Business Processes Compliance in Partially Observable Environments

Isabel Silva, Pedro Sousa and Sérgio Guerreiro

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Isabel Esperança[1], Pedro Sousa[1,2,3], Sérgio Guerreiro[1,2]

[1] *Instituto Superior Técnico, University of Lisbon, Av.Rovisco Pais 1, 1049-001 Lisbon, Portugal*
[2] *INESC-ID, Rua Alves Redol 9, 1000-029 Lisbon, Portugal*
[3] *Link Consulting SA, Av. Duque de Avila 23, 1000 Lisboa, Portugal*
isabel.esperanca@tecnico.ulisboa.pt, pedro.manuel.sousa@tecnico.ulisboa.pt, sergio.guerreiro@tecnico.ulisboa.pt

Abstract. This paper addresses how to design and implement business process compliance through observing the business process instances and controlling the business process models, considering environments that are only partial observable. An organization is a dynamic system where actors assume roles and produce results and decisions autonomously, changing the overall state of the system. These decisions often occur in environments that are not fully observable. In order to face restrictions such as market demand and legal impositions, organizations need to come up with innovative solutions by optimizing their business transaction models. This process allows them to assist in decision-making processes. The business process models are intended to represent an organizational reality and restrict the freedom of design to allow common understanding between stakeholders and to define the roles of the actors. Therefore, organizations need to ensure that operational processes are performed in a controlled way to meet predefined requirements, complying with regulations, laws and agreements established between internal and external stakeholders. The solution is implemented using an enterprise simulation environment, named as Enterprise Cartography(EC). The results obtained demonstrated the ability to observe and control the process instances as a contribution to improving the compliance of business process.

Keywords— Compliance, Enterprise Cartography, Business Process Models, Development process, Observation, Control

1 Introduction

An organization includes a network of people and machines that work and communicate in an integrated way. While organizations operate to meet optimization requirements to increase their effectiveness and efficiency, unexpected endogenous and exogenous situations occur continuously. It is the case of requirements, social and legal changes. The control and management functions are responsible for optimizing the use of runtime resources. These functions, which must conform to predefined restrictions on individual and collective runtime observations. This organizational activity can be divided into three intervals: ex-ante: what happens before execution of business process; ex-dure: what happens during execution; and ex-post: after the executions. This phase includes decision-making processes to estimate future behaviour from the data available from past executions. Integration of these three time intervals provides a complete description of control of organizational behaviour and leads to the problem that organizations have an incomplete understanding of the facts and yet, have to make ex-post organizational decisions based on information collected in partially observable environments. This occur when not all transaction states information is available. This problem is recognized with high impact in the health industries, financial, public administration, etc. The problem addressed by this paper - to design and implement business process compliance through observing the business process instances and controlling the business process models, considering environments that are only partial observable - will be solved taking into account the scientific contributions of EC. The solution consists in enforcing observation and control business process instances using Atlas tool and a business process model, modelled in BPMN. The outline of the rest of the paper is as follows. In Section 2, we present the methodology. Section 3 deals with theoretical concepts and in particular EC, which we apply to build the solution. Related work is presented in Section 4. Section 5 present the Solution Proposed in order to explain the problem to be solved using Atlas tool and Blueprint. Section 6 and 7 contain Demonstration and Validation of the research presented. Concluding remarks and some future research questions are given in the last section.

2 Design Science Resources Methodology

This investigation use Design Science Resources Methodology(DSRM). DSRM consists of an interactive process with six steps and includes rigorous methods for the creation and evaluation of the proposed artefacts[11]. The following steps are: i) identify the problem in the business process models domain, using a simplified case study; ii) how to design, implement and manage a solution in EC for business process compliance; iii) model a solution using Blueprints; iv) using artefacts to obtain business process compliance; v) verify and validate in business simulation environment; vi) contribution in the community, like publications in scientific papers. Figure 1 shows DSRM steps.

