Analysis and Comparison of Business Process Management Frameworks

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ABSTRACT

More and more, the implementation of processes management systems within manufacturing environments not only has increased its popularity, but also has proven that manufacturing productivity can be increased by using better methods for designing, planning and controlling of processes. New technologies and methodologies have been investigated in order to improve the efficiency and effectiveness of company's processes implementation. According to the business process reengineering approach, since the products and services that a company offers to the market are provided through key processes, a flexible manner to graphically (re)design these processes, at different levels of abstraction, represents the road to the success. However, not only the modeling capabilities of a process are required. Due to the fact that management of dynamic processes is an important issue in rapidly changing production systems, a new generation of business process management systems (BPMS) capable of support dynamic behavior has been developed. However, due to the large number of BPMS already available in the market, it has been identified the necessity to make a research with the most recognized software available in the business process management area, as well as evaluate and ranking them according the main functionalities and features identified as essential to achieve the goals defined before. Several BPMS solutions were selected, evaluated and ranked under the same circumstances. From the real test evaluation, the Bizagi solution was the one that presented a more complete package of functionalities through the entire business process management life cycle. However, ProcessMaker and Intalio solutions also presented very interesting functionalities that can be implemented with lower costs. Despite the good results obtained, it was identified that none of the solutions evaluated were capable to perform process quality analysis, multi-instance control, as well as risk assessment, even though its crucial importance in today's business management processes.

1. INTRODUCTION

Due to the changing market conditions and increasing competition, companies were forced to investigate the efficiency of the structure of their business processes. Business Processes (BP) can be defined as a coherent combination of set of activities within an enterprise, with a structure describing their logical order and dependences, whose objective is to produce a desired result [1]. Due to its importance, business processes have become the central approach in many conceptual modelling efforts, being observed an increasing of popularity, since companies are realizing that business processes must be perceived as the most entities to be managed towards enhanced organizational performance [3].

In the same line, Weske [4] stated that, due to the increasing adoption of a process oriented approach by organization, these have been working on the characterization of their operations using BP. This changing of paradigm has supported companies to combine multiple units of work of small granularity into work units of larger granularity in order to simplify control activities and reduce the handover of work. Moreover, this evolution gave the possibility to explore new methodologies and tools capable to agile and become more flexible the tasks related with management of dynamic and complex manufacturing systems [5]. Therefore, the capability to model and compile a process logic (chain the steps of the processes and show how to react to events) not only provides autonomy for the applications and services but also support the achievement of flexibility since the logic for reacting to events can be changed as business needs and policies changes [6].

However, in order to achieve the desired flexibility, the capability of an organization to deploy and give life to a business process also represents a critical add-value. In line with this, process enactment concept aims to compile the business process description into a representation, suitable for enactment, and controls the execution of the

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process by invoking the corresponding services. In fact, the using of enactment platforms provide companies powerful mechanisms to manage in an optimal way processes where exist different stakeholders necessities, human interactions (assigning knowledge workers to process activities) and different services to be executed by proper IT applications and tools. With this flexibility requirement in mind, business process management systems were created in order to narrow the gap between business goals and their realization by means of information technology. In summary, a business process management system (BPMS) can be as a middleware system that provides a central point of control for defining business process and orchestrating their execution [6].

Today, BPMS are deployed in a variety of situations, ranging from the coordination of document-centric processes in office environments, to the automation of application data flow in enterprise application integration scenarios. Thus, the main purpose of this paper is to evaluate BPMSs available on the market according the requirement established from the business process management approach. To do that, ten solutions that present a free downloadable version were chosen. The selection was performed taking into account their acceptance and impact on the market according to the knowledge and experience gathered from participation in the following European projects: Virtual Factory Framework [9] and Adventure [10]. Moreover, only the solutions with significant level of maturity and capable of support the entire business process management life cycle were selected. Finally, aiming to keep the BPMS comparison exercise the most coherent as possible, all the software solutions selected were tested under the same circumstances.

