Generation of Concern-based Business Process Views

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Abstract

Business processes usually have distinct organizational stakeholders with contrasting concerns regarding them. The multitude of concerns often results in multiple business process models with dominant perspectives in detriment of others which is common to see among the different departments of an organization such as Human Resources, Information Technology, Risk, and Auditing. To the best of our knowledge, there seems to be a lack of approaches that explore the generation of concern-based business processes to obtain consistent views shaped by departmental interests. Therefore, this research fills a gap in addressing organizational stakeholders' needs through concern-based business process decomposition and filtering of process activities applied over a consolidated business process model in order to maintain consistency between views. As an outcome, we expect the support and satisfaction of the complex and contrasting concerns of the distinct organizational departments.

Keywords

View generation, business process modeling, process decomposition, organizational concern-based business process views, departmental interests, BPMN.

Resumo

Os processos de negócio possuem inúmeras vezes intervenientes distintos que, por sua vez, têm diferentes preocupações e interesses. Esta variedade de preocupações e interesses faz com que existam variados modelos de processos de negócio em que dominam certas perspetivas em detrimento de outras, o que é comum acontecer entre os diferentes departamentos de uma organização, tais como: os Recursos Humanos, as Tecnologias de Informação, o Risco, e a Auditoria. Tanto quanto se sabe, existe uma escassez de abordagens que explorem a geração de processos de negócio baseados nas preocupações das partes interessadas nos mesmos, de modo a gerar-se vistas que são consistentes e têm em conta os interesses dos departamentos. Como tal, esta dissertação vem colmatar a urgência de ter em conta as necessidades dos intervenientes organizacionais, recorrendo para tal à decomposição de processos e à filtragem de atividades de acordo com os interesses departamentais, e tendo como ponto de partida, modelos consolidados dos processos de negócio, de forma a manter a consistência entre as vistas. Como resultado, pretende-se obter uma solução que ajude a satisfazer as contrastantes e complexas preocupações dos diferentes departamentos das organizações.

Palavras Chave

Geração de vistas, modelação de processos de negócio, decomposição de processos, vistas de processos de negócio baseadas nas preocupações organizacionais, interesses departamentais, BPMN.

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Acronyms

ADM Architecture Development Method

ARIS Architecture of Integrated Information Systems

BP Business Process

BPM Business Process Management

BPMI Business Process Management Initiative

BPMN Business Process Model and Notation

BPR Business Process Redesign

BS Behavioural Science

DS Design Science

DSR Design Science Research

DSRM Design Science Research Methodology

EA Enterprise Architecture

EI Enterprise Integration

EPC Event-driven Process Chains

ER Entity-Relationship

HR Human Resources

IBM International Business Machines

IS Information Systems

ISA Information Systems Architecture

ISO International Organization for Standardization

IT Information Technology

KPI Key Performance Indicator

OMG	Object Management Group
PoEM	Practice of Enterprise Modeling
REST	Representational State Transfer
SESE	Single-Entry-Single-Exit
SPNETS	Semantic Process Nets
TOGAF	The Open Group Architecture Framework
TQM	Total Quality Management
UML	Unified Modeling Language
WF	Workflow
WFMS	Workflow Management System
WSBPEL	Web Services Business Process Execution Language
XML	Extensible Markup Language
YAWL	Yet Another Workflow Language

1

Introduction

Contents

Business processes translate the knowledge about how an organization operates, and represent one of its core assets as a result of their direct impact on the attractiveness of offerings, influence on customer's experiences, and ultimately revenue in the case of corporations [3, 11].

Their significance justifies that business processes often cross inter-organizational boundaries and multiple departments to improve understanding and communication among them, then being shared across different stakeholder groups, which have dominant perspectives in the detriment of others, and give contrasting importance to the same business process.

We argue that these matters arise due to two main reasons. On the one hand, some business processes are so general and simplistic that they don't serve a specific purpose nor suit different stakeholders. On the other hand, the importance of the business process models depends on the purpose for which they were produced. A way to determine the purpose of a model is to understand its target audience [3] which can lead to the generation of different views regarding the same process.

This drives stakeholders to create and look for a business process from a modeler's perspective, which means in a way that better fulfills their concerns and particular requirements. In fact, in real organizations, the business processes are usually defined by different departmental stakeholders that will most likely represent their own needs and specifications.

Although processes are the lifeblood of an organization by determining its potential and speed to adapt to new circumstances, our main concern with this work is focused on the task of business process modeling in Business Process Model and Notation (BPMN) 2.0 [12], considering distinct views to improve different organizational stakeholders' understanding of processes and to give them the type of views of their interest like departmental ones, e.g. Human Resources (HR), Information Technology (IT), Risk, and Auditing.

1.1 Problem Definition

This dissertation addresses the problem of **the need to validate and improve an already existing view generation approach, in order to address the stakeholders' concerns and to generate more complex views like the ones shaped by departmental interests as HR, IT, Risk, and Auditing.**

According to practitioners' comments to previous works as [9], the generation of views only based on the six interrogatives (5W1H): Who, Where, What, When, Why, and How, is too simple and seldom adequate for organizational purposes and to represent stakeholders' needs. Then, there is a need to find out if the views that matter to the organizations are those who rely on the viewpoints of their departments and if those views matter that means there is the need to find a way of modeling these heterogeneous concerns among the process stakeholders.

As mentioned, stakeholders tend to look for a business process from a modeler's perspective, which sometimes results in having different organizational departments creating distinct **process models** - visual representations of processes in an organization - of the same process. Consequently, this can give rise to process models that don't have the same principles applied to all of their parts, meaning they lack consistency due to heterogeneous schemes for naming their activities and entities, usage of different modeling styles, and process hierarchies with arbitrary depth and level of detail [11]. Keeping the required consistency can be a very demanding task, mainly when there are frequent changes to the business process since all the models must be updated accordingly. These inconsistencies make process understanding difficult by stakeholders as well as hamper the tasks of process analysis, redesign, reuse, and automation as they may lead to erroneous interpretations of process content and may neglect information.

One way of providing stakeholders with consistent concern-based business processes is to generate views from a common business process - **consolidated model** - according to the requirements of its stakeholders. This means to have as a starting point, a model that combines multiple business process views and that must be previously designed. The design of this consolidated model is out of the scope of this dissertation yet is introduced in [8].

Given the problem definition, in the scope of our problem, we created the following **hypotheses:**

- **H1:** is the existing view generation algorithm from Cardoso and Sousa [9] extensible enough to generate BPMN 2.0 concern-based business process views for organizational stakeholders?
- **H2:** even if extensible, is the existing view generation algorithm from Cardoso and Sousa [9] viable and easy handling in real life contexts?

We will validate our hypotheses after proposing a solution and applying it in two distinct real life case studies through the investigation in two different industries (a *Bank* and a *Company*). We defined that to answer our hypotheses our objectives are the ones mentioned below.

1.2 Dissertation goals

To the best of our knowledge, there is no existing method that allows the generation of concern-based business processes to obtain consistent views from the perspective of departmental stakeholders interests. To this extent, through the application and exploration of the multi-dimensional process modeling principles that support a unique model of processes for all the organizational stakeholders, we state our **research goals** as:

1. **give results-based answers to the aforementioned hypotheses**;

2. **regardless of eventual limitations one may discover, propose the necessary artefacts to improve Cardoso and Sousa approach [9] to enable the easy generation of complex views that benefit specific organizational stakeholder viewpoints while addressing their concerns.**

These goals define the path taken to answer the aforementioned hypotheses and to solve the research problem. To achieve them, **we continued exploring the tool that supported the previous researches, which is called *Atlas* [13]** and is further detailed in Section 2.5.

