both their role and the informative and legislative framework of the processes in which they are involved.

The *Compliance Management* concept is introduced in (El Kharbili et al., 2008) and the authors define it as "the term referring to the definition of means to avoid such illegal actions by controlling an enterprise's activities. By extension, compliance management also refers to standards, frameworks, and software used to ensure the company's observance of legal texts. In the context of BPM, compliance management applies on business processes and the related resources like data and systems".

In order to facilitate the alignment mechanism of the BPM systems with respect to the regulation rules, companies are already used to refer to the support offered by specific solutions, such as knowledge bases.

In literature, there are already various compliance management frameworks that allow modelling business processes by also using concepts that can be retrieved from knowledge bases, although such frameworks do not guarantee, or do not make it particularly easy, the process of alignment of the corresponding information systems.

The framework we propose, which is called *Process Management System*, might represent a possible solution to these problems. Such framework is capable of enabling business experts to be the most autonomous possible not only during the BPM operating phases, but also during the engineering and prototyping activities of the corresponding information systems, especially from the User eXperience – UX – point of view.

This paper aims to make a comparison and an evaluation between our and traditional methodologies in the field of Business Process Management. In particular, the paper emphasizes the lack of traditional approach with respect to the problem of the alignment between business

processes and information systems, along with their compliance with context domain and regulations.

The present paper provides in section 2 the related works/background with respect to some Semantic BPM frameworks along with the most important BPM solutions and Rich Internet Application – RIA – design methodologies. Moreover, in section 2 it is presented an interesting comparative analysis between the BPM solutions we have considered. Section 3 introduces the traditional approach in business process management, in order to point out its shortcomings with respect to the alignment between business processes, information systems and the operational context. Section 4 introduces our methodology phases, along with the corresponding software components, that *Process Management System* provides. Section 5 shows an evaluation in terms of effort and performance in adopting the traditional and the *Process Management System*–based approaches. Finally, Section 7 includes some conclusions.

2. Background

As previously described, the necessity to design and develop the framework we propose stems from the need to adequately support the business process planning, execution and management, also using the business and regulation knowledge sharing. Moreover, it is necessary to properly model and implement the support web information system able to allow the execution of business process in an informational contextualized environment. In literature, there are already frameworks and methodologies aimed to the RIAs development within the business process management context, and in the following we provide a brief survey of such solutions.

2.1. Workflow Management System

The Workflow Management Coalition (*www.wfmc.org*) defines a workflow as "the automation of a business process or of a part thereof, during which documents, information or tasks are passed from one participant to another in order to be processed in compliance with a set of procedural regulations".

In (Caione *et al.*, 2015) authors propose a survey on five of the most important open source workflow management systems that are selected from a sweeping panorama of both open source and commercial solutions.

Intalio BPMS (*www.intalio.com*)

Its main particularity is to be independent from any other proprietary technologies. Intalio provides a wide set of components in order to support the business process design, deployment and management, along with a specific web application management toolkit.

BonitaSoft (*http://it.bonitasoft.com*)

It is an interesting solution able to combine a specific environment for the business process design, and a powerful workflow engine capable to support the business process management along with the correspondent user interface prototyping.

jBPM (*www.jbpm.org*)

It is an open source and Java-based solution offered by *JBoss* and it is particularly lightweight. jBPM adopt the concept of executable business process, which represents a specific process that is ready to be executed by the workflow engine because it is characterized by a sufficient information detail.

Activiti BPMN 2.0 (*www.activiti.org*)

It is an open source and Apache-licensed lightweight solution, especially implemented for Java developers. An important characteristic of Activiti is its compliance with respect to the version 2.0 of BPMN standard by OMG (Object Management Group).

Camunda (*www.camunda.com*)

It is a Java-based framework for process automation. The most important component in Camunda is the workflow engine, which is responsible for the execution of processes, even defined using the BPMN 2.0 standard.

In order to study and compare the above-mentioned workflow solutions, the analysis is based on of the following eight key aspects:

- Process editor oriented to business and/or IT experts
- APIs availability for business and/or IT experts
- Connectors availability
- BPMN 2.0 compliance
- Fast Prototyping
- Prototyped application customization
- Process Monitoring
- Engine source code customization.