Thus, this paper is organized in the following way. Firstly, the Business Process Management concept will be presented, as well as its life cycle. Following BPMS will be analysed. During this section, not only its architecture will be explored, but also its main advantage for current industry companies. The next section will enumerate the BPMS frameworks selected for evaluation, the benchmarking factors, as well as the comparison methodology adopted, based on Analytic Network Process (ANP) approach. Finally, the main conclusions extracted from the comparison test performed are presented, as well as future features to be introduced in following BPMS versions.

2. BUSINESS PROCESS MANAGEMENT APPROACH

The business process management approach implies a tight connection and alignment with the business strategy adopted by the enterprise as well as by the information systems available [15,14]. Indeed, limitation at the information system can introduce increased complications, or even compromise the successful implementation of the designed strategy. Moreover, the stakeholder's interaction, both at the input and output of the business process management space, must be clearly represented and analysed. From the Stakeholders cluster, it is possible to identify external business partners, customers, and the personnel of the enterprise. Not only the level of competence of the company personnel but also the degree of confidence at the business partners and customer patterns can strongly influence the business strategy selection and implementation thorough business process. Internally, the organizational business processes can be influenced/disturbed by a number of activities performed by the company, such as: management, organization, controlling, and optimization of business processes.

Due to the complexity and diversity of factors that can disturb the business process management, it is critical to explore an approach capable of systematize and compile both internal and external disturbances. Thus, it was developed a business process management life cycle, composed by a series of steps, capable of support the business process creation and management [4]. Aiming to compile the business process management activities and respective tools, the business process life cycle is presented below with its stages and dependencies.

Design and Analysis: During this initial stage, surveys on the business processes and their organizational and technical environment are conducted, in order to, identify, review, validate, and represent the corresponding business process models (BPM). At this phase, factors related with the overall strategic goals of the enterprise (business strategy of the enterprise, target markets, new market opportunities, legacy systems) influence the BPM definition, and, organizations often have difficulties in properly identifying their goals and linking them to their business processes. Therefore, business process modelling tools, as well as validation, simulation, and verification techniques, need to be developed in order to explore this issue [1].

Configuration: Once the business process model is designed and verified, the business process needs to be implemented. During this phase, a business process is translated from the real world into a formal, computer processable definition that facilitates the enactment of the process by the business process management system.

Enactment: Once the system configuration phase is completed, business process instances can be enacted. The process enactment phase encompasses the actual run time of the business process. At run-time the process definition is interpreted by a process engine called Workflow Enactment module, which is responsible for creating

and controlling operational instances of the process, scheduling the various activities steps within the process and invoking the appropriate human and IT application resources. These run-time process control functions act as the linkage between the processes, as modelled within the process definition, and the process as it is seen in the real world, reflected in the runtime interactions of users and IT application tools.

Evaluation: The evaluation phase uses information available to evaluate and improve business process models and their implementations. A monitoring component of a business process management system visualizes the status of business process instances. Process monitoring is an important mechanism for providing accurate information on the status of business process instances. Execution logs are evaluated using business activity monitoring and process mining techniques [7]. These techniques aim at identifying the quality of business process models and the adequacy of the execution environment.

Management Engine: There are numerous artefacts at different levels of abstraction in business process management scenarios that need to be organized and managed well. During this phase, supervisors must be capable to: alter work allocation rules, identify participants for specific organizational roles within a process, track alerts for missed deadlines or other forms of event, trace the history of a particular process instance, enquire about work throughput or other statistics, and possess other features [16].

3. BUSINESS PROCESS MANAGEMENT SYSTEMS

Business process management systems (BPMS) make the automation of business processes possible through the management of the sequence of work activities and the invocation of appropriate human or IT resources associated with the various activity steps. The main concept of a BPMS is the separation of business processes from applications and data, achieving a higher level of flexibility and adaptability to the production system in study, as well as, to support dynamic changes when new/improved business strategies are proposed. Moreover, these systems facilitate not only the realization of individual tasks, but also supports the collective work and management of an enterprise based on business processes, providing accurate inputs xand effective routing control in a timely fashion.