1.3 Research Motivation

Despite diligent efforts made on business processes modeling area to improve enterprise performance through the design and modeling of processes, the failure rate of many projects keeps increasing [14] and the bad quality cause is fully related to poor modeling as suggested in [15]. Some of the efforts are stated in [16] and they go from research in the subjects of business process reengineering, to research in Enterprise Integration (EI). These efforts all concern themselves with the configuration of processes to achieve enterprise goals, albeit with slightly different focuses. This explains the resurgent interests in this field and recognizes the business process modeling as a meaningful topic when developing projects that involve understanding and designing accurate software systems.

Some authors as Petrie [17] define EI modeling as the task of improving the performance of large complex processes by managing the interactions among participants, which can be reflected in process modeling by doing some research work about generating consistent business process views in which the stakeholders are aware of their own responsibilities, but also have an overview of who is in charge of what, facilitating the internal communication.

We consider that multiple views are needed to model the multitude of the stakeholders' concerns that a single organization can have, and that is why the problem of managing diverse business process views should be given more importance in terms of research efforts. Regardless of some advances made in this field, our objective is to enhance the complexity needed by the organizations which is only possible to discern through understanding their stakeholders' interests by capturing the complex relationships between information, people, goals and systems, as well as the underlying control and data flows [11]. We believe that one way of capture that is by understanding the distinct departmental concerns of a traditional organization.

To assist us on this exercise we will also take into account the definition below of a **suitable business process view** to a stakeholder, adapted from the definition of a business process presented in Section 2.1:

Giving two views A and B, the view A is more suitable for a stakeholder S when compared to

B if and only if A represents more vigorously the concerns of S and lead to an outcome that is of value to S.

1.3.1 Motivational Example

To promote the reader's understanding of the research problem and motivation, this section describes a simplified example of a *Bank Credit Granting* process. This scenario is used throughout this work.

The Credit Granting process starts when the client needs funding and requests it from the Bank. At this point, the Bank is responsible for making a proposal and finding the offer that suits the client the best. Once the proposal is drafted and analyzed, an intervention can be required. Otherwise, there is a final decision and an agreement between all the parties involved. Before the granting of the credit, there is also an agreement's check, and the dispatch is handled. At the same time, during the execution of the whole process, there is an examination of compliance with the Bank's credit policies and an evaluation of the efficiency of workflows.

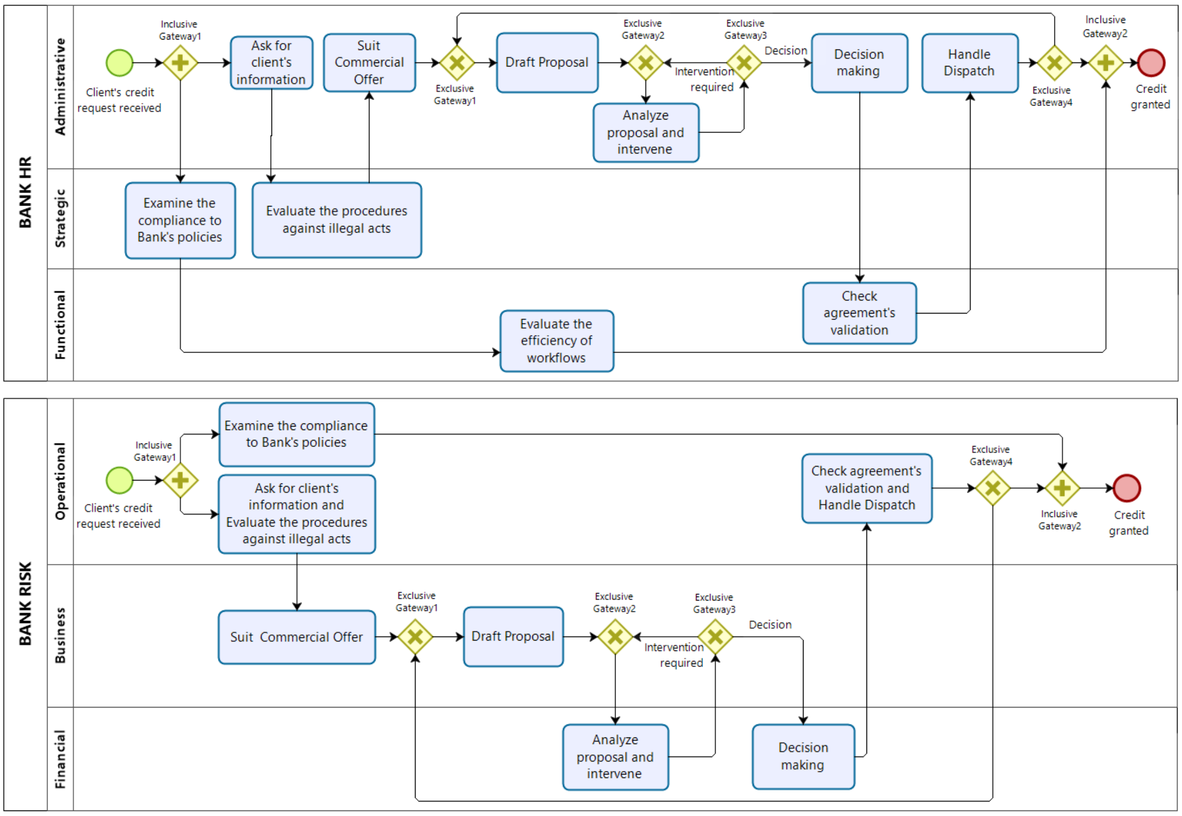

Figure 1.1: BPMN views of a *Bank Credit Granting* process, designed by the HR (top) and the Risk (bottom) departments.

Fig. 1.1 illustrates two models specified in BPMN 2.0, representing the business process views from two out of several departments that monitor the aforementioned process: the HR and Risk departments. To perform this monitoring, each department models their own view of the process based on the concerns of their interest and on the resources that each has to manage. The HR' interests are focused on the management of all the parties involved in the process, while Risk's interests are related to the Risk associated with each activity of the process.

At this level of detail, this simplified Bank process is performed by three distinct parties (functional, strategic, and administrative) and has three types of risk associated (financial, business, and operational). On the one hand, HR department do not aggregate the *'Ask for client's info'* activity with *'Evaluate the procedures against illegal acts'* activity once they are performed by people of different areas: administrative and strategic, respectively. On the other hand, the Risk department aggregates the *'Check agreement's validation'* and *'Handle Dispatch'* activities since they have both an operational risk associated. Also, the Risk view has only 7 activities while the HR view has 10 activities because the Risk view has more activities aggregated and it is not interested in the *'Evaluate the efficiency of workflows'* activity.

In the scope of our problem, we want to make it possible to generate views with the peculiarities described above and to model additional and more elaborate views.

1.4 Research Methodology

Two main paradigms characterize research in the field of Information Systems (IS): Behavioural Science (BS) and **Design Science (DS)**. Whereas BS research is more focused on the development of theories that describe organizational and human phenomena surrounding IS, DS research remains crucial as the dominant BS paradigm is not sufficient for addressing the types of business problems that call for human creativity and novel solutions, with the development of innovative products (i.e., **design artefacts**) [18].

Therefore, our research clearly fits in the DS paradigm, once we try to solve the previously described problem through the development of a method to improve an existing artefact.

