Modelling Business Processes for Outsourcing into the Fog and Cloud Computing

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Abstract. Changes in economic environment force companies to be more flexible and performant. These goals can only be achieved through business process outsourcing (BPO) strategy; which reduces costs, gives companies the opportunity to focus on their core business and delegate secondary problems using capabilities offered by Cloud or Fog computing environments. The company must therefore consider multiple factors to determine which parts of the BP to be outsourced, and to assign them the appropriate outsourcing environment. In this paper, we propose an extension, of the BPMN language standard that allows specifying the requirements of BP activities in terms of security, compliance, cost, performance and storage space. The requirements of BP activities help to select the most appropriate Cloud/Fog service providers.
Keywords: Business Processes (BPs), Cloud, Fog computing, Business Process Outsourcing (BPO), BPMN extension.

1 Introduction

Nowadays, whether it is a small or a big business, the way you store and access personal and business information has taken a huge leap. In the past, businesses and institutions use the resources of computers to store their data, run their applications or develop their programs, but the cost of maintaining them on a regular basis and the difficulty of ensuring their efficient operation have always been a concern for companies, governments and institutions. As a result, they have begun to look for other solutions that ensure two important factors: providing resources and working effectively.

Cloud computing is a model for enabling ubiquitous, convenient and on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [1]. The Cloud eliminates the need to invest in hardware and spend time on the technical complications of managing this equipment as well, it frees the enterprises and their end users from the specification of many details, such as storage resources, computation limitation and network communication cost. However, this bliss becomes a problem for latency-sensitive applications, which require nodes in the vicinity to meet their delay requirements [2].

Accordingly, a new paradigm called “Fog computing” appeared recently extends the Cloud computing to the edge of the network, thus enabling a new breed of applications and services. Similar to the Cloud, Fog provides data, compute, storage, and application

services to end-users. However, Fog can be distinguished from Cloud by its proximity to end-users, the dense geographical distribution and its support for mobility. It provides low latency, location awareness, and improves quality-of-services for streaming and real-time applications [2]. These requirements deal with the Internet of Things (IoT) requirements that make Fog computing as the appropriate platform for it [3].

These technologies will bring several advantages in the management of business processes of companies, including optimization and automation that will ensure their agility and performance. Business process outsourcing (BPO) is one of the very few business tools available to managers with the power to transform their organizations. It enables companies to simultaneously re-engineer their existing operations and create a more flexible and adaptable organizational structure [6].

For better managing the outsourcing of business processes, companies must always have a complete and detailed view of their operations and their internal structure to identify those that require expertise from an external supplier. Business Process modelling can provide this vision, it consists of representing and structuring all the activities of a company based on a graphical modelling method.

A new generation of languages and tools for process modelling has appeared. Business Process Model and Notation (BPMN) is a standard for business process modelling that is very common in professional practice due to its expressiveness, the well defined meta-model and the possibility of workflow integration [18]. This standard focus on providing a comprehensive and integrated notation for business process modelling by giving graphical and informal notations targeted at analysts [7]. In addition, BPMN offers the possibility to reuse its kernel to benefit from its advantages and to avoid the expensive development of a domain-specific modelling language from the scratch by allowing the representation of additional concepts and attaching them to its original elements [20]. The processes of BPMN are assigned to services and executed later through workflow engines such as Business Process Execution Language (BPEL) [19].

Despite the various extensions proposed to define new specific-domains concepts (healthcare, IoT, manufacturing, CPS) using the BPMN language, the lack of a representation of some defined requirement that helps companies to define and recognise which BP to outsource and which environment (Cloud or Fog computing) to choose is needed. To fill the gap of which processes to outsource, we have defined the criteria of security, performance, compliance, cost and data storage that every company should consider it in the decision making of their outsourced BPs. Accordingly, we have proposed for each criterion a graphical representation added in the element "Artifacts" of the BPMN meta-model. Therefore, the proposed representation will help for sure the actors of the system to decide which environment between Cloud and Fog computing to consider it in outsourcing their BPs. The aim of this research is to propose a BPMN extension for BPO to the Cloud or Fog Computing based on some defined requirements.

