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A BPMN Extension for Business Process Outsourcing to the Cloud

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Abstract. The trend of business process outsourcing (BPO) has been intensified with the advent of Cloud computing that brings a new way of paying and consuming resources. Nevertheless, ensuring the compliance of outsourced business processes (BPs), protecting sensitive data, and making the right choices of offers, remain among the most important challenges in BPO to the Cloud. An organization must therefore consider several factors to determine the most appropriate Cloud offers. This paper proposes an extension of the BPMN language (called BPOMN) that allows specifying the requirements of BP activities in terms of security, compliance, cost, and performance. This extension aims to assign to each activity the Cloud offer that best meets its requirements.

Keywords: Business process outsourcing, Cloud computing, BPMN extension, Security, Compliance, Cost, Performance.

1 Introduction

Given the harsh competition that companies face today, many of them opt for business process outsourcing (BPO), which is seen among the most beneficial strategies, especially for small and middle-size companies. The practise of BPO has been intensified with the advent of Cloud computing that has attracted companies with its new economic model of pay-per-use and its high elasticity in resource consumption. In fact, the Gartner research firm [6] estimates the BP market in the Cloud at \$40.8 billion, which exceeds the market of other service models.

However, the Cloud may endanger the security of outsourced BPs by exposing them to different threats such as data breach and denial of service. In order to avoid being sanctioned, organizations are also required to be well aware of the increasing number of laws and standards imposed on their BPs, especially those operating in heavily regulated sectors like the financial or medical sector. Furthermore, companies are struggling to find the most suited deals for their outsourced BPs, owing to the proliferation of Cloud providers that invade the market with services of various qualities and at different prices.

Given the previous factors, a company must identify accurately the requirements of BP activities in order to decide for each of them, whether it should be outsourced or

kept locally, and secondly to select the most suitable Cloud offers for the outsourced activities. Thus, a language is required to specify the activity requirements when modelling BPs. Unfortunately, existing modelling languages are generic and do not support specific domains. In this context, several work extend the BPMN language but do not consider the BPO criteria in a Cloud context and do not also take into account both risk and compliance criteria as recommended by the GRC (Governance, Risks and Compliance) experts [14].

In this paper, we propose BPOMN (Business Process Outsourcing Model Notation), an extension of the BPMN language by defining new artefacts to be able to specify the requirements of BP activities in terms of security, compliance, cost, and performance. BPOMN aims to help organizations in outsourcing their BPs by assigning to each activity, the Cloud offer that best meets its requirements and therefore to obtain an optimal configuration for outsourced BPs. In order to provide a valid extension, we rely on the official documentation of the BPMN language and we use the two formats defined in the extension mechanism, namely, the MOF-based meta-model as well as the XML Schema. For the visual aspect, we propose new graphical elements that we add to the predefined artefacts.

The business process management (BPM) aims to improve processes in a continuous way by handling their iterative lifecycle, which includes the modelling, automation, execution, and optimization phases [23]. BPOMN is intended for the modelling phase and complements the business intelligence (BI) approach that we have proposed in [26]. Indeed, the latter contributes in the optimization phase by exploiting the execution history of outsourced BPs to evaluate the Cloud offers and the activities confided to them.

The remainder of this paper is organized as follows. Section 2 tackles the context of BPO to the Cloud and justifies the consideration of each criterion. Section 3 describes BPOMN and demonstrates its feasibility through an illustrative example and modelling tools. Some related work are addressed in Section 4. Finally, Section 5 concludes this paper and provides directions for future work.

2 The context of BPOMN

This section depicts the field of BPO in a Cloud context and explains the importance of the considered criteria.

2.1 BPO to the Cloud

BPO is a practice that has appeared in the 90's [16], which consists of delegating wholly or partially a BP to a third party. In the recent years, the Cloud has become the most chosen outsourcing environment [17]. In fact, the Cloud has lured companies with an economic model that allows them to save money by paying only for the consumed resources as well as a high elasticity that enables the parallelization of BPs and the support of scaling up.