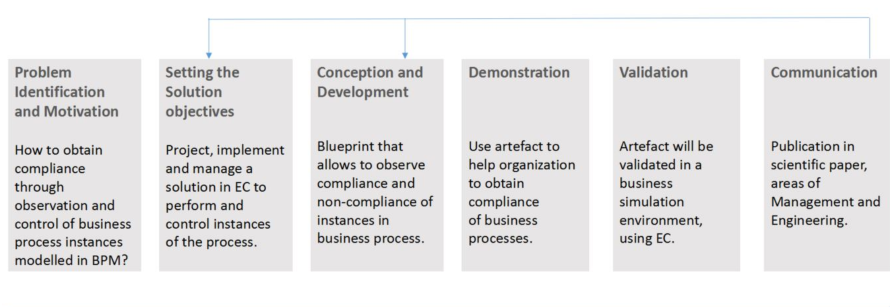

Figure 1: DSRM process adapted from Peffers et al[11]

3 Background

3.1 Enterprise Cartography

An organisation can be abstracted as a dynamic system where a network of actors collaborate and produce results that can be depicted using cartographic maps[2]. Actors collaborate with each other over time, creating a dynamic collaborative network and produce autonomous behaviours that can change the overall state of the system. Actors can be classified as humans or computers. This network runs within a domain where the independent actors behave towards a future state of affairs and thus produce events, some of which may be unexpected. The change produced by a human being can only be observed after the completion of the action. EC is fundamental to managing the transformation processes of an organization.
Transformation is seen as the set of initiatives that change the current state to an intended state. The two states span organizational variables at different points in time. The as-is status represent variables that have changed due to past events, the to-be state represents an expected state configuration of the organizational variables. Between these two states the organization reacts to other events triggered by the operation of the transformation processes. It is important to observe and manage the organization during the transition of states, even if some of the events may not be related to the transformation activity because it can condition the transformation process by diverting the organization from the objectives. Cartography is an abstraction process that systematically and consistently transforms an observation of reality into a map or a graphical representation. The production of a map embraces many different concerns, including scientific, technical, and purely aesthetic. EC denotes the discipline that deals with the conception, production, dissemination and study of the maps of an enterprise to support its analysis and collective understanding[2].

3.2 Business Process Compliance

Compliance verification is a very current issue of great importance in communities to management and auditing business process, due to the availability of event data on one hand and by the other hand, due to changes in legislation[4]. Compliance means to ensure that business practice and processes are aligned at commonly accepted norms[5]. Organizations need to ensure that operational processes are run in a controlled manner, as deviations can expose the organization to serious risks and incur high costs. In order to meet predefined requirements, complying with the regulations, laws and agreements established between the internal and external actors of the organization. In this way, organizations need to continually check whether processes, supported by information systems, are executed within a set of limits. The deviations can be pointed out as negligence, frauds, risks and inefficiencies. Increasingly, organizations are subject to laws and regulations, in compliance with contractual standards and obligations and there is a need to optimize response times for processes subject to these guidelines. At the same time technological advances offer an increasing opportunity to systematically observe processes at a detailed level, with a record of all relevant events in the process. However, increasing computerization of business processes increases opportunities for alternative solutions. Employees use alternative solutions to deal with poor technology and process performance. Information Systems also increase the risk of illusion of control, which means that information systems present information that does not reflect the actual instances of the process[10].

3.2.1 Actor

Actors of an organization are the fundamental part of a company and are organized in social systems (Winograd, T. 1986). An actor is usually associated with a person but can be a machine. An actor performs several activities over time. For the performance of an activity, an actor explicitly or implicitly fulfils a certain role. In company can coexist individual and collective views of the same reality. These actors are endowed with their own will and freedom of action, acting according to their purpose and orchestrations[16]. They are therefore autonomous in deciding what to do next. In companies, some tasks can be automated by software systems, while others are performed by human actors.

3.2.2 Model and instance of a business process modelled on BPM

"Business Process Management (BPM) is the art and science of overseeing how work is performed in an organization to ensure consistent outcomes and to take advantage of improvement opportunities. In this context, the term “improvement” may take different meanings depending on the objectives of the organization. Typical examples of improvement objectives include reducing costs, reducing execution times and reducing error rates. Improvement initiatives may be one-off, but also display a more continuous nature. Importantly, BPM is not about improving the way individual activities are performed. Rather, it is about managing entire chains of events, activities and decisions that ultimately add value to the organization and its customers. These “chains of events, activities and decisions” are called processes."[9]. Business process as a collection of inter-related events, activities and decision points that involve a number of actors and objects, and that collectively lead to an outcome that is of value to at least one customer. Figure 2 depicts the ingredients of this definition and their relations. BPM involve different phases and activities in the life cycle of the business process. It is necessary that the previously designed models be implemented in systems (manual, semiautomatic or automatic) and be contained in the organization, so that they can be instantiated later[16]. The instantiation occurs when actors perform their activities throughout the day. It is the multiple instances of the business process, occurring concomitantly, that reveal the existence of the organization on a day-to-day basis. A business process model defines which roles of the actors are involved in each transaction state. It is these same actors who instantiate the transaction states of the business process. In the same way that business process models can be represented, the instances of business processes can also be represented, making it possible to observe if any of the instances of the business process is not respecting the prescription of the model. The functions of organizational control should be invoked whenever the model is not observed. IT specialists see BPM as a way of communicating with various parts of the business through a common language.