The rest of the paper is organized as follow: Section 2 introduces some related work. Section 3 discusses the concept of outsourcing BPs. Section 4 shows the BPMN extension. Section 5 illustrates a use case of our BPMN extension in the telemedicine field. Section 6 presents the tools used to implement the proposed extension and Section 7 concludes the paper.

2 Related work

Every day, developers are searching for a unified and standard tool in order to allow companies to model their business processes (BPs) easily. Unfortunately, it is impossible to reach this aim and this goes back to a company's own requirements. Therefore, different languages in modelling BPs were developed where BPMN was the most used one thanks to its most feature that allows researchers to extend it according to their specific domain.

Several BPMN extensions were proposed to define a specific-domain. According to [8], BPMN was used to incorporate security requirements into Business Process Diagram, they considered that an explicit identification of them instead of using artifacts will facilitate modelling and will give security specialists a better interpretation.

While in [9], authors proposed a BPMN extension for evaluation and analysis of BPs. Therefore, the BPMN meta-model can be extended to include the performance details of business processes and business objects. In general, they used activities to represent the computed performance data after its execution and artifacts to provide other statistics and performance data about different objects such as organizational units and events.

Otherwise, in [10] authors proposed a BPMN extension for modelling Cyber-Physical Systems (called BPMN4CPS*)*, which provides a set of extensions for BPMN to enable designers to properly and accurately cater for CPS elements, concepts, and properties when modelling CPS processes. They defined CPS devices as technical process participants, the real-world information as the physical entities and their information that can be offered as a set of data objects, and then decomposing CPS business processes into several pools (the physical processes, the cyber processes, and the central controller) where each part has its own type of activities that can be performed.

The work in [22] studied the advances in Cloud computing and discussed the benefits of using Cloud services for businesses. They presented in the first part, a layered architecture for the virtual business proceeding it with a conceptual architecture for a virtual business-operating environment. In the second part, they discussed the opportunities and research challenges in realizing the technical components of this conceptual architecture. In last, they gave an outlook and impact of cloud services on both large and small businesses. This work did not mention any requirements for how to proceed to outsource BPs.

According to [23], they proposed an end-to-end framework entitled Business Process Outsourcing to the cloud (BPO2C), which covers the outsourcing process lifecycle, from the enterprise business concerns to select the appropriate business process to be outsourced, to a finer level of decision to select the business process fragments to be supported by the Cloud. This framework elaborates several phases pertinent to the outsourcing decision, starting from the elaboration of the enterprise business motivations to identify the implied business process in the outsourcing decision, to the identification of outsourceable process fragments to minimize the business process costs, duration and to mitigate cloud risks.

Accordingly, the work in [24] proposed an outsourcing decision method that relies on the analytic hierarchy process (AHP) to decide whether to outsource a business process to the Cloud or not and through which service type. The goal of this work is to enable enterprises to understand, self-assess, select and adopt an appropriate Cloud

computing service type that is aligned to their business context. Besides the enterprise context, they presented how the business motivation model (BMM) of the enterprise also enhances the outsourcing decision-making by taking into account the business plans and vision of the enterprise.

The work in [25] introduced a transformation-based approach that allows companies to control the parts of their business processes that should be allocated to their own premises and to the Cloud, to avoid unwanted exposure of confidential data and to profit from the high performance of the Cloud environments. They proposed in their approach that the user annotates activities and data that should be placed into the Cloud. An automated transformation generates the process fragments for the Cloud.

Although, the proposition made in [23], [24], [25] to outsource BPs and allow companies to benefit for, they did not consider the outsourcing of BPs in Fog computing environment that is became as an emergent solution nowadays, especially for the field of the Internet of Things. As well as, they did not take into consideration the requirements as compliance, security, cost, performance and data storage for outsourcing BPs.

Indeed, the existing solutions address the modelling of a specific-field using BPMN as the most adequate language for modelling BPs. However, companies need a way that helps them to recognise and control which BPs to outsource considering various and distinct requirements. Moreover, they must have the ability to choose the appropriate Cloud or Fog computing environment for outsourcing their BPs. To deal with, we have proposed a BPMN extension that verifies the requirements of security, compliance, cost, performance and data storage that enables companies basing on these requirements to decide which provider is suitable for their BPs.

