Measurement Framework for Business Process Outsourcing to the Cloud

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Abstract: Face to the increasingly stringent business competition, small and medium sized enterprises strive to excel in the marketplace by adopting different strategies and solutions. Outsourcing their business processes to the Cloud has been among the most widely adopted strategies. Among others, enterprises outsource their related business process to improve their performance. However, this strategy is not without inconvenience especially when the decision is taken without being aware about the business process functional and non functional requirements. We focus in this paper on identifying the business process performance enhancement needs so to be able to identify requirements when outsourcing business process to the Cloud. This papers major contribution is the presentation of a measurement framework for SOA-based business process performance. The proposed framework allows firstly to identify essential metrics to monitor starting from an abstract business level. Then, identified metrics are monitored using our Business/Qos (BisQos) listener. The gathered data are then stored in a database for analysis purpose. The output of the framework specifies whether business process instances reveal a degradation of their performance caused by business metrics or by Qos metrics, in addition to the infrastructure properties supporting each web service execution.

1 INTRODUCTION

The number of Small and Medium sized Enterprises (SMEs) emerging in the competitive markets is increasing considerably. This situation urges enterprises to strive for sustaining a good place in such economic context. Basically, many SMEs are relying on their business process (BP) to deliver their goods and services to their clients and to gain added-value. This reveals the need to define a well designed environment for the execution of the BP giving them the ability to perform properly and to attain their predefined goals. Outsourcing business process to the Cloud is considered as an emergent solution thanks to the opportunities it offers. Indeed, according to the National Institute of standards and technology (NIST) (Mell and Grance, 2011), Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. Generally, the outsourcing business process decision is taken thanks to opportunities it may offer such as improve business process performance (Yang et al., 2007). Assessing whether Cloud computing may be an opportune environment for outsourcing should be preceded by observing and identifying functional and non functional requirements in addition to the improvement needs. This paper focus is to identify the business process performance enhancement needs and more specifically those that can be fulfilled when adopting Cloud computing as an execution environment. Usually, business experts define their business models. These models are then refined into executable ones by IT experts and deployed into process engines. The execution of the business process can be made by web service composition following the service oriented architecture (SOA) principles (Josuttis, 2007). To monitor the business process performance, SMEs should be able to depict and monitor relevant IT/business metrics. In this context, enterprises experts should be able to proceed for IT/business alignment serving to link between the business process performance and related influencing IT/business metrics. This in turn will help for enhancing the business facet of business processes and even the IT systems supporting them. Generally, assessing the business process performance is based on Key Per-

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formance Indicator (KPI) by using Business Activity Monitoring (BAM) tools providing near-real time monitoring of business processes (zur Muehlen and Shapiro, 2010). However, these tools are characterized by some shortcomings: they aren't able to provide customized data corresponding to specific need of business processes, reasons behind business process performance degradation are not displayed and finally they can not identify the infrastructure properties (CPU, Memory, etc) supporting business process so to be able to depict requirements of business process performance enhancement (Wetzstein et al., 2011). Our main contribution in this paper is the presentation of the measurement framework assisting IT/business experts to:

- Depict relevant KPI, Qos and Business metrics to monitor for sustaining a satisfactory level of business process performance by using the GQM paradigm.
- Monitor the depicted business/Qos metrics and the business process performance by observing their KPI value.
- Analyze gathered data and distinguish between Qos and business metrics that influence the business process performance degradation. This step will be helpful in the context of our research, to help enterprises to identify business process requirements when outsourcing to the cloud. Moreover, the framework allows for the business/IT alignment as its process starts from a high-level namely the business process goals, to the low level referring the properties of infrastructure supporting it.

The remainder of this paper is structured as follows. Section 2 describes the related work. Section 3 presents in detail our proposed measurement framework. In section 4 we illustrate an application case to present the usefulness of our framework. Section 5 summarizes the work status and highlights its extensions.