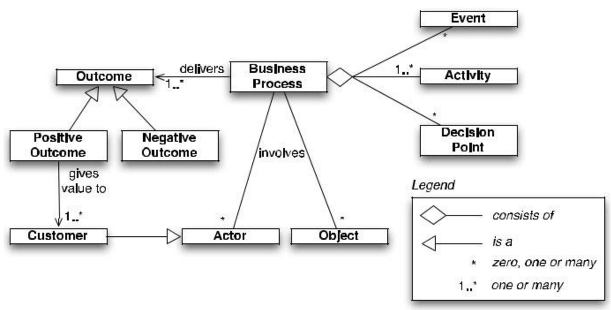

Figure 2: Ingredients of a Business Process[9]

3.2.3 Observation

Observation is one of the stages of the scientific method and consists in understanding, seeing and not interpreting. And it refers to the action and result of observing something or someone. In control of dynamic systems, Franklin et al. (2009) state that "...a system is completely observable if each system state variable affects some of the outputs. Many times, it is desirable to obtain information on the state variables of the output and input measurements. If any of the states cannot be observed from the measurements of the outputs, the state is said to be unobservable and the system is not completely observable or simply unobservable ... ".

3.2.4 Control Actions

In a system there are two type of control variables, those who are controllable and those that are not controllable. Franklin et al.(2009) refers "...a process is named fully controllable if each state variable of process is controlled to achieve a certain objective in finite time by a control u(t) without restrictions. If any of the state variables are independent from control u(t) meaning that there is no way to act, in finite time from that state variable to the desired state. Therefore, this state in particular is denominated as uncontrollable, so the system is called not totally controllable or simply uncontrollable."

3.2.5 Time

Shewhart (1980) proposes a control cycle of a system, composed of the classical sequence PDCA: i) intelligence to observe an organizational problem. ii) the design of potential solutions. iii) the choose of best solution. iv) implementation of the solution and verification if it satisfies the fulfilment of the intended objectives. Among the different control activities there are time delays, for example, when a controller decides for a control action u(t) this is based on observations from the past. y(t-1), y(t-2), ..., y(t-1), and (t-n). This means that when the control u(t) is triggered, it may no longer be valid in the operational reality of the system to be controlled. Conceptually, everything that happens before the execution of business processes is called ex-ante, for example, the prescription of business processes. What happens after the execution of business processes is called an ex-post, relating, for example, to the reaction that is needed when something unexpectedly occurs. The decision processes on the most correct action u(t) to be taken consider the ex-ante models of the business processes as a control reference to be followed.

3.2.6 Control Pattern

The goal of the control is to allow the operation of the business process instance(s) to be conducted, using a limited effort to a stable state previously defined by the organization[16]. And being able to react to the exogenous and endogenous changes and disorders that are occurring. In conceptual terms, Kuo (1995) defines the stability of a system as "...considering the response of a system to inputs or perturbations: a system that remains in a constant state, except when it is affected by an external action, but is capable of returning to the initial constant state soon after this external action is removed then can be considered stable...". The classic patterns for a control system are shown in Figure 3.

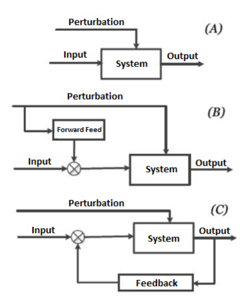

Figure 3: Design patterns of a control system[16]

In (A) a system is presented as not controlled. The disturbance always affects the output delivered by the system. In this model, the behaviour of the output system cannot be guaranteed. In (B), a forward feed pattern is shown, showing that the system input changes according to the disturbance. Thus, the specific dynamics of the system are not included in the control action. At the bottom of the image, at (C), a feedback control pattern is shown, which calculates the input of the system according to the actual misalignment obtained between the output and the input. In this case, the calculation of actuation control takes into account the disturbance of the system dynamics. Thus, the output of the system depends on the perturbation applied in the system and on the dynamics of the system itself. Based on the definitions of the control standards, we can conclude that in order to obtain a control system that produces the expected results, it is necessary to provide observation and performance capabilities in the system to be controlled.