Among the above-mentioned key aspects, particular attention has been paid to the possibility to extend the solutions. Such extension aims to customize the solution in order to make it compliant with the reference requirements, but especially in order to implement the necessary service to interface a knowledge base. The results of this comparative analysis are summarized in Table 1 and have elected *jBPM* as the best solution with respect to the considered key aspects.

Table 1. Comparative analysis between open source workflow engines

Open Source Workflow Engine Solutions					
Analysis key aspects	*Intalio*	*Bonita*	*jBPM*	*Activiti*	*Camunda*
Process editor oriented to	Business expert with IT expert support	Business expert	Business expert	IT expert	IT expert
APIs available for	Non-expert user (engine not customizable)	IT expert	IT and Business expert	IT expert (engine not customizable)	IT expert
Connectors availability	Yes	Yes	No	No	No
BPMN 2.0 compliant	Yes	Yes	Yes	Yes	No
Fast Prototyping	Yes but with the support of IT expert	Yes	Yes but with the support of IT expert	Yes but with the support of IT experts	Yes but with the support of IT expert
Prototyped application customization	Yes	Yes	No	No	No
Process Monitoring	Yes – oriented to the business expert	Yes – oriented to the business expert	Yes – oriented to the business and IT expert	Yes – oriented to the IT expert	Yes – oriented to the IT expert
Engine source code customization	No	No	Yes	Yes	Yes-active support from the community

Another important key aspect we have considered in order to perform the comparative analysis is the possibility for the process editor to be oriented to business and/or IT experts. In effect, such aspect is particularly useful in order to bridge the knowledge gap between these kinds of experts. At this proposal, it is worth mentioning the *SUPER* project (*www.ip-super.org*), whose main goal is to reduce the distance in supporting the BPM automation between business and IT

expert skills. *SUPER* implements a specific semantic-based framework in order to define, execute and analyse business processes. In addition, *SUPER* offers the possibility to organize and share the specific knowledge able to make the most dynamic and adaptable the processes with respect to both company and domain changes. The main focus areas of *SUPER* project are:

- Ontology stack: an ontological business process representation, particularly able to support reasoning and advanced queries;
- Modelling environment and execution engine: respectively able to support business process modelling and execution, also using semantic annotations;
- Composition and discovery framework: used in order to research and compose all the services necessary to implement a business process;
- Mediation framework: useful to manage the specific heterogeneity that characterizes data and processes;
- Use cases and prototypes: able to assess the project results also within real application scenarios.

SUPER Semantic BPM Platform - *SSBPMP* (El Kharbili & Pulvermüller, 2009) represents a framework directly obtained as a *SUPER* extension. *SSBPMP* uses a specific ontology related to both policy and regulation modelling, in order to support the compliance management within the BPM context. Such ontology is used during the phase related to the business process modelling, by defining some references between an element of the process and a policy assertion.

2.2. *Rich Internet Application*

In (Hernandez *et al.,* 2014) authors introduce a comprehensive review of the frameworks, methodologies and tools for developing Rich Internet Applications. RIAs represent a new generation of Internet applications that combine behaviours and features of both Web and desktop applications, such as:

- Client-server architecture;
- Data-intensive handling and business logic execution on both the client and server side;
- Highly interactive multimedia content.

So, RIAs change the way the Web client interacts with the server, by removing or minimizing frequent server transactions from the user experience. In literature there are many software development methodologies for RIAs, and most of them are obtained as extensions of traditional Web application ones. In the following, a list of the most important RIA development methodologies is reported.

Rich User eXperience - RUX - Method

RUX (Preciado *et al.,* 2007) represents a model-driven methodology for the UX design of a RIA application that refers to Web 2.0 paradigms along with features such as multimedia, multi-channel and interactivity. *RUX* can be easily integrated with models for Web engineering, such as *WebML*, *UWE*, *OOHDM*, *OO-H* and *Rich-IDM*, and is able to model data, business logic and UX of a Web Application.

RUX model consists of the following four phases: *Concepts and Tasks*, *Abstract Interface*, *Concrete Interface* and *Final Interface*.