2 RELATED WORK

Monitoring the business process performance and their execution as web service composition is knowing an exponential interest. Basically, several works try to generate and analyze two categories of data related to business processes such as business and Qos metrics. Qos are non functional requirements considered important for the satisfaction of costumers and their objective function such as response time, throughput, and availability (Zhang et al., 2009). In the other side, business metrics are defined by business people based on business goals (e.g., computing process rentability, service reliability) (Wetzstein et al., 2009) and are the basis for monitoring, controlling, analyzing and improvement of the business processes execution(Ruijie and Hong, 2010). In this context, (Grati et al., 2012) and (Comes et al., 2009) present techniques and solutions to monitor different Qos dimensions of web services composing business processes. Besides, assessing the continuous improvement of business process performance is tackled by (Delgado et al., 2014) based on execution measurement model containing a set of execution measures. Observing and assessing whether business processes are attaining their goals is done essentially by monitoring their KPI (Pan and Wei, 2012). KPIs are defined by experts over each business process to measure their performance. They are associated with a target value as an objective to be attained in an analysis period. KPIs may be influenced by business factors named process performance metrics (PPMs) or/and Qos metrics. Different research works focus on finding out how to model and monitor PPMs and KPIs. In this context, (del Ro-Ortega et al., 2010) presents an ontology to define process performance metrics and explicitly depict relations between them and elements of BPMN. Authors in (del Ro-Ortega et al., 2012) propose templates and ontology based linguistic pattern to facilitate the task of defining PPM over business processes. Generally, monitoring business processes performance through KPIs is done by business activity monitoring (BAM) tools. The BAM allows for the supervision of business processes by providing near real time information about their status. It resorts essentially on dashboards where to display needed information to accomplish enterprises objectives. In this context, authors in (Friedenstab et al., 2012) extends the BPMN with fundamental concepts of BAM and the way to analyze and display its value. Although enterprises rely basically on BAM tools to detect possible degradation of business process performance, depicting possible influential factors on KPI isn't provided. Overall, the reported researches present solutions to model, monitor and analyze either business or Qos metrics related to the execution of business processes. In the best of our knowledge, there is no strategy neither a complete tool proposed as a measurement framework allowing: to depict appropriate Qos/business metrics that may influence the business process performance, monitor and analyze these metrics to differentiate between most influencing metrics (business/Qos) and finally identify the infrastructure properties supporting the business process execution. These three aspects

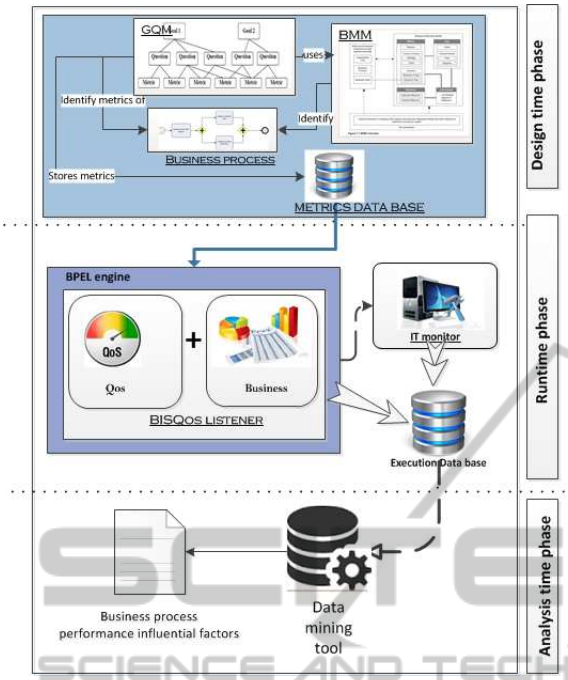

Figure 1: The proposed measurement framework.

allow for defining business process requirements for performance enhancement when migration to another executing environment is decided.

3 PROPOSED MEASUREMENT FRAMEWORK

We proposed a framework based on standards for a fine and logic IT/business alignment contributing to a pertinent collaboration between IT and business experts within enterprises. Next sections present in detail each phase in this framework illustrated in figure 1.

3.1 The Design Time Phase

The first step consists on the depiction of essential metrics to monitor the business process performance, namely the KPI in addition to metrics that may influence its value (business and Qos metrics) which is accomplished using the GQM approach. The GQM (Aversano et al., 2004) is an analytic goal-oriented approach starting with a goal, refined then into questions from which users can identify relevant metrics.