To conduct a DS research in IS, [1] propose the **Design Science Research Methodology (DSRM)** as a subset of principles, practices, and procedures to create and validate artefacts that address a research problem. This methodology includes a process composed of six steps, which are described below:

1. **problem identification and motivation:** define the research problem while justifying the importance of a solution.

2. **definition of the objectives for a solution:** derive the goals from the problem identification, taking into consideration what is possible and feasible.

3. **design and development:** create the artefact after determining its desired functionality and architecture.

4. **demonstration:** demonstrate how to use the artefact to solve one or more instances of the problem.

5. **evaluation:** observe and measure how well the artefact supports a solution to the problem through a comparison between solution's goals and demonstration results.

6. **communication:** communicate the problem and its value, the artefact, its utility and novelty, the intricacies of its design and its effectiveness to relevant audiences.

The mapping between the DSRM process steps and this document outline is presented in Fig. 1.2. The first two steps are covered in this introductory chapter and, to some extent, in Chapters 2 and 3.

1.5 Document Outline

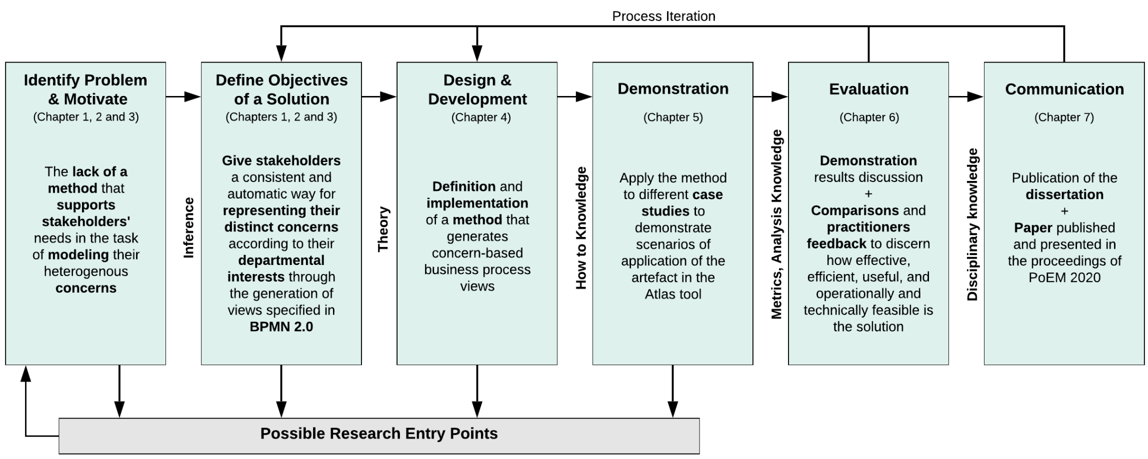

Figure 1.2: DSRM process steps mapped to the steps of our research (adapted from [1]).

The remainder of this dissertation is structured as follows. Chapter 2 sets the background of this work explaining core concepts, along with important notations of Enterprise Architecture (EA) and business process modeling languages that conduct our research. Also, we explain view integration as an opposite approach to ours but whose results have great impact and lead us to end this chapter with the introduction and description of a tool we will make use of.

Chapter 3 starts by presenting the relation between business process modeling and Zachman Framework and how can we exploit that relation to introduce the topic of concerns when modeling business process views. Also, this chapter describes how view integration and view generation have been addressed and solved in the past. An analysis of all the presented approaches ends this chapter.

Next, Chapter 4 introduces the final solution artefact to address the research problem and describes all the elements that support it alongside all the developed work.

Furthermore, Chapter 5 demonstrates the usage of the solution artefact in distinct case studies. The results discussion, and the evaluation itself and its criteria are presented in Chapter 6.

The document ends with a conclusion in Chapter 7 on all the developed work, including its communication, contributions, limitations, and a discussion on future work.

2

Background

Contents

This chapter supports the 1^{st} and 2^{nd} steps of the DSRM: *Identifying the Problem and Motivation* and *Defining the Solution Objectives*, respectively, by presenting background knowledge for the understanding of the following chapters. It starts by introducing the field of Business Process (BP) that leads to a brief historical overview of the Business Process Management (BPM) discipline and business process modeling. It then provides an overview of EA and finishes reviewing some of the languages, methodologies, and notations that support business process modeling, including the tool we will be using in our solution.

2.1 Business Process Management

Several definitions for BP have been proposed since the early period of modern organization theory. Nordsieck, in the early 1930s, describes a business process as a sequence of activities producing an output. An **activity** is then the smallest divisible unit of work performed by a work subject. More recently, Dumas et al. highlight that only one in eight **BP** is defined as:

> **"a collection of inter-related events, activities, and decision points that involve a number of actors and objects, which collectively lead to an outcome that is of value to at least one customer."** ([3], pp. 6)

Armed with the previous definition of BP, Dumas et al. also define **BPM**, presenting the relation between them, as:

> **"a body of methods, techniques, and tools to identify, discover, analyze, redesign, execute, and monitor business processes in order to optimize their performance."** ([3], pp. 6)

Both definitions highlight the importance of BP for organizations and the need for a BPM discipline as a collection of methods, techniques, and tools, to manage and optimize the performance of sequences of activities, events, and decisions, i.e. BP whose ultimate goal is to add value to the organizations and its stakeholders. The performance optimization varies according to organization goals in terms of reducing costs, execution times or error rates. One of the features commonly associated with BPM is its emphasis on the use of process models throughout the lifecycle of business processes. Such models can help to manage process complexity and are also easy for non-business users to interpret.

This section presents a brief historical introduction regarding BPM, accompanied by an explanation of the BPM lifecycle, and concludes with the definition of process architecture.

2.1.1 Origins of Business Process Management

In the last couple of years, there has been a growing interest in BPM. The origin of BPM is not a single breakthrough event in history but emerged from the evolution over time of several ideas and improvements in the organization of work. In essence, the place to begin is with an overview of the world of business process change methodologies and technologies. There are three major process traditions: the Management tradition, the Quality Control tradition, and the Information Technology tradition [2]. Nowadays, the tendency is for three traditions to merge into a more comprehensive BPM tradition.

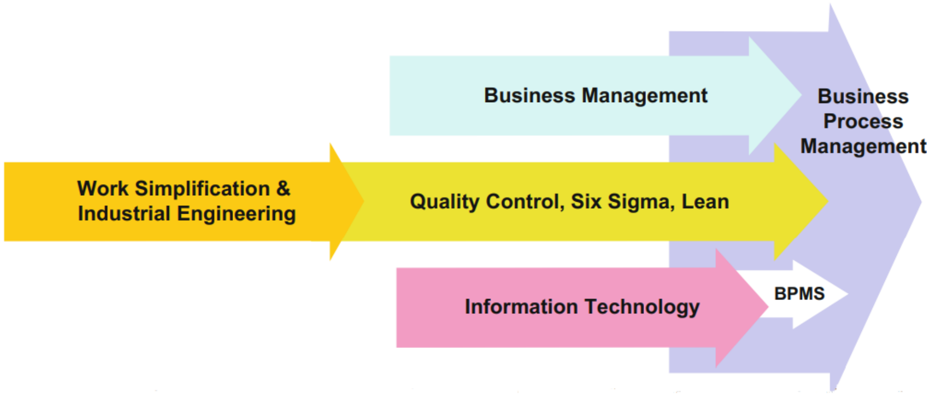

Figure 2.1: An overview of approaches to business process change (from [2]).