Concepts and Tasks represents the first phase provided by *RUX* and is related to the starting Web 1.0 model. On the contrary, the remaining phases are mainly based on components of the UX defined by *RUX*.

The *Abstract Interface* represents the abstract conceptual representation of the UX model with all the features that are common to every device and platform, and therefore devoid of any spatial, graphical and behavioural dependence. In effect, each *Abstract Interface* component is also independent from both the device and the RIA rendering technology.

Finally, while *Concrete Interface* aims to optimize the UX model with respect to one or more specific target devices, *Final Interface* represents the final result of *RUX* methodology, and consists of the source code that implement the corresponding RIA application.

WebML Extension

WebML Extension (Bozzon *et al.,* 2006) provides a methodology for distributed data and events modelling in data-intensive RIAs. It specifically focuses on client or server side actions and aims to enrich data specifications along two dimensions: data location and data duration; while location can be either server or client side, duration can be persistent or temporary.

Object Oriented Hypermedia - OOHDM Extension

OOHDM Extension (Urbieta *et al.,* 2007) represents a new approach in the RIA interface design that uses Abstract Data View - ADV - models to express a high level of abstraction directly from the structure and behaviour of the user interface. Using advanced techniques for the requirement separation, *OOHDM Extension* enables to create even complex interfaces with a very simple composition.

OOH4RIA

OOH4RIA (Meliá *et al.,* 2008) extends the *Object Oriented Hypermedia* – OOH – method by introducing many new model elements, which complement the *OOH* models for RIA domain and navigation, using the following two additional models:

- Presentation model: which captures the different widgets used to implement the user interface;
- Orchestration model: which represents the interaction between widgets and the rest of the system.

By adopting a model-based approach, *OOH4RIA* introduces new structures and behaviour models to constitute a complete RIA and to apply transformations that reduce the effort and accelerate the Web development. The OOHRIA models use UML syntax, based on MOF (Meta-Object Facility) meta-models.

UWE-R

UWE-R (Machado and Ribeiro, 2009) represents a lightweight extension of *UWE* for RIAs that is able to particularly cover navigation, process and presentation aspects. For this purpose, *UWE-R* introduces new modelling elements that directly inherit structure and behaviour from *UWE* elements.

Model-Driven Approach Proposed - UsiXML

UsiXML (Martinez-Ruiz *et al.,* 2006) is based on the assumption that designed interfaces have to be platform and vendor independent. *UsiXML* implements a model-based design and uses a series of XSLT - Extensible Stylesheet Language Transformations - model transformations to generate a final user interface starting from an abstract interface model and coded for a specific platform.

Object Oriented Web Solution – OOWS – and Interaction Patterns

Interaction pattern concept (Valverde and Pastor, 2008) represents the reference model able to describe a common user-system interaction. Such pattern can be a guideline in generating RIA interface code, using a specific transformation rule set. In effect, interaction patterns can adequately model the RIA structural aspects, while behavioural ones are just textually described. Finally, no specific details are given about the transformation rules in (Valverde and Pastor, 2008).

3. The Business Process Management Traditional Approach

Business process management provides significant support for the identification and structuring of business processes with the purpose of optimizing the activities and workflow management. *Enterprise Architect* represents the traditional discipline whose focus is the alignment of business strategies with processes and resources, business and IT (Zachman, 1997). As stated in (Wegmann, 2002), "EA projects deals with the enterprise in all its aspects. As a consequence, EA teams have to be multi-disciplinary. An EA team includes specialists (typically upper management, functional managers and senior staff members) together with architects. The role of the architect is to federate the efforts of the specialists to ensure successful projects". In EA projects, the adopted strategy is to analyze a company in order to produce a representation in terms of AS-IS and TO-BE. To achieve this goal, it is necessary to establish a close interaction between the different professionals inside and outside the company, as well as to create process models that are aligned with the organization's processes and in line with business requirements, regulations and laws. So, considering that models should reflect all the changes that occur inside and outside the company, it is necessary to own a clear and complete knowledge about the entire business domain, for sure in terms of organization, processes and activities, but also about the reference regulations, laws and standards. In effect, such knowledge is essentially prerogative of domain and legal experts, so they have to share that information with process and IT experts during the definition, implementation and monitoring of business processes. Moreover, having experts a different cultural background, it is also necessary to define a common dictionary in order to obtain an efficient and effective know-how sharing and transferring process. At this proposal, in (Guido *et al.,* 2015) some guidelines for domain and legal experts are presented. These guidelines are particularly useful in order to provide a schematic representation of regulation rules, in an attempt to make them easy to understand by process and IT experts. In this way, it is possible to reduce the skill and knowledge gap among the various specialists.