2.2 BPO criteria

Organizations should examine several criteria in order to successfully outsource their BPs to the Cloud. Currently, the focus is shifting towards problems of security risks and compliance [10]. Hence, in our work, we approach the criteria from the perspective of Governance, Risk and Compliance (GRC) that is defined as a framework to govern an organization through strategic decision-making by taking into account the incurred risks and compliance. In fact, the decisions to make in BPO are strategic for an organization and therefore they are part of its governance. Moreover, given the overgrowth of Cloud providers that propose services at different prices and with different quality levels, we have decided to combine the criteria of cost and performance with those considered in GRC, namely risks and compliance. In what follows, we explain and justify the choice of each criterion:

- **Security:** The main goals of security consist in ensuring confidentiality, integrity, availability, non-repudiation, and authenticity (CIAANA) [19]. These types of security can be endangered because the outsourcing of BPs exposes them to different Cloud threats that are regularly published and ranked by the Cloud Security Alliance (CSA). The CSA also indicates in its reports the types of security affected by each Cloud threat [4] as well as the security mechanisms implemented by each Cloud provider [5].
- **Compliance:** The organizations have to ensure that their outsourced BPs comply with regulations, contracts, laws, standards, etc. Compliance is a significant criterion for organizations since it allows them to maintain a good reputation and avoid fines that may outweigh the cost benefits of Cloud. Ensuring compliance becomes more challenging when BPs are under the control of Cloud providers. Indeed, BP activities may be spread, replicated, and shifted across different data centers that follow laws and regulations of the country in which they are located [10]. Furthermore, the location of the data center may remain unknown since several Cloud providers hide it to prevent cyber-attacks [10].
- **Cost:** Saving money is a much-awaited profit when outsourcing BPs to the Cloud [17]. Nonetheless, the Cloud market is flooded with a growing number of offers, some of which are cheap for storage services and expensive for computation while others propose the contrary. Therefore, it becomes very difficult for an organization to choose the adequate offers for their BPs.
- **Performance:** As for the cost, there exists an increasing number of Cloud offers that propose similar services but at different performance levels. Furthermore, the activities that make up time-constrained BPs should be assigned to Cloud offers with enough calculation capacity to respect the imposed deadlines.

3 A BPMN extension for specifying BP requirements

This section motivates firstly the choice of the BPMN language and then presents the BPOMN extension.

3.1 The choice of BPMN language

We have chosen the Business Process Model and Notation (BPMN) to propose our extension for several reasons:

- BPMN is defined by the Object Management Group (OMG) and approved as an ISO standard.
- BPMN allows the definition of semantically rich BPs and facilitates human interpretation by providing a readily understandable visual representation.
- BPMN provides an extension mechanism to represent specific domains.
- BPMN models can be easily converted into executable languages (e.g., BPEL) and it is supported by a wide range of modelling tools like Bizagi and MS Visio.

3.2 BPOMN representation

By examining more than twenty BPMN extensions, [25] has found that they have two major steps in common. The first step consists of identifying the requirements of the targeted domain as we did in the previous section. The second step is devoted to the presentation of the BPMN extension, as we will do in this section. Indeed, this part describes the proposed extension based on the MOF meta-model and XML schema as well as the corresponding graphic elements.

Extension based on MOF meta-model

The extensible meta-model defined in [14, p.55] allows to be still BPMN-compliant [13] and it consists of four elements: Extension, ExtensionDefinition, ExtensionAttributeDefinition, and ExtensionAttributeValue. Figure 1 presents the proposed class diagram corresponding to the MOF-based meta-model. The BPO criteria class represents the ExtensionDefinition class that contains the extension attributes: security, compliance, cost, and performance.

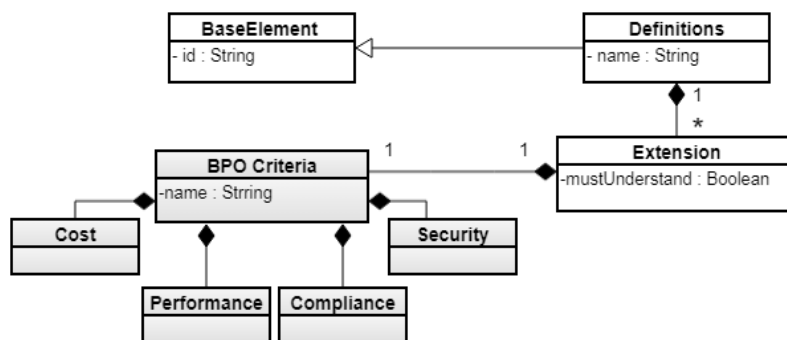


Fig 1. The proposed BPMN extension based on MOF meta-model

Extension based on XML schema

To specify an interchange format for BPMN models, we present in Listing 1 an XML Schema for BPOMN. We adopt the same structure as that defined in [13] and used in most BPMN extensions like [2, 16, 23]. However, unlike them, we use the constructor ‘all’ instead of ‘sequence’ to nest the ExtensionAttributeDefinition elements in ExtensionDefinition, since the appearance order of the attributes is not important in our case. We also mention via comments the correspondences with the elements of the MOF meta-model as indicated in [21].