4 Related Work

Approach 1: MDP and DEMO The article propose a novel approach to elicit the set of business rules that optimize the value function of business transaction operations, combining the theory of Markov decision process (MDP) with the DEMO business transaction space. Following the general system theory and DEMO the three fundamental dimensions for a business transaction space are considered: State space, representing the set of allowable states of a system; Transition space, representing the set of allowable sequences of transitions of a system; Actor role space, representing the set of allowable competences, authorities and delegations of a system[12]. **Conclusion:** During operation, the business rules are the component responsible to decide which control action to take: the controller. Decisions are supported by the observed variables, and are implemented by the control variables. However, organizational steering is most of the time considered as an independent and isolated organizational add-on component that reacts according with the behavior of the part of the organization that is supposed to control. Moreover, elicitation of the business rules is usually an intuitive and error-prone process. This is refer due to the organizational complexity, these actual approaches are insufficient because it is impracticable to preview the results of a given business rule without using supporting simulation tools to aid the process-decision.
Approach 2: Risk and DEMO The article, aims to propose an innovative risk-based approach supporting compliance in complex business processes. Business transaction model is the result of applying design constraints for a particular organizational reality, valid over a given period of time, and are useful to share a common understanding between the stakeholders that have a diverse interpretation of it. DEMO theory and methodology introduces capabilities to deal rigorously with the dynamic aspects of the process-based business transactions using an essential ontology that is compatible with the communication and production, acts and facts that occur in reality between actors in the different layers of the organization[8]. **Conclusion:** Business transactions prescriptions are fundamental to represent and share a common understanding between the different stakeholders of an organization. However, due to the raising complex-

ity, and fast changing pace of the surrounding environments, many risks occur during business operations. When managers get aware about a change in the operational conditions, it is often too late to enforce a change in the business transactions prescriptions. Therefore, a new business process compliance solution, able to evolve along with the real-time occurrence of risks, is needed.

5 Solution Proposed

5.1 Atlas

Atlas is a EC tool that supports the organizational transformation of an organization. Atlas is an automation-based solution to enable efficient management of Enterprise Architectures. It enables organizations to: i) Capture information from enterprise repositories, tools, files and human input into a consolidated repository providing a conciliated and view of the organization. ii) Create, customize and analyze repository Data, Architectural Blueprints, Reports and Analytics. iii) Time-travel. The proposal for the solution is made using the Atlas tool, a commercial tool that is used in several medium and large corporate architectures[2].

5.2 Problem Clarification

In order to explain the problem to be solved, we used the process modeling in BPMN, view Figure 4. This process was created by the company where our case study focuses, Link Consulting.