Looking at Fig. 2.1, we pictured the Quality Control tradition as a perpetuation of the Work Simplification tradition which started with a set of principles published by Frederick Winslow Taylor, known as *Principles of Scientific Management*, in 1911, with an extreme focus on the labour division, describing ideas to improve the business of the managers who had an important role in supervising the productivity of workers that were responsible with only a single part of a given business process. Only later, the most popular Quality Control methodology was termed Total Quality Management (TQM) and other approaches like Six Sigma and Lean emerged in order to leverage process improvements.

The Management Tradition gives more emphasis to the overall performance of a company by aligning strategy, with the means of realizing that strategy, and on organizing and managing employees to achieve corporate goals [2]. Geary Rummler, the most prominent figure in this field, always emphasized the need to improve corporate performance and argued that Business Process Redesign (BPR) is the best way to do that. Afterwards, BPR is arguably recognized as the most relevant movement of the IT tradition and since some of BPR's ideas lead to the appearance of BPM, BPM can be viewed as a revival of BPR. However, BPR focuses on planning and organizing the process and does not encompass all the phases of the BPM lifecycle which we will explain in the next section. Thus, it should be seen as a subset of techniques that can be used in the scope of BPM ([3], pp. 15). Michael Porter is another guru that strongly believed that strategy is intimately linked with how companies coordinate their actions into value chains. His book, namely *Competitive Advantage* [19], shows how these value chains were, in turn, the basis of a company's competitive advantage and led to the increasing concern of how an organization aligns its strategic goals with its processes.

2.1.2 BPM Lifecycle

The BPM discipline is composed of concepts, methods, techniques, and tools, represented through the BPM lifecycle. Since our objective is to assist stakeholders, supplying them with consistent and updated models that convey their concerns, our research is mainly focused on one of the phases of the BPM lifecycle - **process discovery**. However, the BPM lifecycle, illustrated in Fig. 2.2, provides a structured view comprising all the phases of how a given process can be managed ([3], pp. 22-24).

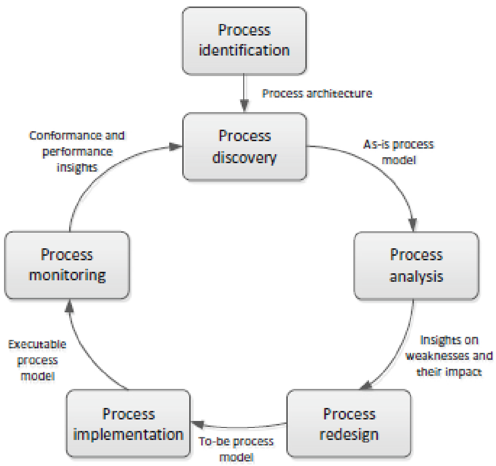

Figure 2.2: The BPM lifecycle (from [3], p. 23).

- **process identification:** a business problem is posed, and its relevant processes are identified. The outcome is a new or updated process architecture that provides an overall view of the processes in an organization and their relationships. The **process architecture** subject is further discussed in Section 2.1.3.
- **process discovery or AS-IS process modeling:** the current state of each one of the relevant processes is documented in one or several AS-IS process models. Later on Section 2.3, some of the most relevant business process modeling languages and notations are described.
- **process analysis:** the issues related to the AS-IS process are identified, documented, and quantified using performance measures, whenever possible. The output of this phase is a structured collection of issues, typically prioritized by impact and estimated effort required to resolve them.

- **process redesign or process improvement:** the goal of this phase is to identify changes by creating a TO-BE process model that would help to address the issues identified in the previous phase. As a result, process analysis and process redesign work together to meet the organization's performance objectives.

- **process implementation:** this phase covers the organizational change management, and process automation, in order to prepare and perform the changes required to move from the AS-IS process to the TO-BE process.

- **process monitoring and controlling:** this phase collects and analyzes relevant data to determine the process performance regarding its performance measures and objectives. If performance issues like bottlenecks are identified, corrective actions are taken. In the future, new issues may arise, requiring the cycle to be repeated on a continuous basis.

2.1.3 Process Architecture

Organizations develop and maintain collections of hundreds or even thousands of BP models. These models and the BP that they depict, represent an entire organization through a complex system of cooperating entities. Designing and analyzing the structure of this system of BP models arises as a new kind of problem, which is covered by the field of business process architecture.

A **business process architecture** is then a structured overview of the processes that exist in an organization, including their interdependencies with each other to make relationships explicit. The different types of relations that have been used by business process architecture design methods include [20]:

- *composition*, which represents that one BP is composed of other business processes, called subprocesses. With this type of relationship, one can define different levels of detail in a process architecture from the highest level like a process landscape to the lowest level like **detailed process models**, e.g. BPMN, in which we will focus. In BPMN, business processes show control flow, data inputs, and outputs as well as the assignment of participants;

- *specialization*, which represents that one BP specializes another;

- *trigger*, which represents that one BP causes another BP to instantiate and start;

- *information flow*, which represents that information or other objects flow from one BP to another.

A business process architecture is typically designed before the organizational processes, once it assists organizations to learn which processes exist and where one process ends and the next starts.

2.2 Enterprise Architecture

An EA tries to describe and control an organization's structure, processes, applications, systems, and techniques in an integrated way [21]. According to the Open Group, EA consists of defining and understanding the different elements that compose the enterprise and how those elements are interrelated [22]. Zachman described it as the set of representations required to describe a system or enterprise regarding its constructions, maintenance, and evolution [23]. It has a crucial role in the design and realization of an enterprise's organizational structure and business processes.

The point of EA is that **business processes play a central role in integrating enterprises' different perspectives**. Distinct frameworks as the ones we will further detail below have been proposed for capturing the various perspectives of an enterprise architecture. Among others we find relevant to mention The Open Group Architecture Framework (TOGAF) developed by the Open Group, providing a modeling language, namely ArchiMate, to support it, and alternatively the Zachman Framework. This section starts by presenting core EA notions defined by the International Organization for Standardization (ISO) 42010, which our research adheres to.

2.2.1 ISO/IEC/IEEE 42010

The ISO/IEC/IEEE 42010:2011 standard [24] addresses the creation, analysis, and sustainment of architectures of systems through the use of architecture descriptions. Architecture descriptions are adopted by the parties that create, use, and control modern systems to improve communication and co-operation, enabling them to work in an integrated way. Given their importance in our work, we list below the most relevant concepts introduced by the standard:

- **stakeholder:** *'an individual, team, organization, or classes thereof, having an interest in a system'*.
- **concern:** *'an interest in a system relevant to one or more of its stakeholders'*.
- **view:** *'a work product expressing the architecture of a system from the perspective of specific system concerns'*.
- **viewpoint:** *'a work product establishing the conventions for the construction, interpretation and use of architecture views to frame specific system concerns'*.
- **model kind:** *'conventions for a type of modeling'*.

We will introduce some examples of model kinds in Section 2.3, however, our work will focus on only one of them: BPMN modeling. Since the ISO 42010 standard also states that a view is composed of one or more models with each model adhering to the conventions stipulated by a model kind, we will use the concepts *model* and *view* interchangeably throughout this document.

2.2.2 The Zachman Framework

The six contextual dimensions (5W1H): What, Who, Where, Why, When, and How, were defined in the first place in an enterprise architecture framework called the Zachman Framework that was initially presented by John A. Zachman in 1987, when he worked at International Business Machines (IBM) [25], although back then it was called 'Framework for Information Systems Architecture (ISA)'.