Process and IT experts represent the main actors in the context of BPM lifecycle. While the former care about business processes analysis and modeling, the latter are involved in the processes implementation and execution, along with the design and development of the relative supporting information systems. Going into the details of the BPM lifecycle, we describe below the main phases reported in literature:

- *Business process design*: involves the collection of useful information that characterizes the organization in order to model business processes and tasks. Considering that only part of this information is well known, in order to retrieve the remaining part, it is necessary to affect both domain and legal experts. The design consists of a graphic representation that typically adopts a standard notation, such as Business Process Modeling Notation (BPMN), which includes actors and activity flows along with any annotations and comments written in natural language. At this level, the processes do not have sufficient information in order to be executed by a workflow engine. In effect, to achieve this goal it is necessary to perform a specific transformation able to obtain an executable process starting from an analytical one.
- *Process implementation*: during this phase, IT experts transform the processes modeled in the previous step into executable processes. This operation implies the addition of the execution parameters, the use of web services along with the interaction with storage systems and knowledge bases. Web services are assigned to each task in a manual and static way; similarly, data format and execution parameter types are defined. The resulting processes can then be deployed within a workflow engine.
- *Process execution*: after the processes deployment, the process instances can be created and executed. Web service calls eventually defined for a task are automatically performed, except for those that need of input parameters that the user has to directly specify. In this case, user must explicitly start and run the task, providing the necessary input parameters. During this phase, the user may require the support of both domain and legal experts.

- *Process analysis*: during this phase the running process instances are monitored through the analysis of various execution details, such as the branches followed by the control flow, the current values of the process and task parameters, etc. In this phase, some key performance indicators are specified and are evaluated during every instance execution. It is also possible to check both the process and the output compliance with respect to the company domain and the regulations. The process mining activity operates on process log and is used in order to perform the conformance checking, optimization and performance analysis.

In the BPM context, another important necessity is the possibility to design and implement an easy to use information system, able to support the process management also referring to the application domain, company organization, regulations and activities. In particular, the most important aspect of the information system to realize is the user experience modeling that must aim to organize the contents in an exhaustive and appropriate manner, also by using the contributions that complementary information systems can provide.

As can be noted, traditional approach requires considerable effort in terms of modeling and development and especially it strongly depends on the knowledge offered by both the domain and legal experts, along the whole BPM lifecycle, but also during the support information system modeling and development.

Therefore, if on one hand there is the necessity to resort to semantic technologies, such as knowledge bases, on the other it is necessary to have supported by software tools able to perform an automatic model transformation along with the support information system generation. In that way, it becomes possible: i) to increase the BPM lifecycle automation degree, ii) to support the process and IT experts during the domain and regulation information retrieval, iii) to ensure a certain adaptability of business processes in order to respond to changes and/or unexpected events and iv) to automate the process of modeling and creation of the web application.

4. The Process Management System Approach

The approach we propose is based on a specially designed and implemented framework called *Process Management System* (Caione *et al.,* in press) starting from a specific methodology. This methodology involves a process management that consists of four main phases, as many as those that temporally characterize the process lifecycle, and which are respectively known as: *Planning time*, *Design time*, *Situation Time* and *Run-Time*. Each phase is characterized and supported by specific interactions with a knowledge base. In particular, knowledge base contains all the information about the business domain, regulations, standards, corporate structure and business processes, in the form of concepts and relationships between them (Paiano et *al.,* 2015). This kind of support can facilitate the activities performed by business experts, process designers and IT specialists since they can directly retrieve from the knowledge base the information to model and execute the necessary business processes. In that way, it is possible to reduce the gap in knowledge domain and the necessary interactions with both domain and legal experts. In effect, skills and knowledge that these experts can provide are strictly necessary during the definition and implementation of the knowledge base.