From an IT architectural perspective, a BPMS can be described as an extra layer of software that sits above other software applications and uses business process specifications to determine when to call on other software applications. Figure 1, indicates the main layers of operation, as well as, the main functionalities expected for each of these layers [8]. Firstly, it is possible to depict two phases, the build-time phase and the runtime phase. During the build-time phase, all of the functions that support the modelling and materialization of the business processes and constituent activities should be developed. Indeed, this operational layer is strictly connected with the BP Design and Analysis and BP configuration lifecycle stages analysed previously. The business process modelling subsystem is used to create business process models that contain information on activities, their operations and the structure of the business process. This architecture subsystem must be realized using proper business process modelling tools. The business process model repository holds business process models that are created by the business process-modelling component.

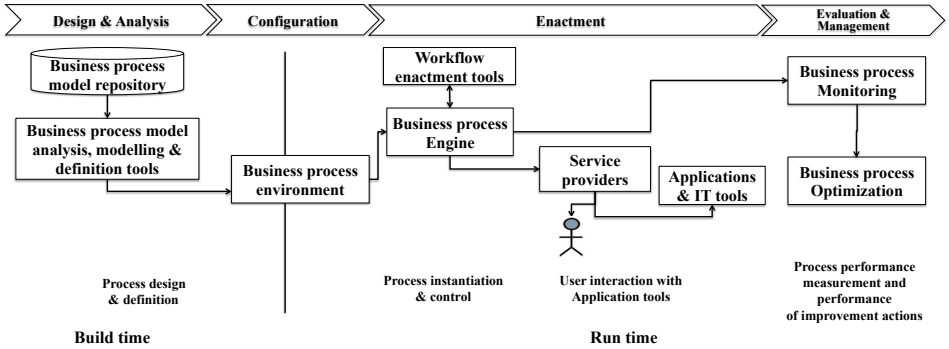

Figure 1 Business Process Management System Architecture [Adapted from 4]

During the runtime layer, three sub-layers can be found with well-defined functions. The control functions are mainly concerned with managing the business processes in an operational environment and sequencing the various activities that will be handled as part of each process. This layer is strictly connected with the BP Enactment lifecycle stage. Therefore, using an important element called the workflow enactment service, the business process

engine is responsible for instantiating and controlling the execution of business processes, according to the business process environment triggers. It uses process models to instantiate and control the enactment of process instances. To execute a particular instance, it calls entities residing in the second layer of the runtime phase that act as providers of the required function. In a service-oriented architecture, service providers are called to execute individual services that realize business process activities.

Finally, in order to evaluate the performance of the processes designed, full BPM systems should be capable to associate Key Process Indicators, which measures in comparison with the established targets, should be used as feedback metric control.

4. EVALUATION CRITERIA

Having now presented the main concepts behind the business process management approach and the supporting systems, this section presents a benchmarking exercise between a series of BPMS available in the market. Following the requirements identified during the literature review, the main factors for the comparison test are presented. The methodology applied in order to keep the results as accurate and reliable as possible, aiming to reduce subjectivity, will also be presented.

4.1 COMPARISON FACTORS SPECIFICATION

To compare the different BPMS available, one process template considered, rich enough to follow the entire business process management life cycle and verify the requirements identified was used, in order to, keep the coherence and reliability of the comparison test done by the authors. A detailed description of the factors used for the BPMS comparison, are listed in Table 1. The criteria were selected not only based on authors experience, but also inspired on the research done by Gartner and MWD Advisors, IT consultancy companies [13,14].

A job application process template was selected, Figure 2, and despite representing a very straightforward process, it's implementation represents the main necessities found during the business process management life cycle. In total this process contains 3 different actors (the candidate, and in the company, the recruiter and interviewer) and 13 tasks covering all phases of an application process (creation, submission, evaluation, interview, offer, rejection and hire).