It is probably the best-known framework to describe the architecture of an enterprise by proposing a two-dimensional matrix-like structure to classify and organize the business and technical models of an organization. The matrix, presented in Fig. 2.3, intersects two historical classifications:

- Each **column** represents one out of the six aforementioned contextual dimensions (5W1H from [23], pp.115), also known as primitive linguistic interrogatives of communication. Although multiple classification schemes allow categorizing the modeling perspectives, we posit that these always cross-cut the fundamentals of communication summarized in Table 2.1.
- Each **row** is according to reification transformation - changing an abstract into a concrete idea -, representing a view of the solution from the most important and particular perspectives on the enterprise, such as the *planners* in the *Scope* or the *designers* in the *Logical*.

Table 2.1: Dimensions of the Zachman Framework (from [6]).

Dimension	Focus	Purpose
What	Data	Defining and classifying the organization's information.
How	Function	Translating the organizations' mission into the business and into successfully more detailed definition of its operations.
Where	Network	Describing the geographical distribution of the organization's operations and assets.
Who	People	Describing who (departments at a higher level and users at a lower level) is associated with the major assets of the organization.
When	Time	Describing how the organization's assets evolve with time.
Why	Motivation	Translating goals into actions and objectives.

Each **cell** (i.e. intersection) of the matrix models a discrete and only one portion of the enterprise. For instance, cell (3,2) representing the intersection between the System Model (Logical) and the How (Function) must contain only the 'Application architecture' and nothing else. After the construction of all the cell models, they can be integrated to realize an enterprise as a whole.

Accordingly, EA has to obey certain ground rules imposed by The Zachman Grid as the following from [26]:

	What (Data)	How (Function)	When (Time)	Who (People)	Where (Location)	Why (Motivation)
Scope (Contextual)	List of things	List of processes	List of events	List of organizations	List of locations	List of goals
Enterprise Model (Conceptual)	Semantic model	Business process model	Master schedule	Work flow model	Logistics network	Business plan
System Model (Logical)	Logical data model	Application architecture	Processing structure	Human interface architecture	Distributed system architecture	Business rule model
Technology Model (Physical)	Physical data model	System design	Control structure	Presentation architecture	Technology architecture	Rule design
Implementation (Detail)	Data definition	Programs	Timing definition	Security architecture	Network architecture	Rule specification
Functioning Enterprise	Usable data	Working function	Usable network	Functioning organization	Implemented schedule	Working strategy

Figure 2.3: The Zachman Framework (from [4]).

- **Rule 1:** *The columns have no order.* All columns are equally important.
- **Rule 2:** *Each column has a simple, basic model.* Each column describes one complete aspect from the real-world enterprise using primitive models only.
- **Rule 3:** *The basic model of each column must be unique.* Each model in a column is related to the others since they are abstractions of the same real-world enterprise, yet each model represents a distinct and unique concept.
- **Rule 4:** *Each row represents a distinct, unique perspective.* Each perspective is different in that it is dealing with a different set of constraints relevant to that perspective.
- **Rule 5:** *Each cell is unique.* Each model representation or cell differs from the others in essence and not merely in the level of detail.
- **Rule 6:** *Combining the cells in one row forms a complete view.* Each row provides a comprehensive view of the enterprise from the perspective of a group of stakeholders.
- **Rule 7:** *The logic is recursive.* The framework logic can be used for describing virtually anything.

2.2.3 The Open Group Architecture Framework

The Open Group claims that TOGAF - developed in 1995 by the United States Department of Defense - is used by most of the world's largest corporations and it is nowadays the most popular and standard EA development framework, being process-driven generic and flexible enough to provide a comprehensive approach for designing, planning, implementing, and governing an enterprise information architecture. This framework is designed to support the four closely inter-related architecture domains that commonly constitute an EA [27]:

- **Business Architecture:** defines the organization's strategy, governance, and business processes to achieve business goals;
- **Application Architecture:** plans the systems to be deployed, their interactions and their relationships with the organization's business processes;
- **Data Architecture:** describes the organization's logical and physical data assets;
- **Technology Architecture:** describes the hardware, software and network infrastructure.

The steps necessary to develop these architectures are described by TOGAF's Architecture Development Method (ADM), an iterative method for developing and managing the lifecycle of an overall enterprise architecture that meets the needs of a business, forming the core of TOGAF. Each iteration of the ADM will populate an organization-specific landscape with all the architecture assets identified and leveraged through the process, including the final organization-specific architecture delivered.

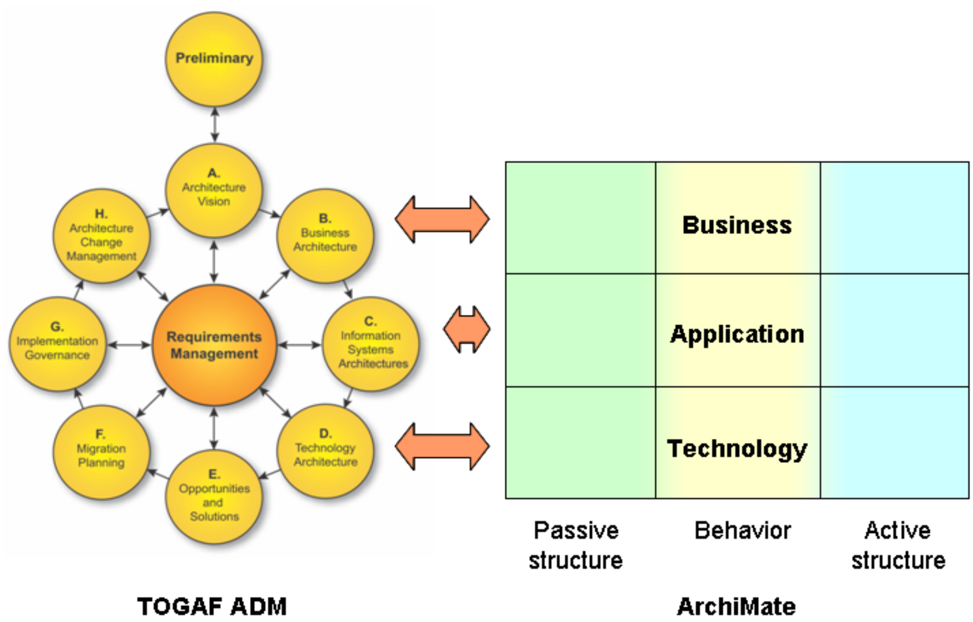

Figure 2.4: Correspondence between ArchiMate and TOGAF (from [5]).

The ArchiMate language complements TOGAF by providing a vendor-independent set of concepts, including a graphical representation that helps to create a consistent and integrated model that can be depicted in the form of TOGAF views. Then, ArchiMate features a metamodel, a set of architecture viewpoints, and a notation for representing architectures that neatly corresponds with the three of the main four architectures addressed in the TOGAF ADM. This correspondence would suggest a fairly mapping between TOGAF views and ArchiMate viewpoints, which is illustrated in Fig. 2.4.

2.3 Business Process Modeling Languages and Notations

Mendling defines **business process modeling** as the human activity of creating a business process model [28]. Business process modeling specializes in describing how activities interact with organizational entities to support the performance of the business. As mentioned by Becker et al. [29], it becomes more and more an important task not only for the purpose of software engineering but also for many other purposes besides the development of software with the increasing number of different models from different viewpoints. The following business process modeling languages and notations are the most relevant ones, offering a predefined set of elements and relationships for guiding the task of modeling in different architecture domains, such as business processes, organizational structures, information flows, and IT support.