3 Business Process Outsourcing

In this section, a general overview about the outsourcing of business processes had been presented, as well as the outsourcing towards the Cloud and Fog Computing. In the following, the criteria that a company must consider it when outsourcing its BPs had been discussed. Then, an extension of the domain based on BPMN Meta-model annexed to its representation in XML schema were presented. Finally, the added graphical elements were classified in a table with their appropriate descriptions.

3.1 Principle of outsourcing

In general, BPO means moving internal business processes to external service providers to manage it based on an agreed upon service level agreements. It might be done with one or more service provider who will execute the transferred processes based on the client's requirements [11]. Therefore, it implies for this purpose a closer and lasting collaboration link between the company and the service provider.

3.2 Outsourcing business processes to Fog/Cloud Computing

The concept of Cloud Computing has made an interesting development in the field of business process management that is especially appreciated by small and medium-sized businesses. This latter have now access to a larger computing resources and a powerful

infrastructure that they would never have dared to afford before. However, the explosion of data, devices, and interactions, the Cloud architecture alone cannot handle the flow of information. Thus, its centralized resources can create delays and performance issues for remote devices and data in a centralized public cloud (data center). Therefore, Fog Computing is another type of solution that companies can take into consideration to outsource their business processes by avoiding these problems. The major benefit of this solution for businesses is that it gives a new perspective to Internet of Thing (IoT) for real-time data processing.

The IoT can be integrated into operational business processes of such companies in order to offer a better user experience for their customers and their collaborators. In Table 1, we present a set of differences between Cloud and Fog computing that companies should consider it when outsourced their BPs:

Table 2. Cloud vs. Fog Computing

Requirements	Cloud Computing	Fog Computing
Response time	Less speed	Faster
Number of server nodes	Little	Very large
Traffic on the network	More transfer	Less transfer
Security	Less secure	Safer
Compliance	Less compliant	More compliant
Performance	Less performant	Performant
Data Storage	Huge	Limit

3.3 The proposed criteria for BPO

Before outsourcing their business processes, companies must consider a set of criteria to ensure that they choose the right vendors to manage their processes. The criteria that we have considered are:

Security: Security issues are a major concern for companies that want to outsource their business processes, because they find it very difficult to trust a third party to manage their processes and view their data. Outsourcing business processes with its many benefits can be a real security disaster for businesses, so companies should consider it during the entire outsourcing process.

Compliance: the term "Compliance" is a commonly used to refer to compliance with a set of laws, regulations, policies or best practices. It consists of ensuring that business processes, operations and practice comply with a set of prescribed and / or agreed standards. Compliance requirements may come from legislatures and regulators (Sarbanes-Oxley, Basel II, and HIPAA), standards and codes of practice (SCOR, ISO9000) and from business partner agreements [12]. Compliance with these different regulations can be costly in the event that the company does not respect these rules because of the fines imposed on them.

Cost: Outsourcing business processes has become an easy and cost-effective technique because it allows companies to control costs and do their jobs at a very low cost. Each

provider has its own financial offers to companies, some of which may be expensive and others may be cheap. This is why companies must choose the provider whose offers match their financial capabilities.
Performance: Outsourcing business processes can optimize them and improve overall performance in terms of time that is why companies should choose the best performing services.
Data Storage: Companies can outsource data storage because it is cheaper to contract a third party than to buy and maintain their own data storage, devices and facilities. Therefore, it becomes easy to access to this data and use it at the right time and without restrictions. Thus, companies need to consider the data storage they need before choosing the provider who will manage their business processes.

4 BPMN extension

Two representations for extending elements in BPMN are defined in the official documentation of the Object Management Group (OMG) [21]:

- The BPMN meta-model: it consists of four elements (Extension, ExtensionDefinition, ExtensionAttributeDefinition and ExtensionAttributeValue).
- The XML Schema representation: it specifies the interchange format for BPMN models and support the definition of complex extensions that can be processed by BPMN tools.

4.1 BPMN extension based on a meta-model

Business Process Model and Notation (BPMN) provides a mechanism that guarantees the validity of BPMN basic elements and allows the integration of new domain-specific concepts. BPMN extension is the reuse of BPMN kernel to take advantage of its advantages and to avoid the expensive development of a domain-specific modelling language [13].