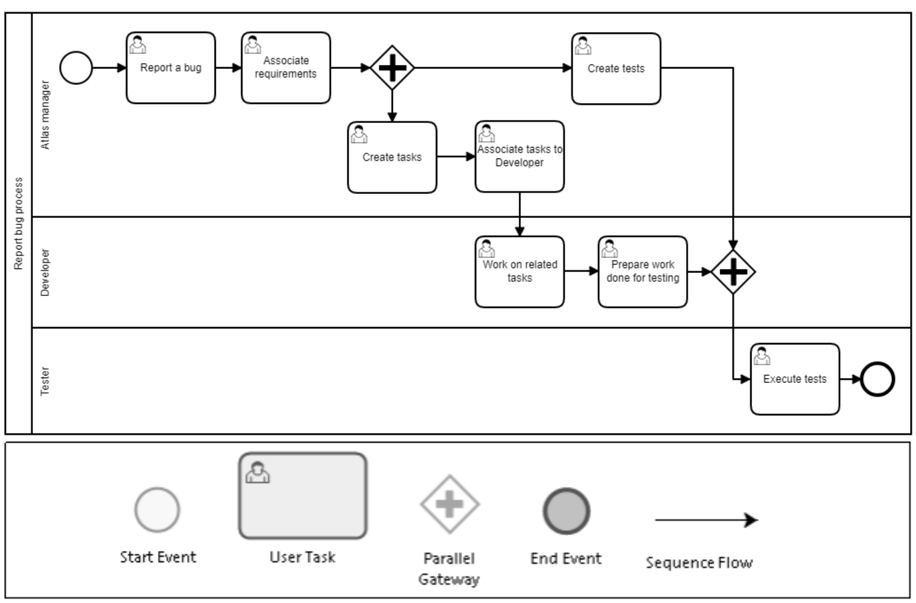

Figure 4: BPMN Process Report a Bug

Figure 5 shows the Form, produced by the Atlas tool. Whenever an actor find a bug, he must register it through the Bug Form.

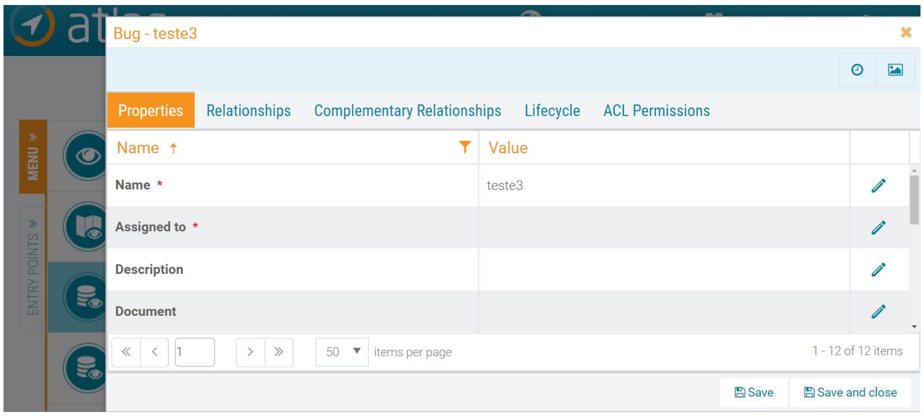

Figure 5: Form Report a Bug

An actor in this context can be an Atlas manager, a programmer or a tester. Registration of Bugs allows that the company has a repository of the bugs found and reported by the actors; and give to company the ability to observe at any time current state of a particular Bug by actor.

5.2.1 Transaction states

When the instances of the Report a Bug process are executed, they go through three states: **ex-ante**, it refers to the state of the process instances before it is executed; **ex-dure**, during the execution of the process instances and **ex-post**, after executing the process instances. It is during the ex-dure phase (execution of the process instances) that noncompliance can occur. Non compliance relate to non-fulfilment of rules or restrictions. The restrictions correspond to the business rules identified by the company and serve to ensure compliance in the execution of the instances of the business process.

5.2.2 Activities of Report a Bug process

Description of the activities of Report a Bug process during transaction states and mapping, according to decision rules, show in Figure 6.
State ex-ante: an actor identifies a Bug.
State ex-dure: the actor enters in the Atlas tool and accesses the Form to report a new Bug. The associated activities of the Report a Bug process are:
Activity Report a Bug Restrictions: The actor must fill the properties (fields): Start Date and the field State: On Going.

Activity Associate Requirement Restrictions: The actor must fill the property (field) Requirement.
Activity Create Task Restrictions: The actor must fill the property (field) State: Start.
Activity Associate Tasks To Developers Restrictions: None.
Activity Work On Related Tasks Restrictions: None.
Activity Prepare Work Done For Testing Restrictions: The actor must fill the property (field) Tests.
Activity Create Tests Restrictions: The actor must fill the property (field) State: Validated.
Activity Execute Tests Restrictions: The actor must fill the property (field) State: Finished, if the task is completed; or Rejected if the task is not completed.
State ex-post: after the process instances are executed. The compliance and non compliance that occur during the execution of the instances of the Report a Bug process, ex-dure, but it's only observable after the execution. From the activities identified above, those in which there are no restrictions are considered as unobservable activities: Associate Tasks To Developers and Work On Related Tasks. Then we can assume that we are dealing with a partially observable environment because not all state information is available.