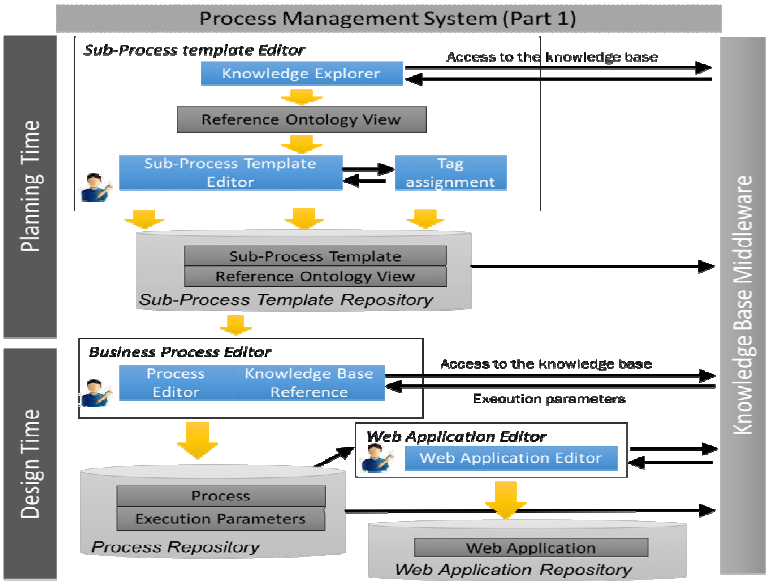

Figure 1. Project Management System – Conceptual Model (Part 1)

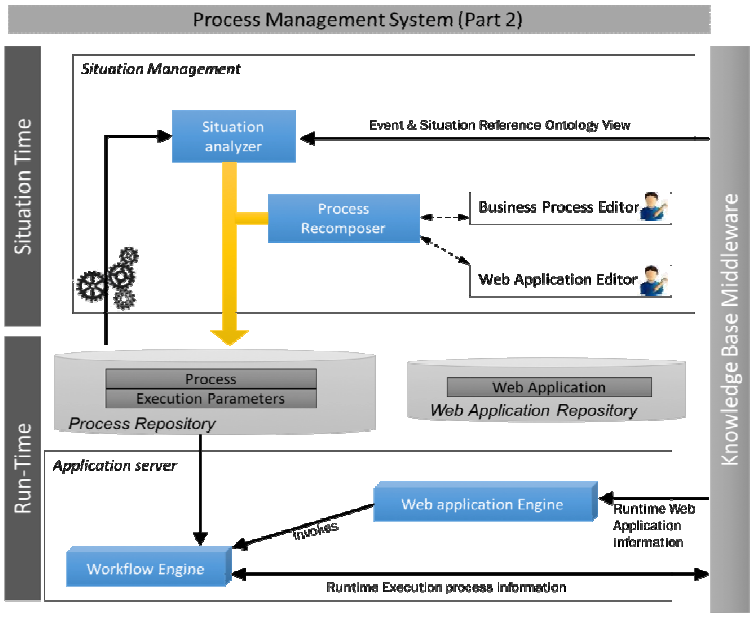

Figure 2. Project Management System – Conceptual Model (Part 2)

The following is a detailed description of the macro-phases provided by the *Process Management System* framework (Figure 1 and Figure 2). In particular, the description is intended to identify and characterize each macro-phase, in order to provide information on the specific functions performed by each of the software components in the game, in addition to a precise description related to the respective dynamics of interaction.

Considering that, with except for *Situation Time,* it is possible to make a mapping between the phases provided by the approaches we are evaluating, for every macro-phase we report in brackets the corresponding traditional approach phase/phases.