The elaboration of the GQM approach in our framework passes through three essential steps presented in table 1. This metric identification step is elaborated by business experts. The second step defines goal using the depicted KPI. This in turn will help IT/business experts to identify influential metrics that may lead to business process performance degradation namely business/Qos metrics. The final step helps IT experts to define implied IT properties that may influence KPI values such as CPU, RAM, memory. We focus in the context of this paper on response time Qod metric and IT properties that may influence it.

3.2 The Runtime Phase

We develop a Business/Qos (Bis/Qos) listener for assessing business process performance. It uses as input metrics identified when applying GQM approach. Our proposed listener accesses to the database where metrics and formula used to calculate each one of them are stored. Details about techniques used to access the database and how to manipulate data are non mentioned in this paper for space limitation. The BisQos subscribes to the process engine allowing to generate different data related to the business process instances, such as the KPI value and its relative influential metrics (PPM/Qos). Moreover, more detailed data may be provided such as the IT properties supporting the business process. The calculator component uses the filtered event data on which it applies formula described on metrics database to calculate PPM and Qos values. Furthermore, the BisQos listener calls the IT monitor responsible for gathering IT properties and characteristic supporting BPEL instances when execution begins, which is in our case the Nagios monitor tool. The Nagios is an open source tool commonly used by different projects and researches (Barth, 2006). Finally, the output of the execution data is stored in a specified database.

3.3 The Analysis Time Phase

The analysis step of the business/Qos data is based on data mining methods offered by the WEKA data mining software (Hall et al., 2009). Principally, the goal of the data mining is to extract information from a considerable number of data and transform it into an understandable structure for further use. We choose data mining as it enables studying and depicting knowledge from historical business process execution. This helps then to identify, based on this new knowledge, reasons behind business process performance degradation. Different methods are proposed in the data mining. However, we used the decision tree method as it can respond to our needs in the analysis step (Quinlan, 1986). A decision tree is a flowchart-like structure in which each node corre-

Table 1: Identifying metrics using GQM.

First step			
Team	Goal	Question	Metric
Business	enterprise objectives	Questions raised to depict metrics to achieve the objective	Metrics and KPI are depicted
Second step			
Business	enterprise objectives	Questions raised to depict metrics to achieve the objective	Metrics and KPI are depicted
Business and IT	KPI to fulfill the objective	Questions raised to depict IT and business influential metrics	Influential metrics of KPI
Third step			
IT	IT components affecting Qos influential metrics	Questions raised to depict implied IT components	Implied IT components

sponds to an attribute and each branch corresponds to a test on this attribute. Finally leaf node corresponds to the class which is in our case yes/no. Classification rules are identified starting from the root to leaf. Our focus is to identify whether Qos or business metrics influence most the KPI violation (business process performance degradation). We proceed for the analysis as follows: We firstly identify classification rules corresponding to the class yes (KPI violated). Next, we calculate the number of occurrence of each type of metric (business/Qos). Whenever Qos metrics influence most the KPI violation (number of Qos metric occurrence is greater), we proceed for the analysis of IT properties of machines supporting the web services executions using similarly, the decision tree method. Solutions to enhance the business facet of business process performance are not the focus of this paper as we aim to depict the non functional requirements of business process to outsource it to the cloud computing.

4 APPLICATION CASE

In this section we will present an example to illustrate in more details the utilization of our measurement framework.

4.1 Identifying the Enterprise Vision and Goals

We take as an example a Tunisian enterprise which sells its products over the Internet. The enterprise vision is to be the leader in Tunisia for online product selling, depicted goals should insure the achievement of this vision. These long-term (strategic) goals are SG1 ”Have a good relationship with costumers”, and SG2 ”Be known in all Tunisia cities”. Objectives quantifies goals by presenting measures and target values to attain. In the studied business strategies of the Tunisian enterprise, objectives are OB1 ”In the end of December 2015, the number of adherents in the enterprise web site increase to 2000” and the second objective is OB2” In the end of 2016, number of purchase order achieved in time and in full attains 60% against the number corresponding to 2015”. The second cited objective quantifies the strategic goal SG1. Experts collaborate to decide about business processes that follows each strategic goal. This step allows to restrain the number of business processes to be monitored in ulterior steps.