			RB_StarteEvent	RB_Report Bug	RB_Associate Requirement	RB_Create Tasks	RB_Associate Tasks to Developers	RB_Work on Related Tasks	RB_Prepare Work done for Testing	RB_Create Tests	RB_Execute Tests	RB_TerminateEvent
Activity				x	x	x	x	x	x	x	x	
Event			x									x
Property	Name / Assigned to (*)			x	x	x	x	x	x	x	x	
	End Date										x (red)	x
	Owner			x	x	x	x	x	x	x	x	
	Requirement				x (red)	x	x	x	x	x	x	
	Start Date			x (red)	x	x	x	x	x	x	x	
	State	Start				x (red)	x	x	x			
		On Going		x (red)	x							
		Finished									x/or (red)	
		Validated								x (red)		
		Rejected									x/or (red)	
	Tests								x (red)	x (red)	x	

Figure 6: Matrix of Decisions Associated with Report a Bug Activities. In Red: Compliance restrictions

5.3 Conception and Development

The proposed solution is to create an artifact - Blueprint, which allows to show the compliance and non-compliance that occur during the execution of the instances of the Report a Bug process, by actor.

1. Create Class SystemBPMN

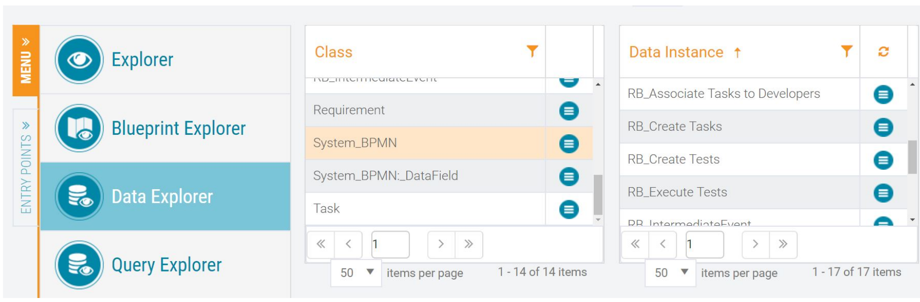

Figure 7: Class SystemBPMN and instances from process Report a Bug

2. Creation of Blueprint in ERML language, using the Atlas tool.

Algorithm 1: All Instances Algorithm

```
Data: All Bugs
Result: List of compliance bugs and non-compliance bugs from all instances
begin
    if (instance = "Report A Bug") then
        if (Start Date != NULL) and (State == On Going) then
            Compliance = TRUE;
        else if (Start Date == NULL) and (State == 0) then
            Compliance = FALSE;
    end
    if (instance = "Associate Requirements") then
        if (Requirement != NULL) then
            Compliance = TRUE;
        else if (Requirement == 0) then
            Compliance = FALSE;
    end
    if (instance = "Create Tasks") then
        if (State == Start) then
            Compliance = TRUE;
        else if (State == 0) then
            Compliance = FALSE;
    end
    if (instance = "Create Tests") then
        if (State == Validated) and (Tests != NULL) then
            Compliance = TRUE;
        else if (State == 0) and (Tests == 0) then
            Compliance = FALSE;
    end
    if (instance = "Prepare Work Donw for Testing") then
        if (Tests != NULL) then
            Compliance = TRUE;
        else if (Tests == 0) then
            Compliance = FALSE;
    end
    if (instance = "Execute Tests") then
        if (State == Finished or State == Rejected) and (End Date != NULL) then
            Compliance = TRUE;
        else if (State != Finished or State != Rejected) and (End Date == 0) then
            Compliance = FALSE;
    end
end
```

3. Blueprint

In the IT domain, blueprints have always been perceived as an important asset, especially by the IT Architecture teams or departments. As in any complex system, enterprises would be better understood if one could have a Blueprint (schematic representation)[7]. They represent a common ways of communication between people, namely to express an architectural description of things, like a system, an object, a model or, in our case, an Enterprise[7]. Figure 8 show Blueprint from actor Miguel Correia. Blueprints are automatically generated and represent the compliance and non-compliance of the instances of the process Report a Bug. And a time bar allows traveling into transaction states: the past (ex-ante), to the present (ex-dure) and to the future scenarios (ex-post).