Listing 1. An XML Schema definition for the proposed BPMN extension

```

<?xml version="1.0" encoding="UTF-8" ?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
<xsd:element name="BPOcriteria" type="BPOcriteriaType"/><!-- ExtensionDefinition -->
<xsd:complexType name="BPOcriteriaType">
<xsd:all>
  <xsd:element name="security" minOccurs="0"> <!-- ExtensionAttributeDefinition -->
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element name="SecuRequirement" maxOccurs="5" type="SecuRequirementType"/>
      </xsd:sequence> </xsd:complexType> </xsd:element>
    <xsd:element name="compliance" minOccurs="0"/> <!-- ExtensionAttributeDefinition -->
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element name="regulation" type="xsd:string" maxOccurs="unbounded"/>
          <xsd:element name="standard" type="xsd:string" maxOccurs="unbounded"/>
        </xsd:sequence> </xsd:complexType> </xsd:element>
    <xsd:element name="cost" minOccurs="0"> <!-- ExtensionAttributeDefinition -->
      <xsd:complexType>
        <xsd:simpleContent>
          <xsd:extension base="xsd:decimal">
            <xsd:attribute name="currency" type="xsd:string" use="required"/>
          </xsd:extension> </xsd:simpleContent> </xsd:complexType> </xsd:element>
    <xsd:element name="performance" type="xsd:duration" minOccurs="0" /> <!-- ExtensionAttributeDefinition -->
  </xsd:all> </xsd:complexType>
</xsd:schema>

```

New graphical elements

The BPMN specification does not provide any graphical notation for the representation of extensions. However, new graphic forms can be added as artefacts [13]. Thus, we have proposed a set of graphical elements presented in figure 2 that allows us to annotate BP activities. For providing further details about activity requirements, we use the 'Text annotation' artefact. Thus, for security, we can specify precisely the types of security (CIANA) that are required. Regarding compliance, we can list the rules and standards that must be respected. Finally, for performance and cost, we can indicate the

runtime that should not to be exceeded and the amount of estimated cost. Seen that BPOMN applies to the activity element, we consider that the requirements of an activity also depend on the objects it manipulates.

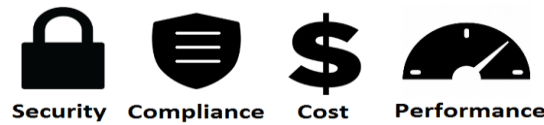


Fig 2. The graphical elements of BPOMN

3.3 Illustrative example

In order to illustrate the use of BPOMN, we give a simplified example (see figure 3) on the patient's medical visit to a healthcare institution. Furthermore, we consider in this example that the health organization desiring to migrate to the Cloud is in the USA. Hence, it must comply with the regulations imposed in that country. For representing participants, we have defined two pools: Patient and Healthcare institution. The second one is divided into three lanes: secretariat, doctor, and infirmary. Concerning the requirements that we have annotated for decision-making in BPO to the Cloud, we specified that:

- The activity 'check patient record' requires confidentiality. Indeed, when the secretary verifies the existence of a record, she has to see only the administrative data but not the medical data that must remain confidential. This activity has also to comply with Health Insurance Portability and Accountability Act (HIPAA), which imposes rules on access rights and protection of medical data.
- The creation of the patient record has to comply with the norm ISO 18308:2011 [8], which recommends a certain structure for the electronic health record.
- The activity 'consult medical history' requires two types of security. Firstly, availability because the medical past is primordial for the doctor in his diagnosis. Secondly, integrity since the doctor must have at his disposal complete and reliable medical data. This activity is also exigent in terms of performance, as the data to be downloaded can be very voluminous (e.g., medical imaging).
- When recording the consultation report and new medical data, it is necessary to respect the international health regulations (IHR) [24] that imposes on 196 countries the declaration of certain epidemiological diseases. This activity can also be very expensive if the new data require a large storage space.
- If the patient wants to pay by card, the secretary has to verify that the provided card meets the Payment Card Industry Data Security Standard (PCI DSS).

From the process model modelled through BPOMN, we can determine an appropriate cloud offer for each activity. For instance, activities to be performed by the secretary and that are involved in the management of patient's records should be assigned to Cloud providers that respect the medical confidentiality and the record structuring standards. As for the physician' activities to be performed during the consultation, they

should be entrusted to providers that guarantee the integrity and availability of medical data and that propose a low storage costs.