Meta-model for structuring BPMN elements.
A meta-model is a formal definition of a model that helps to understand it and facilitates reasoning about its structure, semantics, and usage [14]. BPMN describes all of its elements in a class diagram, which is the meta-language for it [15].

BPMN Extension for BPO.
Using the meta-model of BPMN, we have proposed a BPMN extension for BPO (Fig. 1) by adding new concepts related to our domain that are the criteria discussed in (section 3.3). Therefore, we used the element Artifacts of the BPMN meta-model to integrate these requirements. Accordingly, the requirements of security (CIA triad: Confidentiality, Integrity, Availability), Performance, Cost (Cost of execution, Cost of data transfer) and Compliance were affected to Activity element while Data storage requirement concerned Data store element. This latter is used to express the necessary data storage that a company may need to store data during BPs execution.

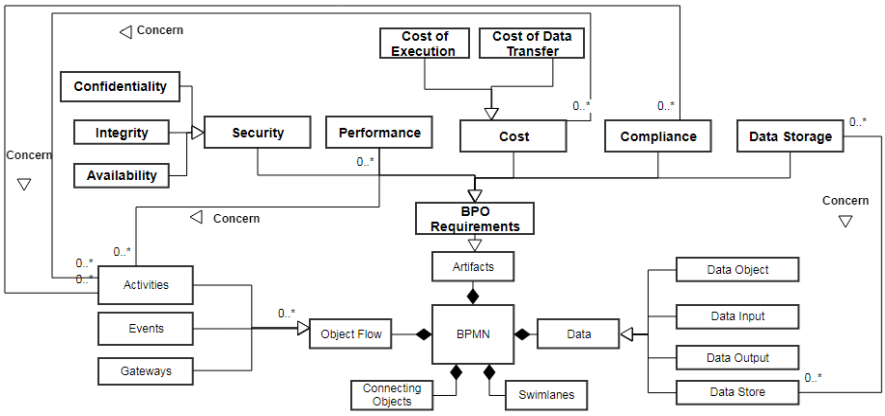

Fig. 1. An extended meta-model of BPMN for BPO.

Representation of the extension in XML Schema format.

For BPMN representation, BPMN defines a set of XML schema documents specifying the interchange format for BPMN models. Thus, to model and exchange BPMN models that include state transitions and nodes, we derive an XML schema for our extension:

```
<? XML version= "1.0" encoding="UTF-8”?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
<xsd:element name=" BPOcritaria” type=" BPOcritaria Type"/>
<xsd:complexType name=" BPOcritaria Type">
<xsd:all> <xsd:element name=”Security” minOccurs=”0 ”>
<xsd:complexType> <xsd:sequence> <xsd:restriction base=”xsd:string”>
<xsd:enumeration value=”Availability”/> <xsd:enumeration value=”Confidentiality”/>
<xsd:enumeration value=”Integrity”/>
</xsd:restriction> </xsd:sequence></xsd:complexType></xsd:element>
<xsd:element name=”Compliance” minOccurs=”0”>
<xsd:complexType> <xsd:sequence>
<xsd:element name=”rule” 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”>
<xsd:complexType> <xsd:sequence> <xsd:restriction base=”xsd:string”>
<xsd:enumeration value=”Cost of execution”/><xsd:enumeration value=”Cost of data transfer”/>
</xsd:restriction></xsd:sequence><xsd:simpleContent>
<xsd:extensionbase=”xsd:decimal”>
<xsd:attribute name=”money” type=”xsd:string” use=”required” />
</xsd: extension></xsd: simpleContent></xsd: complexType></xsd: element>
<xsd:element name=”Performance” type=”xsd:duration” minOccurs=”0” />
<xsd:element name=”Data storage” type=” xsd: decimal” minOccurs=”0” /></xsd:all>
```

Fig. 2. XML schema for the proposed BPMN extension.

The graphical elements added in the extension.

The BPMN specification provides no graphical notation for the representation of extensions. However, new graphical shapes can be added as artifacts. Thus, a set of graphic elements to annotate the activities of BPs are proposed, as well as for the data store. In table 2, the graphical representation of the proposed extension on the Activity and Data store elements of BPMN meta-model followed by their descriptions are presented.

Table 2. Graphical representation of the proposed BPMN extension.