- **Planning Time (Process Design)**. In this phase, the process designer essentially refers to a specific editor called *Business Process Editor* to model the necessary sub-process templates using the BPMN standard notation. Sub-process templates are similar to business processes, but they cannot be executed by workflow engine. They can model blocks of BPMN elements that can be used by process designers in order to model runnable processes. In addition to supporting the sub-process template creation and editing, the *Business Process Editor* allows

the process designer to characterize, also semantically, the elements of the model. In effect, during the modeling activity, the process designer can semantically characterize the elements of a sub-process template by establishing an association with specific concepts/resources directly retrieved from the knowledge base. To this end, the process designer uses a graphical interface made available by the software module called *KB Explorer*. Using this interface, the process designers can consult the knowledge base in order to explore and select the related concepts/resources during the semantic characterization of the model. Actually, the software module called *KB Middleware* is responsible to make available the feature related to the knowledge base consultation. In particular, this module performs web service calls to implement interaction with the knowledge base. In that way, it is possible to make available a consultation that is based on the knowledge base concepts rather than on their structure. At this phase, the output generated by *Business Process Editor* consists of the sub-process template model designed by the process designer using two formats: one compatible with the workflow engine standard and another suitable for the transmission to the knowledge base;

- **Design Time (Process Design and Implementation)**. It represents the phase during which the process designer creates the business process models, using the *Business Process Editor*. To this end, the process designer can use the primitives provided by the BPMN notation, but above all he/she may use the sub-process templates previously defined, during the *Planning Time* phase. As before, even during this phase it is possible to semantically characterize a process. At the completion of the business process composition, the process designer can proceed with its implementation through the setting of: i) the execution parameters; ii) the business logic that underlies the single task of a process; iii) the User Experience model of the web prototype by which the user starts the business process execution. The process designer may decide to explicitly specify the parameter values for the execution or to recover them from the knowledge base, referring to the features implemented by *KB Middleware*. The process designer, possibly supported by IT experts, implements the business logic related to the corresponding tasks of the process, also by using the appropriate environment provided by the workflow engine. For the web prototype generation, the *Process Management System* refers to its specific module called *Web Application Editor - WebAE*, which adopts IDM and Rich-IDM methodologies in order to model the UX schema. During this operation, the web application designer can define some access points to the workflow engine, possibly associated with some integration points of information. While access points are references to the workflow engine able to start one of the processes defined in *Design Time*, integration points represent the information and legislative framework for the process referenced by the corresponding access point. In order to define the integration point for a process, the web application designer can also refer to the resources present in the knowledge base. From the point of view of the prototype user interface, *WebAE* module translates the integration points into contents to make available to the user and the access point into a hyperlink able to start a new instance of the related business process. Like sub-process templates, even processes are stored in two formats: one compatible with the workflow engine standard and another suitable for the transmission to the knowledge base. Finally, the format used to represent the UX models of the web prototype is XMI – XML Metadata Interchange – especially because it is not necessary to store them in the knowledge base;
- **Run-Time (Process Execution and Analysis)**. It represents the phase during which the processes previously modeled are executed. This phase is completely delegated to the workflow engine, which makes available the necessary infrastructure for the processes execution. In effect, the reference workflow engine has been further extended in order to enable a more detailed process monitoring, but above all to support the execution parameters storing in the knowledge base, using the software module *KB Middleware*. In fact, these

parameters are particularly relevant in order to improve processes themselves during the analysis phase. For the purposes of the web prototype deployment and implementation, the reference servlet container for the *Process Management System* is *Apache Tomcat* (*http://tomcat.apache.org*);

- **Situation time**. It represents the phase during which, following to an alert related to an unexpected event, it is necessary to identify a process, or a composition of processes and/or sub-process templates, able to handle such an event. Actually, *Process Management System* is able to handle both unexpected and expected events, and uses a publish/subscribe communication pattern in order to support the subscription for receiving signals about a specific topic. After analyzing the event occurring, the knowledge management system sends an *Event & Situation Reference Ontology View* object to the *Process Management System* module called *Situation Analyzer*. This object is constituted by a subset of concepts/resources of the knowledge base that is able to fully describe the occurred event. At this point, *Situation Analyzer* tries to identify the business processes of the workflow engine that can eventually handle the event, by comparing the concepts in *Event & Situation Reference Ontology View* and those referenced by each of the models, related to both processes and sub-process templates, produced in *Planning* and *Design Time*. If the *Situation Analyzer* identifies a process that is fully compatible in terms of concepts with the occurred event, then it elects such a process to be the event handler. Otherwise, the *Situation Analyzer* identifies processes and/or sub-process templates that suitably compounded can possibly handle the event. To this end, the *Process Management System* offers a specific module called *Process Recomposer*. This module enables the designer to specifically compose the event handler, starting from the processes and/or sub-process templates previously selected by the *Situation Analyzer*. Finally, the *Process Recomposer* also represents the *Business Process Editor* module the designer uses in order to: i) check the consistency of the process that results from the composition performed by the process designer using the processes and/or sub-process templates identified by the *Situation Analyzer*; ii) complete the realization activities related to the compounded process, such as the definition of both the execution parameters and the UX model of the web prototype.