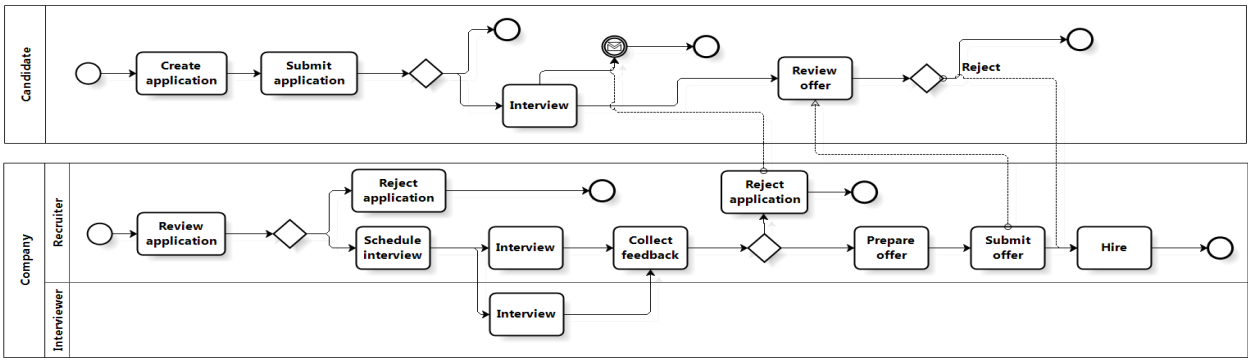

Figure 2 Job Application Process Template

During the application process design and analysis stage, the user interface of the workflow management system was analysed in terms of its adequacy for the users and the tasks supported. An evaluation was conducted aiming to assess if the solution provides reusable processes capable of enhance the application process design, as well as, if the notation used and the range of attributes provided supported the development of the expected model: express correctly the control flow with decision points, data structures and data flow.

For the application process configuration, the integration criterion was tested. Integration criteria specify application and data integration aspects. In particular, the data structures and types of application systems that can be integrated in the workflow application were taken into account (email services, Oracle Database, calendar integration, application process forms integration, users database integration). In fact, from an enterprise point of

view, this is a critical criteria, since the success of a workflow project may rely on the integration of existing domain-specific applications, which have typically been developed separately from workflow applications.

Table 1 Factors for BPMS comparison

Life Cycle Phase	Factor	Description	Criteria
Design and Analysis	Method Supply	Which notation is used in the design of the processes?	Qualitative (BPMN, Petri Net)
	Cardinality	Are different cardinalities at input/output of the process possible?	Quantitative (1 or 0)
	Model Creation Environment	Which functionalities are available to support the design, is integration with external objects supported?	Quantitative (1…9)
	Process Model	Are there any templates or possibility to create them?	Quantitative (1 or 0)
	Discovery and Analysis	Is the tool able to design complex models and is it feasible to have a truly collaborative approach to discovery and analysis? Is it possible to export and share documents?	Quantitative (1…9)
	Model Management	Is it possible to have different views of the same model?	Quantitative (1…9)
	Model Consistency	Does the software provide automatic validation functions to ensure the model consistency?	Quantitative (1…9)
	Straight-throught processing	Is it possible to model tasks that don't have human intervention (E.G. error handling)? Is the runtime environment scalable to meet high-performance, low-latency operational requirements?	Quantitative (1…9)
	Version	Do the software allows the creation of model versions?	Quantitative (1 or 0)
Configuration	Rules	Is it possible to implement decisions in the process? How sophisticated can they be? Is it possible to reuse rules?	Quantitative (1…9)
	Third party integration	Can the software be integrated with other software available in the company? E.G. user database already built in the company.	Quantitative (1 or 0)
	Simulation & Validation	Is it possible to simulate the execution of the process, in order to have a clearer validation of the design?	Quantitative (1 or 0)
	Sequential workflow	Does the software allow the design and development of forms and task lists and associate them to tasks in the process?	Quantitative (1…9)
	Collaborative work & roles	Is it possible to configure collaborative work activities with the processes while distinguishing users by their company roles?	Quantitative (1…9)
	Data base reengineering	Is it possible to derive a new database from the legacy database and adapting the software components accordingly?	Quantitative (1 or 0)
Enactment	Deployment & Execution	Is it possible to deploy and execute the designed processes?	Quantitative (1 or 0)
	Monitoring & Animation	Does the software animated monitoring functionality? Does it allow the user to see the actual evolution of the process with an animation?	Quantitative (1 or 0)
Evaluation	Total quality management	Does the software provide functionalities that emphasize incremental improvement in work processes, and outputs over an open-ended period of time?	Quantitative (1…9)
	Risk management	Does the software provide evidence-based information and analysis to make informed decisions on how to treat particular risks and how to select between options?	Quantitative (1…9)
	Process mining	Does the software as the capability to perform quantitative processes performance analyses through logs analysis.	Quantitative (1…9)
	Activity based	Is it possible to give weights to each task to compute the cost?	Quantitative (1 or 0)
Management Configuration	Case management	How do organizational structures are managed and influence the work is distribution? Is content/document management available?	Quantitative (1…9)
	Business process reengineering	Is it possible to: identify the processes to be redesigned; understand and measure existing processes, design and build a prototype of the new process.	Quantitative (1…9)
	Dynamic process optimization	Can the user optimize the process in runtime?	Quantitative (1 or 0)