2.3.1 Petri Nets, Workflow Nets, and Yet Another Workflow Language (YAWL)

Petri nets were firstly introduced by Carl Adam Petri and we assume their standard definition as a model for procedures, organizations, and devices where regulated flows, in particular, information flows, play a role [30]. Petri nets were one of the first formal languages used for the specification of business processes and ended up forming the base for the development of other business process modeling languages such as Workflow nets and YAWL. They consist of directed bipartite graphs of two finite disjoint sets of *transitions* (squares) and *places* (circles) together with a *flow relation* (directed arcs) to connect them. These elements are graphically represented on the left in Fig. 2.5.

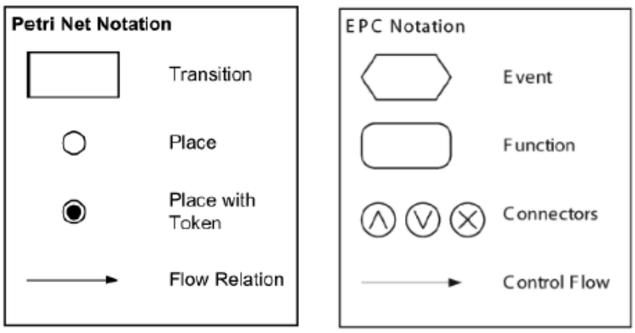

Figure 2.5: Elements of the Petri Net notation (left) and the Event-driven Process Chains (EPC) notation (right).

Workflow nets are a subclass of Petri nets [31] to support the modeling of business processes. They have one *input place (i)* and one *output place (o)* since any case handled by the procedure represented by the Workflow (WF)-net is created if it enters the Workflow Management System (WFMS) and is deleted once it is completely handled by the WFMS, i.e., the WF-net specifies the lifecycle of a case. Unlike other business process modeling languages such as BPMN and EPCs that will be covered in the next sections, WF-nets have a well-developed mathematical theory for process analysis [32]. Their *transitions* are used to represent process activities or routing conditions, and *places* are assigned to the pre/post conditions of each *transition* (roughly corresponding to the BPMN event elements).

YAWL [33] derive from WF-nets and is based on Petri nets but extended with additional features to facilitate the modeling of complex workflows, and support, in a more directly and intuitively way, the most frequent control-flow patterns found in the current workflow practice.

2.3.2 Event-driven Process Chains (EPCs)

EPCs introduced by Keller et al. [34] become popular in the 1990s as a wide-spread method for business process modeling language representing temporal and logical dependencies between the activities of a process.

Similarly to Petri nets, EPCs are ordered graphs with two main different types of elements (i.e. nodes): the *function* type elements used to capture process activities which can be compared to Petri nets' transitions, and the *event* type elements used to describe the pre and post-conditions of functions, corresponding to Petri nets' places. For the definition of the routing rules, there are three kinds of logical *connectors*: AND, OR and XOR, to join or split the process flow. Furthermore, OR- and XOR-splits cannot be placed after events since the latter cannot make decisions. Syntactically, since connections between two elements of the same type are not allowed, *functions* and *events* have to alternate, either directly or indirectly when they are linked via one or more *connectors*. The elements that compose the EPC notation are illustrated on the right in Fig. 2.5.

2.3.3 Business Process Model and Notation (BPMN)

BPMN [35], developed by the Business Process Management Initiative (BPMI).org, is a *de facto* standard for business process modeling and provides a graphical notation for specifying business processes [36] in three different ways: business process diagrams, sub-processes, and tasks. Sub-processes encapsulate complexity, i.e., they portray a child business process diagram, while tasks are considered the lowest-level process. Since 2005, BPMN has been maintained by the Object Management Group (OMG) and is also ratified as ISO 19510 with the primary goal of providing a notation that is readily understandable by all business users and able to represent complex process semantics. This modeling language took EPCs' place as the chosen modeling language of the Architecture of Integrated Information Systems (ARIS) toolset.

Initially, BPMN was a purely graphical notation employed for the business user-centered and often used in conjunction with Web Services Business Process Execution Language (WSBPEL) that performed the technical specification. Later, BPMN gained its own Extensible Markup Language (XML) format, providing a mapping between the graphics of the notation and the underlying constructs of execution language. This innovation led to a loss of interest in WSBPEL because BPMN could now fulfill both user and IT needs.

BPMN consists of four basic graphical elements groups that contribute to the design of business process diagrams:

- **Flow objects:** contains *events, activities,* and *gateways*. *Events* depict an occurrence during the execution of the process. *Activities* can be of various types, including tasks and sub-processes, and they denote the work that is done within a company. *Gateways* are used for determining branching, forking, merging, or joining of paths within the process.

- **Swim lanes:** can be *pools* or *lanes*. *Pools* model process participants who perform the activities) or may be used to model the process locations (where the activities are performed, e.g. organizational units or geographical locations). *Lanes* further categorize activities within a pool.

- **Artefacts:** are *data objects, groups,* and *annotations*. *Data objects* represent information resources required or produced by activities. The *group* element is a visual aid for documentation or analysis purposes while the text *annotation* is used to add additional information to the model.

- **Connecting objects:** are *sequence flows*, *message flows*, and *associations* used for connecting the flow objects. *Sequence flow* defines the execution order of the activities within a process, while *message flow* indicates a flow of messages between entities or roles. *Associations* are used to associate both text and graphical non-flow objects.

Under this work, we will be using version 2.0 of BPMN, released in January 2011 by OMG.

2.4 View Integration

The concept of view integration portrays opposite but necessary knowledge and inputs for our solution to work. View integration first emerged in the field of conceptual database design to support the coexistence of different representations of the same real-world objects.

As explained in [37], since 1978 that it has been identified as the design step aimed at producing a global conceptual schema of a database from a set of formally defined users' views. Also, a framework proposed by Navathe and Schkolnick [38] for conceptual database design based on the Entity-Relationship (ER) Model, considered the view integration as one of the four main phases of conceptual database design and describes it as a combination of conflicting user views into one data model that represents a global view of the required data.

Later, in contrast with the existing approaches that aimed for a fully automated view integration method, Navathe et al. in [39] present an important step in this field by arguing that view integration is subjective and can only be accomplished with interactive design tools in a continuous dialogue with the designer who must play a key role in helping to resolve semantic conflicts.

2.5 Atlas Tool

We wrap up this chapter by presenting a tool we will be using in our solution. *Atlas* [13] is a highly-configurable enterprise cartography tool from Link Consulting[1] that includes two major components:

- the **Process Repository**: it is configured in *Atlas* itself and holds the consolidated process models, the organizational taxonomies with the corresponding taxonomy trees and the mapping of their concepts to the consolidated models.
- the **Process Modeler**: it was developed in *Javascript* using the *bpmn.io*[2] library and implements the already existing generation algorithm.

The Process Repository is implemented in *Atlas* through the configuration of its metamodel classes that we introduce in Figure 4.2, in Section 4.2.2. The Process Modeler is composed by the following three main elements that include:

1. a **Retriever** which uses Representational State Transfer (REST) services to retrieve the consolidated process model and the organizational taxonomies from the Process Repository.
2. a **Generator** which transforms the retrieved consolidated process model into a new model, taking into account the provided levels of detail.
3. a **Designer** which designs the business process model for presentation in a canvas through the use of the *bpmn.io* library to design the BPMN elements. The canvas is perceived as a matrix to avoid positioning business process elements at the same place, then assigning each element per cell of that fictional matrix.

This tool will have a significant impact to test the feasibility of the solution proposed in the Chapter 4, and, most importantly, to showcase it.