5. Evaluation

In order to evaluate effort and performance obtained in using traditional and *Process Management System* based approaches, we refer to a case study related to the implementation of a system for the academic exam management.

5.1. Traditional Approach - Design and Development

In order to design and develop the exam management system using a traditional approach, we have referred to a struts-based application already implemented in-house by our university staff. Business processes have been modeled according to the BPMN standard. To this purpose, the exam management know-how already acquired by the technical staff has been enriched with the information obtained during the interviews with both professors and administrative staff. The technical team has also referred to documents like the student guide and ministerial regulations in order to acquire the know-how related to more precise legal and administrative rules.

In Table 2 are shown the canonical phases that distinguish a software design and development project, along with both the corresponding working hours and the effort in percentage terms. The amount related to the working hours represents the number of hours of productive work, which is obtained excluding from the calculation holidays, illness and other activities in the project (training, meetings, etc.).

Table 2. Traditional Approach - Effort and Working Hours

Traditional Approach - Effort and Working Hours		
Project Phases	*Effort %*	*Elapsed Time Working Hours – Wh (40/Week)*
Analysis	17 %	400 WH
Process Design and Implementation	7 %	160 WH
UX Design	7 %	160 WH
Development and Unit Test	54 %	1.280 WH
System Test	13 %	320 WH
Deployment	2 %	40 WH
Total on the phases	*100 %*	*2.360 WH*

5.2. Process Management System Approach - Design and Development

For the evaluation of the approach using the Process Management System, we have referred to a student team during the Web Information Systems academic course that have a good knowledge of both the application domain and the IDM notation.

In order to compare the performance achieved using the *Process Management System* based approach, we have decided to make available to the students a knowledge base already modelled and developed by specific domain experts, essentially for supporting their know-how. In effect, the knowledge base contains information about the academic exam management domain, along with its reference regulations and laws.

In this way, it is possible to ensure the comparability between the application developed by the academic staff and those implemented by the students, with the same domain and functional requirements.

The student team has modeled the processes, in BPMN standard notation, also using the interaction with the knowledge base. During both the design and implementation time, students were constantly supported by the information consulted and retrieved from the domain knowledge base.

During the application development, it is important to note that using a traditional approach, the developer fulfils all the activities provide by the business process, while using the *Process Management System* based one, the developer intervenes at both design and run time. In particular, at design time the developer manages the integration of the Rich-IDM model of the RIA prototype with the previous modeled business processes. While the operations at run time the developer directly performs on the RIA prototype aim to:

- Manage the integration with the database in order to implement the *Create*, *Read*, *Update* and *Delete* – *CRUD* – operations. To this end, it was possible to reuse all the business logic already implemented by the technical team;
- Intervene on the user interface of the RIA prototype in order to make available the *CRUD* operations within the user interface;
- Intervene on the visual aspects of the RIA prototype application.

The learning curve related to the use of the Process Management System has an average of two weeks, in analogy with the learning curve of the Struts framework.

The activities carried out during the trial in the classroom are the following:

- Business process modeling based on the use of the editor provided by the *Process Management System*;
- User experience modeling of the RIA prototype based on IDM methodology and fulfilled by using the IDM Editor provided by the *Process Management System*;
- Validation and adaptation of the BPMN models designed by students compared to those obtained by academic staff;

- Validation and adaptation of the IDM models designed by students compared to that obtained by academic staff;
- RIA application creation, using the prototype generator provided by the *WebAE* framework.