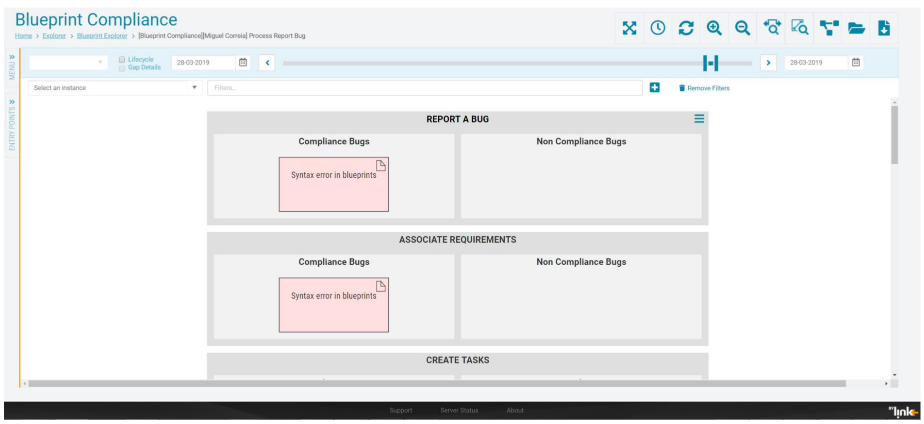

Figure 8: Blueprint Canvas page

6 Demonstration

In this section we present the case study that follows within a business simulation environment. A solution developed in EC was used to provide observation and control of the instances of the Report a Bug business process. The approach used in the design, development and implementation of the solution was based on the methodology DSRM[11]. The application in real context, from this solution, aims to provide the company with greater compliance in the business process instances, at run-time: ex-dure. The compliance achieved by complying with the predefined restrictions allows the organization to have a better understanding of what is going on in the company, rewarding it in decision making. Memory of the past state (as-was) and the future state (to-be) define the behaviour of an organisation. To-be state specifies the goals of transformation projects. Without to-be state the transformation processes cannot be executed or measured since no project goals are defined[2].

7 Validation

During the study period, 80 instances of Report a Bug process were considered. Corresponding to some 480 operations performed by the actors. On these instances, cartographic maps were extracted where it is possible to observe the activities of the Report a Bug process described in 5.2.2. For the observation and control of the compliance from instances of the process, cartographic maps have been created - Blueprints. The Blueprints were produced by Actor. On a total of 9 Blueprints. In these Blueprints we can observe 78 instances of the 80 contemplated, divided by activity, between compliance and non-compliance. Based on the initial problem - how to design and implement business process compliance through observing the business process instances and controlling the business process models, considering environments that are only partial observable - our investigation concerns the beginning of a solution to find compliance, once that simulation occurs of a just one business process. The goal is to extend this solution to any business process, provided that is modelled in BMPN, and to any organization. Through Blueprints we can observe the compliance and non-compliance based on predefined restrictions and to make error corrections when is verified non compliance. By assuring the business process instances are executed on a controlled way, the solution can benefit the company because it reduce execution errors on processes and with that assures fulfillment of legal impositions and performs the cost management and risk management.

8 Conclusions and Future Work

The present article presents an innovative solution that allows to observe compliance, ex-dure, during the execution of business process instances using the EC. The results obtained through the simulation, show us that through the Enterprise Cartography it is possible to observe the compliance and non-compliance associated with each instance of the business process. Thus contributing so an operational improvement in the execution of business processes modelled on BPM. We can more easily identify deviation situations in order to carry out corrective actions to encourage the Actors that operate in the instantiation of the business process. When compared with existing solutions, this solution allows the identification of situations of deviation from the prescriptions, ex-dure, during the execution of the instances. In order to achieve greater compliance, is identified the need to: i) Increase the actors' awareness of compliance with restrictions introducing the concepts explained by Dietz - production acts and coordination acts. An enterprise – or a network of enterprises – consists of social individuals who perform two kinds of acts: production acts (resulting in production facts) and coordination acts (resulting in coordination facts). The transaction axiom aggregates these acts/facts into the universal pattern of the (business) transaction. Consequently, two worlds are distinguished in which the acts of the social individuals have effect: the production world (P-world) and the coordination world (C-world). Regarding coordination acts, the forma ability concerns the form aspects, the informa ability concerns the content aspects, and the performa ability concerns the being engaged in commitments[1]. These concepts are implicitly referenced in BPMN model and can benefit from body of knowledge offered by DEMO in order to enrich the contextualise of each act in BPMN. ii) Create an automatism from solution, that allows the observation and controlling the process instances during transaction state, ex-dure.

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