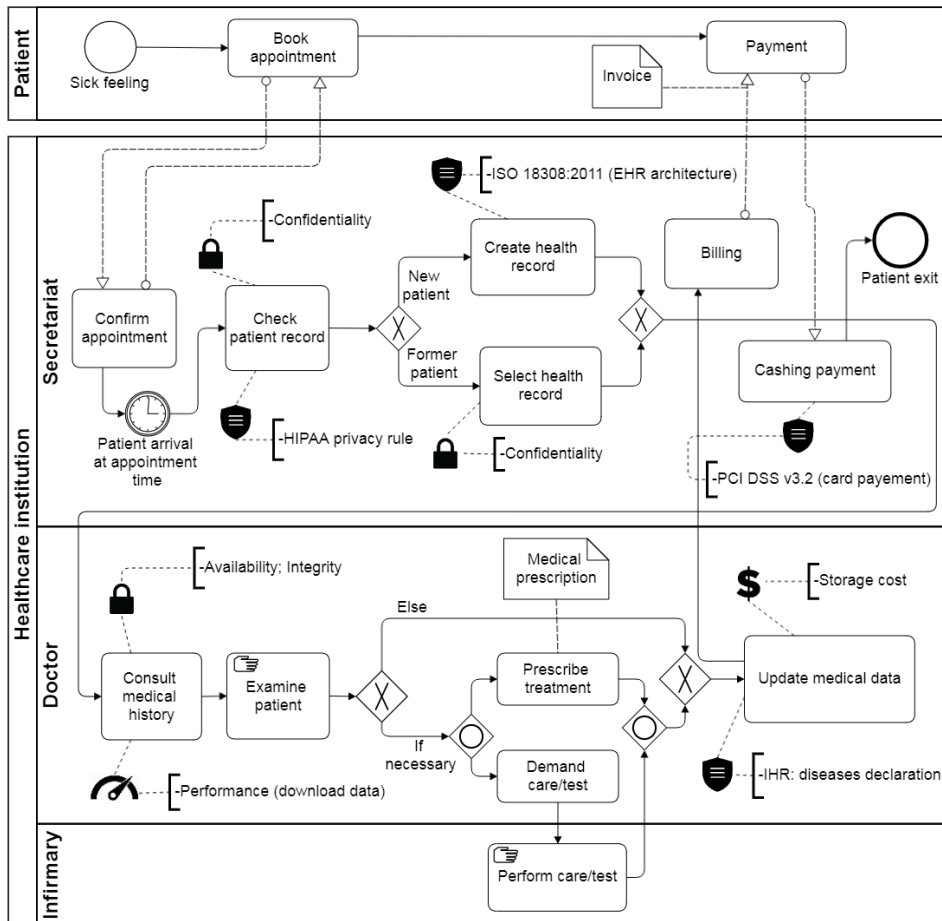


Fig 3. An example of a business process modelled using our BPMN extension

3.4 Implementation

Modellers or modelling tools are free to add as many artefacts as necessary but without changing the shapes of existing elements [13]. Therefore, we have defined new artefacts and added them to the palette of BIZAGI BPM Modeler, which is a well-known tool for process modelling as it has more than 500 000 active users. We have also integrated the BPOMN extension into the Microsoft Visio tool by defining the four artifacts as stencils as shown in the left screenshot of the figure 4. As for tools that do not offer the possibility to add new artefacts like Activiti and jBPM, we define custom tasks bearing the BPO criteria icons, namely cost, compliance, performance, and cost.

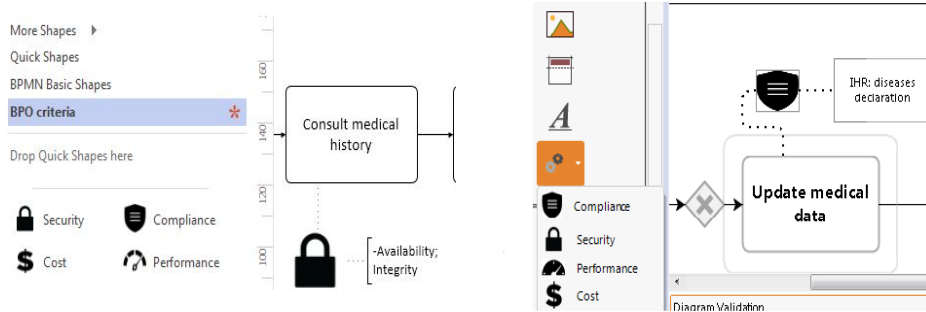


Fig 4. Integration of BPOMN elements in MS Visio (left) and Bizagi (right) tools

4 Related work

There exist many work in the literature that extend the BPMN language. We have classified and compared in table 1 a set of fairly recent extensions that seem to us closer to our work, that is, those that extend BPMN for specifying BP requirements.