Criteria		Graphical elements	Description
Security	**Confidentiality**		This element is used when the activity ensures that only authorized entities have access to resources.
	Integrity		This element is used when the activity ensures that the data has not been tampered with/or destroyed in an unauthorized manner.
	Availability		This element is used when the activity ensures that access to resources is possible when needed, and that resources are not uselessly occupied.
Compliance			This element indicates that the activity must comply with the rules and / or standards.
Cost	**Cost of execution**		This element indicates the cost of carrying out an activity; the red, yellow and green colours represent the activities that require a high, medium and low execution cost, respectively.
	Cost of data transfer		This element is used to indicate that an activity requires some cost to transfer its data to another activity.
Performance			This element is added when the activity requires a lot of performance to work efficiently and to respect the temporal constraints.
Data Storage			This element is added when data storage occurs while performing an activity. Alphabets H and L represent Huge and Lower data storage, respectively.

5 Use case

For organizations that want to increase productivity by improving business process management, a superior Business Process Management System (BPMS) is required. BPMS provides a suite of tools that gives organizations the ability to design, test, and implement automated business processes by facilitating the efficient simulation of the life cycle of a business process for a very precise implementation [16]. In this section, the BPMN extension for BPO has been demonstrated through an illustrative example followed by a set of BPM tools that allow implementing it.

5.1 Illustrative example of the telemedicine system

What is telemedicine?
Telemedicine (healing at a distance), signifies the use of information and communication technologies (ICT) to improve patient outcomes by increasing access to care and medical information [17]. In our example, the telemedicine system consists of the following actors:

- **Patient:** represents the person who needs health care.
- **Server:** represents the intermediary between patient and doctor and it processes the patient's data.
- **Doctor:** A medical expert who communicates with the patient and receives information about the patient in order to give him a solution to his health problem.
- **Medical device:** Any device, equipment or material used alone or in combination with humans for the treatment of a disease.

Representation of the process using the BPO extension.
In Fig. 3, an extended version of the telemedicine process using the proposed elements has been illustrated to represent BP requirements for outsourcing into the Cloud and Fog computing environments, which are Security, Compliance, Cost, Performance and Data storage. Associating with each activity the requirements that it may need during its execution.

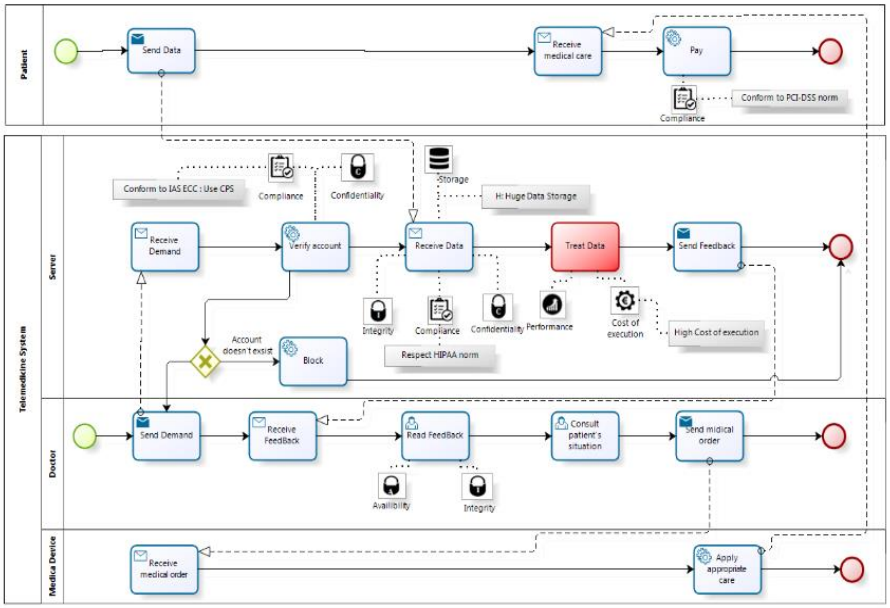

Fig. 3. Modelling the telemedicine process using the BPO extension.