During the process enactment phase, the business process deployment characteristics were validated. Indeed, the aim was to validate if the system supports task distribution and allocation and if it provides adequate functions for monitoring the designed process evolution on a technical level and also on an executive aggregate level.

The BP Evaluation phase represents one of the phases most studied by current researchers in the area. Indeed, the ability to detect process bottlenecks in order to optimize their performance as well as analyse the risks that can arise from the application of a specific process in a defined environment can add critical value in the current market environment. Therefore, for the job application process, it was selected some indicators that would be important to monitor and possible to be used in process improvement actions were selected three KPIs were select: hours per application, application form quality and application process effectiveness.

Finally, since the BP Management stage aims at understand if the BPMS under analysis supports flexible process instance management, during this phase of the evaluation test, it was expected to understand if the BPMS support the dynamic control of the application process, through the adaptation of running workflow instances according to the parameters defined during the BP Evaluation phase.

To improve this evaluation test, future research is expected to assess the different solutions taking into account the vendor and product requirements and specifications. Thus, some of the issues that should be taken into account would be the reputation and product strategy of the vendor, long-term relationships with the vendor and the availability and pricing of the product.

5. Analysis, Discussion and Research Directions

Once the network had been defined and the pairwise comparison had been specified between the different BPMS solutions according to the parameters defined as critical, the Superdecision software returned the BPMS ranking. In Table 2, it is possible to see the results of the evaluation of the business process management systems. As seen, the Bizagi is the best solution and was defined by the software as the pivot element for comparison. This solution presents a very interesting and complete platform to design, deploy and monitor process execution. In the case of flexibility and module integration, Intalio and ProcessMaker also present very good options. From the tests performed, all the BPMS present similar approaches and notation in the design stage. However, in terms of functionalities, some differences can be pointed when designing one process where the user wants to automate some actions in tasks, even for error handling. The Bizagi solution stands out from the rest in this point. With this solution it is transparent for the final user the access to databases and decisions made according to the data retrieved from these data sources. In terms of process templates, the Bizagi and ProcessMaker support the process design with templates that can be easily downloaded and installed. However, regarding the process versioning management, only the Activiti and Barium solutions are capable of keeping track of changes.

Regarding the BP configuration life cycle stage, almost all the solutions support third party integration, except Activiti, Barium and Adeptia. Since this represents a critical factor for enterprises, this is one of the reasons why they appear in the bottom of the ranking list. During this stage, the simulation and validation of the process schema were also assessed. Also for this parameter, the Bizagi solution presents a very good classification, as well as the Intalio, Bonita and uEngine solutions. However, concerning the collaborative process work (E.G. collaborative work on the same task) issue none of the modules were capable to support with success. Concerning the BP Enactment stage, and despite not having interactive and high user-friendly environment, all the BPMSs allow business process management teams to deploy and follow process execution.

In the BP Evaluation and Management life cycle stages critical gaps can be found. In order to support business process evaluation and management lifecycles, BPMS must provide managers tools that are capable of associate Key Performance Indicators (KPI) with each of the business processes, and support its monitoring through KPI measurements and target values. To be able to redesign a process, the primary information needed is how the process interacts with the system and where and why they deviate from the targeted process. In line with this, since process's performance management technologies that support the business process diagnosis and redesign need to be explored as an extension of business process management systems, following are presented new features and functionalities that need to be explored.

More Multi-Enterprise Integration - Since companies, more and more, will adopt collaborative approaches to increase their competitiveness in this volatile market, solutions for business-to-business integration will represent key advantages. Thus, business process networks (BPNs) concept need to be explored as well as the supporting technology: pre-bundled solutions for multi-enterprise integration projects, prebuilt translation packages, or business activity monitoring components.