Table 1. Presentation and comparison of existing work on BPMN extension

Work	Aim of the BPMN extension	Domain
[17]	Specifying the outsource-ability characteristics of BPs	BPO
[18]	Specifying security requirements (e.g., attack harm detection, integrity, privacy, access control).	Security
[20]	Modelling security concepts (like authorization, encrypted message and harm protection) in BPMN-based healthcare processes	
[15]	Specifying privacy requirements and capturing data leakage.	
[11]	Handling security risks by aligning BPMN constructs to the IS security risk management (ISSRM) domain model	Risks
[1]	Management of security risks based on the alignment of BPMN constructs to the ISSRM concepts	
[12]	Representing audit-relevant concepts into BP models for improving process audits.	Compliance
[7]	Representing legal constraints and business rules through artefacts	
[22]	Facilitating access and interpretation of accurate cost information at the activity level	Other non-functional requirements
[2]	Specifying performance and reliability properties in BPMN models	
[9]	Extending BPMN with new elements for the performance and cost analysis of BPs	

Based on existing BPMN extensions, we have found that regarding the involved domains:

- A large number of studies are concerned with security in general or by targeting a particular sector such as security in healthcare. Their main objective is to secure the BPs during the modelling phase but they do not consider Cloud-related threats.
- There exists some work that extend BPMN for risk management and others for compliance but not both at once.
- There are work that extend BPMN for specifying other non-functional requirements such as cost, performance, and reliability. However, they do not consider the Cloud context, which has its own characteristics like pay-per-use and resource allocation.
- Finally, we found only one work in [17] that proposes a BPMN extension for BPO to the Cloud. Unfortunately, it does not take into account the compliance, which is a very important criterion. Moreover, we found a problem in the graphical representation. Indeed, the authors propose to add icons inside the rectangle representing BP activities (in the four corners of the rectangle) which leaves no place for specifying the type of activity with the icons predefined by BPMN (e.g., manual task, user task, service task, etc.)

As regards the extension mechanism, we have retained the following points:

- Despite XML Schema specifies an interchange format for BPMN models, existing work rarely use it to define their extension as has been done by [2, 16, 27]. In fact, none of the BPMN extensions cited in table 3 used XML Schema.
- Some works propose new graphic elements while others reuse existing elements such as artefacts.
- Most work overlook the BPMN extension mechanism by extending their own meta-model and not the one specified by the OMG. This hampers comprehensibility and comparability of BPMN extensions and impedes their straightforward integration in modelling tools [3].

5 Conclusion and future work

The Cloud computing allures companies that opt for a BPO strategy to be more competitive. Indeed, it ensures them a high elasticity by adjusting the resource consumption according to the BP demand. The Cloud also allows companies to save money by paying for only what they consume.

Despite these advantages, there are many worrisome concerns in BPO to the Cloud that are mainly related to compliance violation, security issues, and loss of control over BPs. In fact, the organizations wanting to outsource their BPs are afraid to expose their critical activities and sensitive data to Cloud threats. Moreover, it becomes very difficult for organizations to choose the adequate Cloud solutions given the growing number of offers available on the market and the diversity of prices and service qualities. Furthermore, companies should not entrust all the activities of a given process to the same Cloud provider. On the contrary, they have to spread their BPs across several Cloud providers to take advantage from the strengths of each of them.

Hence, BPO to the Cloud may be very beneficial for organizations on condition that they make the right choices by investigating thoroughly the characteristics of their BPs as well as the incurred risks. In this context, we have proposed in this paper BPOMN,

an extension of the BPMN language that enables organizations to specify clearly and precisely the requirements of their BPs in terms of security, compliance, cost, and performance. BPOMN was developed on the basis of two representations provided by the BPMN extension mechanism, namely, the MOF meta-model and the XML Schema. These two representations were supplemented by new graphical elements that we integrated into a modelling tool.

For future work, we envisage to consider the criteria of cost and time of data transfer between BP activities. Indeed, the data generated by an activity may be needed to execute another and the data centers of Cloud providers are geographically dispersed. Therefore, activities that exchange a large amount of data should be assigned to the same provider. It would also be interesting to consider technical aspects such as data formats, platforms, and programming languages to avoid incompatibility with the heterogeneous Cloud providers. Finally, we plan for an automatic deployment by taking into account both activity requirements and Cloud offer features.

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