Discussion on the outsourcing of the process.
Using the BPO extension, we can classify the activities in the example (Fig. 3) according to the provider that suits them Cloud or Fog Computing:

- **Pay:** The appropriate provider for this activity is Fog Computing, as it must comply with the PCI-DSS standard that protects the patient's bank account to prevent fraudulent use because of privacy.
- **Verify Account:** The environment for this activity is Fog Computing because it must comply with the IAS ECC standard by the use of a professional health card (CPS) that guarantees a high level of system security.
- **Receiving data:** The appropriate environment for this activity is Fog Computing because this activity requires high-level of security and must comply with the HIPAA standard that protects patient's data.
- **Treat data**: We can migrate this activity to Cloud computing because it requires a great performance.
- **Read Feedback:** The appropriate environment is Fog Computing because it requires security (Availability and Integrity), the purpose of which is to prevent the unauthorized use, alteration, or misuse of patient's data and guarantees access to the patient's information when it needs.
- **Send demand**, **Consult patient's situation, Send medical order, Receive medical order and Apply appropriate care**: These activities remain in the company to avoid outsourcing its key operation aspects because they represent the heart of the business.

6 Implementation

Several BPM tools are used to model extensions, the proposed extension had been implemented by using three tools, which are Bizagi Process Modeler, Gliffy Diagram and yEd Graph Editor. Each tool gives the ability to add new Artifacts for the proposed extension that are Security, Compliance, Cost, Performance and Data storage without changing the shape of existing elements. In this section, tools that were extended to allow the use of the proposed extension are presented as follow:

1. **Bizagi Process Modeler** is an application for modelling and documenting business processes. The tool allows us to visually map, model and document business processes in the Business Process Model Notation (BPMN) standard [26] (Fig. 4**):**

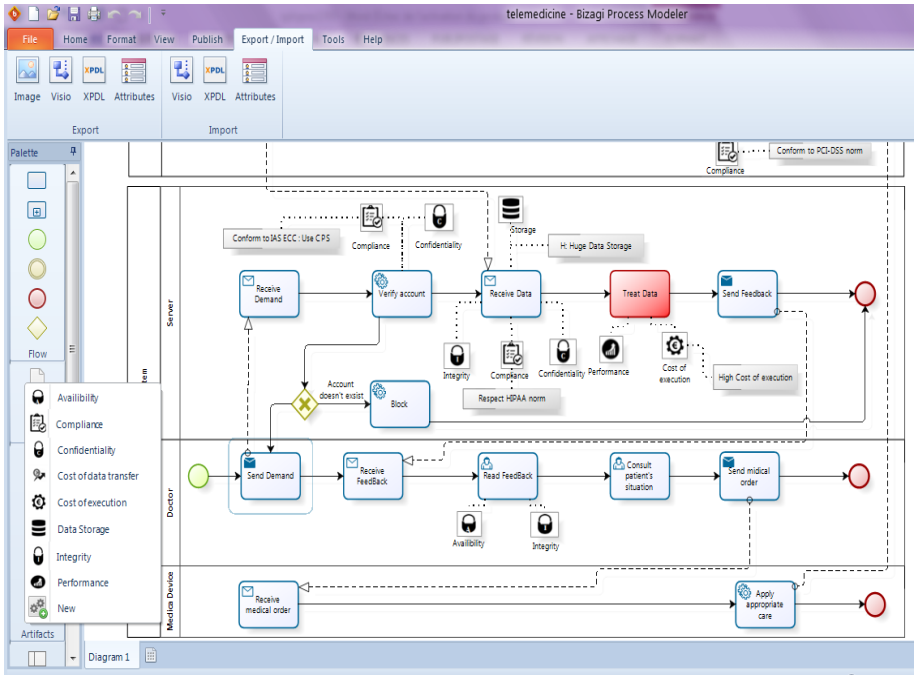

Fig. 4. Bizagi Process Modeler.