Table 2 BPMS evaluation results

Solution	Ranking	Solution	Ranking
A1-Bizagi V9.1.15 (www.bizagi.com)	100%	**A9-jBPM V5.1.0** (www.jboss.org/jbpm)	50%
A3-ProcessMaker V2.0.33 (www.processmaker.com)	70%	**A8-uEngine V1.1.0** (www.uengine.org)	47%
A6-Intalio V6.1.12/6.24 (www.intalio.com)	69%	**A2-Questetra V8.0.1** (www.questetra.com)	47%
A7-BonitaSoft V5.5.2 (www.bonitasoft.com)	60%	**A5-Barium V2011.1.13** (www.bariumlive.com)	43%
A10-Adeptia V5.2.25 (www.adeptia.com)	52%	**A4-Activiti V5.8** (www.activiti.org)	43%

Business Process Total Quality Management: Total Quality Management and Business Process Reengineering share a cross-functional relationship. Quality specialists tend to focus on incremental change and the gradual improvement of processes while proponents of reengineering often seek the radical redesign and drastic improvement of processes. However, independently of the concept differences, both identify the necessity to assess process quality in a quantitative way, in order to detect critical bottlenecks or make improvements. In line with this, from the evaluation performed, it was possible to identify a lack of quality management functions, which emphasize incremental improvement in work processes over an open-ended period of time [2].

Business Process Performance Management: Organizations that obtain and use information about their processes in a timely manner, proved to be more competitive. The main purpose of the BP performance management approach is to provide the company decision-makers with the tools and information to support the alignment between the company business model, its strategic plans and the implementation of operational processes. Process-mining techniques should be explored. This approach introduces an efficient way of analysing work practices: a diagnosis based on a process workflow logs. With this information, it is possible to infer process execution performance information with more objectivity and using fewer resources [16].

Business Process Risk Management: One of the major problems that contribute to the failure of business process implementation is the lack of tools for evaluating the effects of designed solutions prior to implementation [15]. An interesting approach is to focus on using performance measures to help managers make decisions through risk analysis, aiming to understand if the defined metrics measure something that can suggest action (Leading indicators), or whether they simply report on a situation that cannot be altered. Therefore, it is our proposal that BPMS must explore risk analysis systems that can estimate the probability of achieving the goals established, if a company keeps its current strategy until the end of the time period defined, when analysing the measures related with leading factors.

Dynamic Process Optimization: To enhance their competitiveness, companies need to update their processes rapidly and throughout the business process life cycle, taking into account information retrieved from quality management instruments [7]. This functionality would offer an important add-value to the company, however, since BPMS work above BPMN instances and this notation does not allow the manipulation of process instances Dynamic process optimization is difficult to be achieved, thus, after its deployment, the process instance cannot be changed.

Change of Cardinality: From the benchmarking test performed, it was possible to conclude that none of the solutions were capable to automatize a process which activities have different cardinalities at the input and output of the process. In other words, none of the solutions allowed creating different instances within a process instance. This gap is critical during an operational process management since it does not allow representing sharing of resources by different entities. Using the candidature process as example, an unknown number of candidates send their application form that are buffered in the secretary and, at a certain date, sent to the course director to be serialized. With BPMS selected it was not possible to directly represent and analyse the behaviour between the n cardinality of students and 1 cardinality of the secretary. It is recommended to include in BPMS this capability.

6. CONCLUSIONS

A growing number of leading companies have begun to believe that a corporate-wide focus on processes provides a superior way of managing the company. These companies, which are normally in industries that are undergoing rapid and extensive changes, have concluded that they need the insight and the agility provided by a BPMS to manage in a quickly and effective way. These organizations are making major commitments to implement enterprise-level business process tools and management systems to assure that they have aligned all of their business resources and functions with their value chains, and can manage those processes in something close to real time.

Understanding this position from the industry side, this paper was written aiming to explore which BPMS solution, currently available on the market, could provide higher levels of functionalities for enterprise operations. From the real test evaluation, the Bizagi solution was the one that presented a more complete package of functionalities through the entire business process management life cycle. However, ProcessMaker and Intalio solutions also presented very interesting functionalities that can be implemented with lower costs.

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