[1] https://www.linkconsulting.com/atlas
[2] https://bpmn.io

3

Related Work

Contents

As aforementioned, our problem addresses the concern of having different business process views focused on different stakeholders, trying to understand their needs. The contents of this chapter present a literature review of the main contributions on the topics that support business process modeling, like EA, view integration, and view generation. It also refers to the contents of the previous chapter, background, whenever it is appropriate, and covers other works which, although not having triggered this research, had a major influence on its development. This chapter ends with a brief analysis of the related work regarding its relevance to the proposal of the present work.

3.1 Business Process Modeling within the Zachman Framework

Despite the number of notations and techniques referred to in the background chapter to support business process modeling, there is no agreement on the modeling criteria to be used by different organizational stakeholders. This section describes the contributions that applied Zachman Framework (introduced in Section 2.2.2) to support business process modeling. Some approaches, to broaden the theory of business process modeling, mention the six contextual dimensions and they are actually used as a solution to solve simple problems in this field and to identify business process activities.

To tackle the existence of conflicting process specifications for the same organizational process, depending on the distinct stakeholder's perspectives and on the modeler's view regarding that particular process, Sousa et al. in [6] propose a rule for identifying business process activities by applying a number of properties derived from the six Zachman Framework dimensions. They use the six communication questions (what, how, where, who, when, and why) as independent concerns for the decomposition of a business process which makes each activity being determined by the values of the six dimensions.

The activity decomposition rule states that an activity α can be decomposed into two or more distinct discrete activities if and only if one of the conditions stated in Table 3.1 is satisfied.

Table 3.1: Criteria for activity decomposition presented in [6].

Dimension	Criteria
What	α is composed by two or more activities which receive/create different data entries.
How	α is composed by two or more activities which are processed using distinct applications.
Where	α is composed by two or more activities which occur in different locations.
Who	α is composed by two or more activities which are managed by different business actors.
When	α is composed by two or more activities which are performed in distinct periods of time.
Why	α is composed by two or more activities which exist to serve different purposes.

This rule aids business process modeling by facilitating the task of different stakeholders consistently modeling the same process.

Following [6] and due to the fact that common definitions of business process concepts include a sequence of activities producing value, Pereira and Sousa in [40] use the aforementioned decomposition rule to define business process equivalence through activity equivalence. First and foremost, their approach is based on three of the six rules of the Zachman Framework, all mentioned in Section 2.2.2: classification (rule 3), recursiveness (rule 6), and cell uniqueness (rule 5). Considering the latter, each dimension of the framework is, in fact, a hierarchy of concepts, typically presented as a tree (Fig. 3.1).

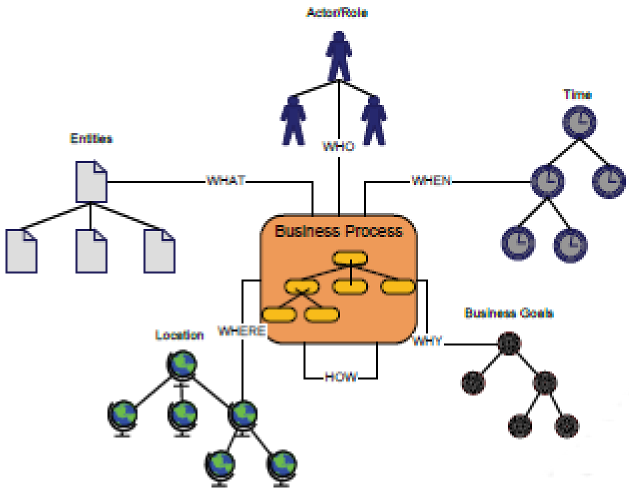

Figure 3.1: Business process relationship with the hierarchical representation of Zachman Framework dimensions (from [6]).

Once processes can be decomposed until the level that one dimension is enough to describe that process, the leaves of the process tree can be called activities which means processes that have no further decomposition. Then, using the activity decomposition rule, the authors define dimensional activity equivalence as the following: *An activity (A) is dimensional equivalent to another (A') when they have no different when, what, where, who and why* [6]. For example, considering that the activities of a given process are only characterized by the who and what dimensions, if the activity *driving* is carried out by *Peter* (who) using a *car* (what) and the activity *riding* which is carried out by *Peter* (who) using also a *car* (what), the activities labeled as *driving* and *riding* are dimensional equivalents. Taking into account these considerations, *a process (P) is dimensional equivalent to another (P') if all their children are dimensional equivalent, regarding the dimensions that are used.*

In line with [6] and [40], Pereira et al. [7] state that *a business process can be functionally decomposed into a set of individual tasks* which formally speaking means that the decomposition results in a hierarchical structure defined as organizational taxonomy. A taxonomy helps to structure, classify, model and represent the concepts and relationships pertaining to business process design while enabling a community to come to an agreement and to commit using the same terms in the same ways [40]. This organizational taxonomy defines a controlled vocabulary to design business processes and encompasses six business concepts, each associated with one of the six Zachman Framework dimensions to be understandable to all the process stakeholders. For each of the concepts, there is a **taxonomy tree**, meaning they can be decomposed infinitely into other instances that conceptually belong to the same concept. The resulting process is a digraph whose underlying graph is a tree depicted in Fig. 3.2. The concepts and their association with the six dimensions are listed below.

- **Business Process (how):** from [7] is "a set of connected activities which consumes (inputs) and produces (outputs) tangible or intangible artefacts [information entities], is performed by people or systems [actors], contributes to achieve goals [business goals], takes place in a specific location [organizational unit] and occurs during a period of time [business schedule]".
- **Information Entity (what):** meaningful input or output in the business context.
- **Business Schedule (when):** determines temporal restrictions of a business process.
- **Actor (who):** people or systems that play a role in one or more business processes.
- **Organizational Unit (where):** a logical unit (e.g. department) or a physical/geographical separation in the organization's structure.
- **Business Goal (why):** the objective of a business process, e.g. Key Performance Indicator (KPI).

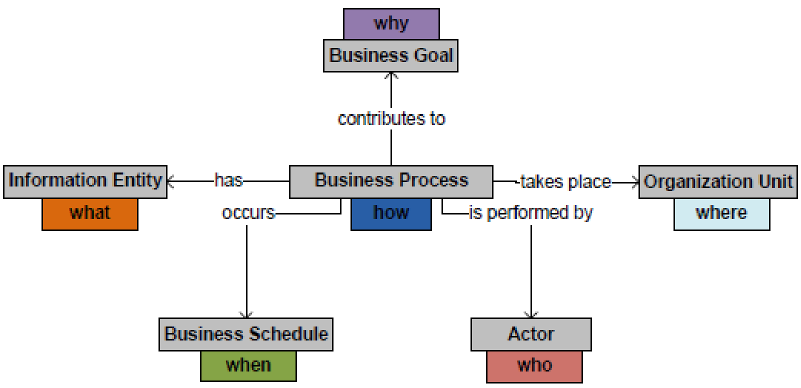

Figure 3.2: The six core concepts of a BP and the corresponding six classification dimensions (from [7]).

Next, we present other works in the field of business process modeling. Some of them are triggered by [7] and based on the use of the six contextual dimensions of the Zachman Framework. Those works concentrate on integrating different business process views and generating new views from a common knowledge base.

3.2 View Integration

3.2.1 In Business Process Design

Firstly addressed in Section 2.4, view integration tended to be increasingly important. While work procedures singularly executed are easy to document, business processes often span several departments of a company and include several activities performed by different people.