2. **yEd Graph Editor**: is a powerful desktop application that can be used to quickly and efficiently generate high quality diagrams [27] (Fig 5)**:**

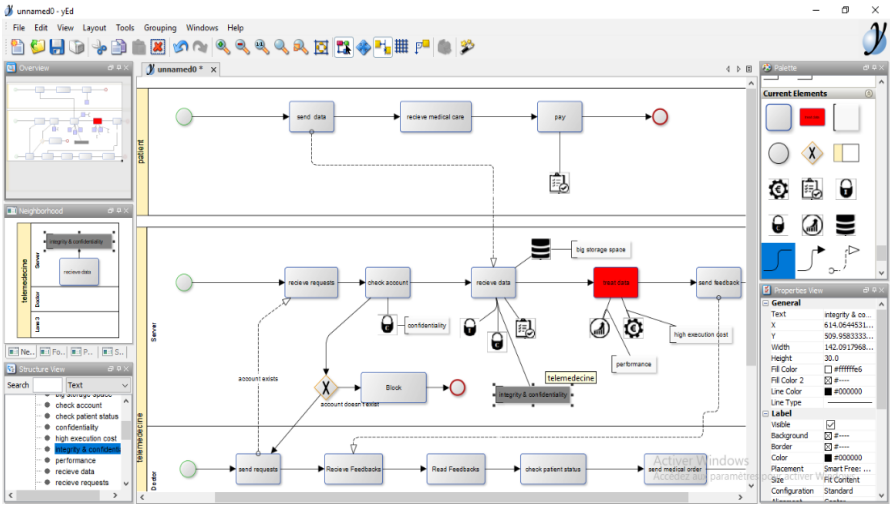

Fig. 5. yEd Graph Editor Diagram.

3. ***Gliffy* Diagram**: is a diagram software through a cloud-based HTML5 application. It is used to create UML diagrams, floor plans, Venn diagrams, flow charts and various other types of online diagrams [28] (Fig. 6.).

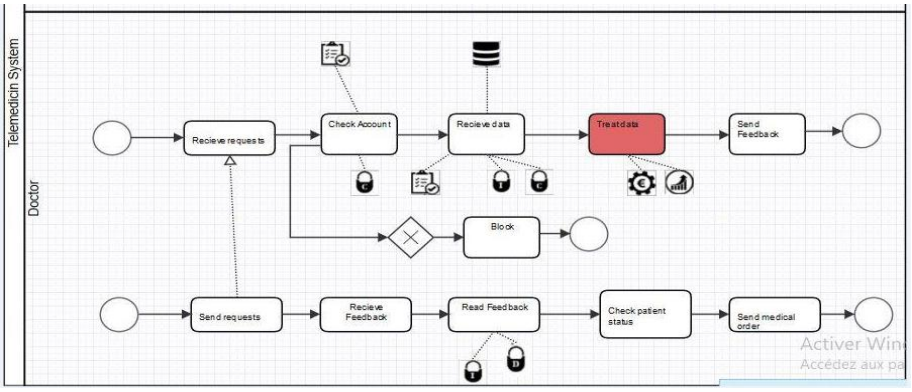

Fig. 6. Gliffy's Diagram.

3. Conclusion

Business Process Outsourcing is a medium-term strategic approach for companies to maintain a high level of performance, a lower operating cost, focus on the core business and flexibility. However, outsourcing is not a decision to take lightly; it requires careful thought and management as a mistake in this area can be costly both financially and humanly and it is very difficult to reverse. The difficulty of outsourcing management is related mainly to the difficulty of choosing the ideal provider for the required service

Cloud or Fog computing. On the other hand, we argue that the model is not universally applicable, and that emergent IoT applications demand a platform with novel characteristics as Fog computing [3].

In this paper, it was proposed an extension of the BPMN language considering our main objective was to improve and assist companies for a better decision in outsourcing the adequate BPs. The requirements of BPs activities of this latter were specified according to several criteria that are Security, Performance, Compliance, Cost and Data storage. Our extension was developed using two representations provided by the BPMN extension mechanism that are the BPMN meta-model and the XML Schema. We completed the model by adding new graphical elements into a modelling tool. Finally, we chose the telemedicine system to explain our proposed extension and to express its decision-making role in choosing the right provider.

As a complement to this work, we wish to apply our approach in the field of the Internet of Things, based on the criteria presented in our BPMN extension to facilitate the selection of the best provider (Cloud or Fog computing). We wish also to compare the suppliers Cloud or Fog once the adapted environment is determined .Thus, we aim to consider other criteria for outsourcing BPs besides the criteria presented in our paper and we discuss the case of changes in processes requirements. Finally, we look at whether there is a possibility to extend other tools.

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