We will only focus in this paper, on the business process ”Purchase Order” (PO) for space limitation. The PO process follows basically the SG1. Next step aims to depict essential metrics to monitor based on the GQM approach.

4.2 Applying the GQM Paradigm

This phase encompasses three essential steps allowing to identify firstly KPI to assess performance of business processes, then potential influential metrics and finally implied IT components.

4.2.1 Identifying KPI and Related Metrics

In this phase we aim to extricate for each business process, the KPI to monitor its performance and its behavior towards the achievement of its related strategic goal. Table 2 presents the process used to this purpose. It should be noted that we focus in this pa-

per on KPI that can be calculated and derived from runtime data of executable business processes. Business experts are concerned in this phase. In this section we will present an excerpt of metrics monitored by the BisQos tool. In this step, several metrics are depicted, only essential ones are designed to be the KPI. In the presented example, the ”order confirmation lead time” is designed by business experts to be the KPI reflecting the performance of the PO business process.

4.2.2 Identifying Influential Metrics of the KPI

This step is intended to identify Qos and business metrics that can deviate the KPI from its target value. Table 3 presents in detail the process used to identify influential metrics of the studied KPI. Next step focus on the IT properties and characteristics influencing the depicted Qos metrics.

4.2.3 Identifying Implied IT Properties

This phase helps to identify IT properties requirements for the enhancement of the business process performance. The goal is identified from the Qos requirements elicited previously. The excerpt of metrics extracted when applying the GQM approach should serve as input for our monitoring tool. Further details are given in table 4. Next section presents the result generated by our monitoring tool for the PO business process.

4.3 Applying the Monitoring Tool for the ”Purchase order” Business Process

After identifying the KPI, influencing business and Qos metrics, in addition to the related IT properties, our tool monitor this metrics and display results for experts for ulterior analysis steps. To do so, we consider the simplified business process modeled with BPMN ((OMG), 2011) presented in figure 2. In the execution phase, BPMN is mapped to an executable business process (BPEL process), and then an Apache ODE is used as BPEL engine. The implemented BisQos listener access to the repository where predefined metrics are stored. Essentially, the tool gathers the monitoring data from specified repository that encompasses different relevant data related to: the target value of KPI and formula necessary to calculate its value, and influential metrics identified using the GQM. To properly monitor and calculate influential metrics, we store in addition to their ID, the allowed range of value and the attachments relating

Table 2: Extraction of KPI relative to PO process.

First step (Business team): Identifying KPI to monitor and its related metrics		
Goal: (OB2) In the end of 2016, number of purchase order achieved in time and in full attains 60%.		
Question	Metric	Formula
Q1: What is the number of POs of the current year?	M1: number of PO	$\sum PO$
Q2: What is the percentage of approved and accorded orders?	M2.1: number of Accorded Orders in Time (AOT) M2.2:number of Total Orders requests(TO)	$\frac{\sum PO}{TO}$
Q3: What is the Order Confirmation lead Time (OCT)?	M3.1: time stamp (TR) corresponding to the reception of PO request M3.2 time stamp (TA) corresponding of the PO confirmation	OCT=TA-TR

each BPEL element with its needed events Our developed listener filters unnecessary metrics from repository and tackles only metrics identified by GQM as input for the monitoring tool.

4.4 Analyzing Generated Data

Different decision tree methods are used to generate pertinent results, namely, J48,CART, ADTree, and REPTree. Following, we will give an example of classification rule generated when applying the J48 method on the business/Qos data.

```
Rule1: if (check shipment
availability RT > 97)
 and
 (order in stock = true)
  and
 (check warehouse availability
 RT > 101)
  and (check with supplier
   RT >10)
```

Table 3: Identifying influential metrics.