Table 3 shows the results in terms of effort and working hours for every canonical project phase, using the *Process Management System* based approach.

Table 3. Process Management System Approach - Effort and Working Hours.

Process Management System Approach - Effort and Working Hours		
Project Phases	*Effort %*	*Elapsed Time Working Hours – Wh (40/Week)*
Analysis	44 %	320 WH
Process Design and Implementation	11 %	80 WH
UX Design	17 %	120 WH
Development and Unit Test	11 %	80 WH
System Test	11 %	80 WH
Deployment	6 %	40 WH
Total on the phases	*100 %*	*720 WH*

Comparing the results obtained in using the two approaches (Figure 3), it is possible to note a significant reduction in terms of both effort and working hours in correspondence of design and development phases.

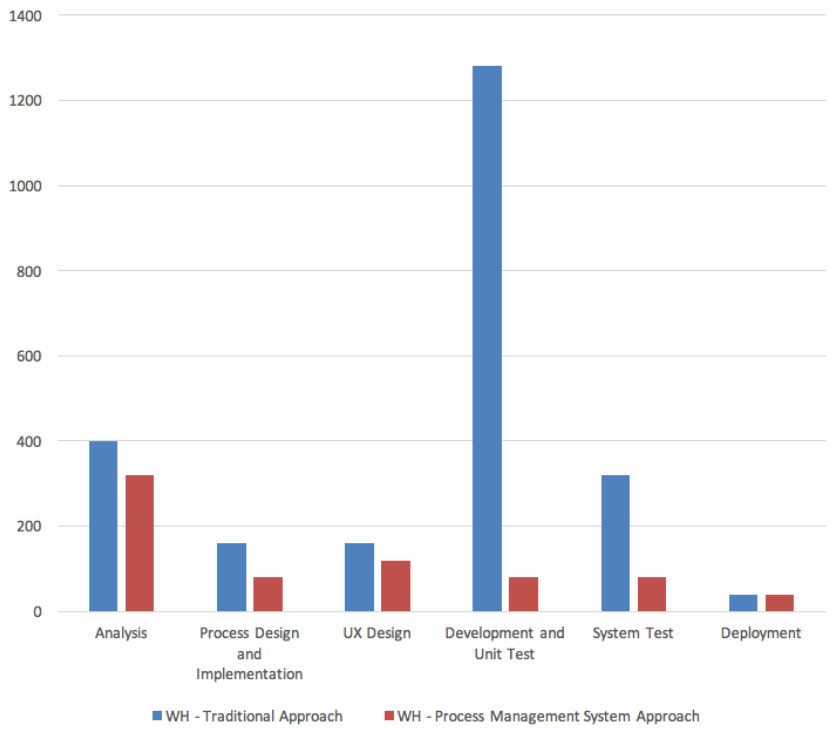

Figure 3. Traditional Approach and Process Management System Approach – Effort Percentage Comparison

6. Conclusions

The present paper aims to make a comparison between a traditional and the *Process Management System* based BPM approaches, in order to evaluate the improvement in terms of performance and effort that is possible to obtain using the methodology we propose. In this case, the most important result that the adoption of the *Process Management System* realizes is the

continuous and constant alignment of BPM systems to the changes that occur in the operating context of a company. In addition, using the solution we propose it is also possible to obtain relevant results in the short, but mostly in the long period. The results that our methodology can obtain in the short period are:

- Compression of the analysis phase, especially in terms of time spent for interviews and knowledge exchange;
- Compression of the design phases, especially in terms of time spent for checking the compliance with regulations and laws;
- Compression of the implementation phase related to the web prototype that supports the BPM system.

On the contrary, the results that are possible to obtain in the long period are:

- Alignment and compliance of the business processes affected by possible changes in a quick and easy manner;
- Adjustment and improvement of the UX model of the web prototype in a quick and easy manner;
- Automatic generation and fast prototyping of the web application that supports the BPM system.

In summary, the results obtained in terms of performance and effort during the case study we have conducted to perform the evaluation can confirm what was our expectations.

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