Second step (Business & IT team): Identifying influential factors of the KPI			
Goal: The Duration of the PO process is lower than 3 days.			
Question	Metric	Formula	Type
Q1: What is the duration of a web service i corresponding to REC process ?	M1.1: time stamp TEi relative to the end of web service i M1.2 time stamp relative to the start of web service TSi	duration=TEi-TSi	Qos
Q2: What is the identity of costumers that almost all their PO requests lead to a rejected response?	M2: identity of costumers		PPM
Q3: Is the product always available?	M3: availability of the product		PPM

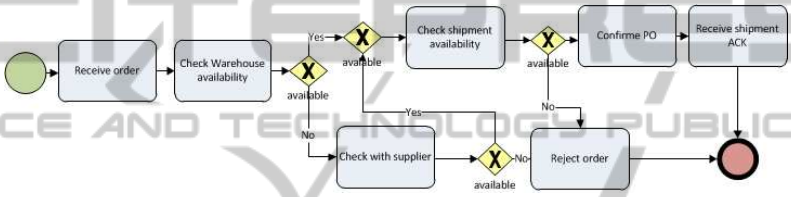

Figure 2: The simplified purchase order process.

Table 4: Identifying implied IT components.

Third step (IT team): Identifying implied IT components	
Goal:Ameliorate duration of web services composing the business process	
Question	Metric
Q1: What is CPU properties of server on which web service i is running corresponding to a BPEL process j?	M1: CPU rate of usage related to server supporting web service i corresponding to a BPEL process j
Q2: What is the System disk properties of server on which web service i is running corresponding to a BPEL process j?	M2: System disk rate of usage related to server supporting web service i corresponding to a BPEL process j

```
then violated = true;
```

Table 5 presents the results corresponding to each applied decision tree method, more specifically, the decision tree method name, the percentage of correctly classified instances and the number of occurrence of the business/Qos metrics.

When calculating the occurrence of each attribute (business and Qos), we observe that the number of Qos metrics is greater then business metric. More specifically, we can precise which web services Qos influence the most the KPI violation which are in our case ”check warehouse availability RT” and ”check shipment availability RT”. To enhance the Qos metrics, we go further in the analysis phase by depicting the IT properties of the violated business instances generated using the Nagios monitor. Monitored IT properties in our case are CPU usage, memory usage, system disk, virtual memory, page file, and total processes. We choose to monitor these IT properties as they are components that influence most the response time Qos the focus of our paper. Herein an example of classification rule generated when we apply the J48 method on the IT properties data:

Table 5: Experimental results: the application of decision tree methods on business/Qos data.

Decision tree methods	Percentage of correctly classified instances	Number of Qos metrics	Number of PPM metrics
J48	85,48%	3	1
CART	87,36%	2	0
ADTree	86,26%	4	1
REPTree	86,26%	4	1

```
if (MemoryUsage1 > 82.5 and
 MemoryUsage6> 90)
then violated=true ;
```

MemoryUsage1 and MemoryUsage6 refers respectively to the MemoryUsage of the machines supporting respectively the web service ”check warehouse availability” and ”check shipment availability”. Regarding the huge number and the variety of compute instances offered by Cloud provider, the generated classification rule presents a means to limit the range of choices. Referring to our example, enterprises should focus only on finding computing instances providing better memory usage for the execution of the identified web services

5 CONCLUSION

Monitoring SOA based business processes presents an interesting means for SMEs to analyze, interpret and ameliorate the business process performance. Despite the evolving number of researches focusing on that issue, realizing a method for identifying essential processes to monitor, identifying and monitoring business and Qos metrics is not tackled in the best of our knowledge. Thus, the framework presents a pertinent solution to assist business/IT experts for achieving enterprise goals. The tool we presented in this paper is characterized by its top down aspect. In fact, it links between business and IT levels helping experts to depict the relation between eventual KPI violation and the concerned IT properties. Moreover, the framework identify the outsourcing to the Cloud requirements. The presented framework is beneficial for both IT and business levels for displaying, analyzing and enhancing different business processes data. We are working on defining an outsourcing algorithm allowing to depict most relevant business process parts to outsource and the evaluation the performance of business processes executed in the Cloud.

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