Mendling and Simon in [41] were already aware that view integration can become a difficult task, so they propose a method applied to business process design through view integration and using EPCs. Firstly, they started by identifying semantic relationships between activities of different business process models, then they defined a merged operator for EPCs to integrate business process views and finally they propose a set of restructuring rules to achieve an integrated model without unnecessary structure. Beyond that, this approach also supports a merger scenario where business process models of two companies with overlapping semantics have to be integrated into one repository.

Later on, Morrison et al. in [42] also provide a framework for process integration based on process structural and semantic descriptions, using Semantic Process Nets (SPNETS). The interesting element of their method is in the use of minimal change of processes leading to cost minimization and reduction of change risks.

3.2.2 Using the Zachman Framework

Once a concept is solely characterized by its properties in data modeling, in an ER model an entity is then defined by an identifier, its attributes and the relationships with other entities, despiting its name. Thus, two entities are equivalent if they have the same identifier, attributes, and relationships. This approach is similar to the one mentioned in Section 3.1 since Pereira and Sousa [40] argue that the same should occur with business process models, defining structural process equivalence using the six dimensions. In the scenario shown in Section 3.1 the two activities are dimensional equivalent because, for each of the six dimensions, the concepts that represent them at the chosen level in the dimension's taxonomy tree are the same.

Following [40], Colaço and Sousa in [8] propose a method for integrating business process views specified in BPMN 2.0 into a single consolidated model, using a business process repository for supporting the view integration process. The method guides process stakeholders in uploading their models to the repository. During the upload, stakeholders must classify the various elements of their model, allowing the creation of a consolidated model and an organizational taxonomy, which is a taxonomy tree for each dimension. The method presented is an iterative one, which means that the organizational taxonomy and the consolidated process model become more and more detailed as more models are uploaded to the repository.

3.3 View Generation Using the Zachman Framework

Caetano et al. [43] introduce a conceptual tool called The View Generator to create business process views from a knowledge base implemented by a business process repository. The generated views are inherently consistent because they are based on the same process data. This tool is built upon the components fully described in Section 2.5.

However, [43] had two gaps. It only focuses on describing a conceptual tool without formally defining the algorithms that support the generation of the views. Moreover, it does not apply the problem to a specific process modeling notation like BPMN.

Thereafter, Cardoso and Sousa [9] propose a solution to fill those gaps, taking advantage of the work of Colaço and Sousa [8] which, as mentioned in Section 3.3, defined a method for merging distinct views of a business process into a single consolidated model then stored in a process repository (Fig. 3.3), similar to the one used by Caetano et al. [43]. The solution of [9] considers the use of that process repository to do the opposite work, generate views from a consolidated process model, by using a generation algorithm. The algorithm is based on the application of a rule derived from one decomposition rule presented by Sousa et al. in [6], described in Section 3.1. Although [6] also presents an aggregation condition, Cardoso and Sousa create a rule that state that two activities α and β can be aggregated into an activity δ if and only if for every dimension one of the following two conditions applies:

- the taxonomy concepts mapped to α and β are the same.
- the taxonomy concepts mapped to α and β are different but they have a common ancestor at the chosen level of detail.

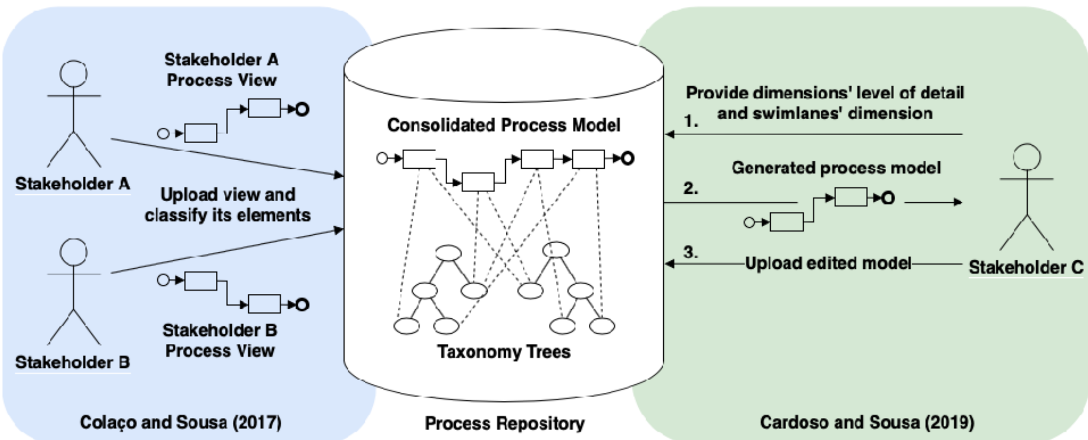

Figure 3.3: View Integration [8] (on the left) and View Generation [9] (on the right).

Afterwards, the stakeholders may generate simple process models, simply by providing the level of detail desired for each dimension.

3.4 Analysis

This section presents an analysis of the aforementioned contributions regarding the *Background* knowledge, highlighting their relevance to our proposed solution.

A **view** is a partial expression of a system's architecture concerning a particular viewpoint. A **viewpoint** establishes the conventions by which a view is specified, depicted, and created [44]. We define in detail these and other architecture concepts in Section 2.2.1.

Subsequently, our approach can be considered an application of ISO 42010 [24] to business process modeling. ISO 42010 addresses the creation, analysis, and sustainment of architectures of systems through the use of architecture descriptions. The stakeholders of a system are parties with interests in that system and their interests are expressed as concerns. Then, it states that an architecture description includes one or more architecture views and a view addresses one or more of the concerns held by the systems' stakeholders, which means they are governed by a particular viewpoint. According to ISO 42010, a view is also a suitable fit to address one or more of the concerns of the system's stakeholders. Thus, we want our business process views to help leverage BPM benefits by giving each stakeholder an appropriate process description and representation.

Even before existing a concern about the generation of business process views, Mendling and Simon in [41] studied an approach never taught before while boosting the importance of having a view integration method applied to business process design and supporting the EPC notation. Thereafter, their work led to Colaço and Sousa [8] research with the purpose of filling a gap in knowledge by defining a new view integration method applied to business process modeling and supporting BPMN 2.0.

At the same time, the Zachman Framework is applied to business process modeling in Sousa et al. [6] work that proposes a rule for identifying business process activities through the application of a number of properties derived from the six Zachman Framework dimensions. Moreover, Pereira and Sousa in [40] use the aforementioned decomposition rule to define business process equivalence through activity equivalence and refer a master process repository that is aligned with the proposed solution, given that it is supported by a business process repository. Later, Caetano et. al. [43] introduce a new conceptual tool to create business process views. After, Cardoso and Sousa [9] also created a tool by formally defining the algorithms that support the generation of those business process views with the use of BPMN 2.0. That tool uses consolidated models previously uploaded by Colaço and Sousa [8] to a shared process repository. This repository serves as the common knowledge base for the view generation approach we detail in Chapter 4.

The work of Cardoso and Sousa [9] laid out the foundations of our work. Our work will fill the gap in knowledge existing in [9] in the sense of solving the problem described in Section 1.1.

The next section introduces the proposed solution to the research problem.

4

Proposed Solution

Contents

This chapter corresponds to the 3^{rd} step of the DSRM: *Design and Development*, and it describes our approach to address the research problem. We start by shortly explain the big picture and finish detailing the components and the generation method of our proposal.

4.1 The Big Picture

In the current state of affairs, our research is an add on to the work recently performed by [8] and [9], as illustrated in Fig. 4.1. The existing approaches guide process stakeholders in constructing taxonomy trees by classifying process activities according to the Zachman contextual dimensions (5W1H) and allow the generation of views by providing the level of detail desired for each dimension.

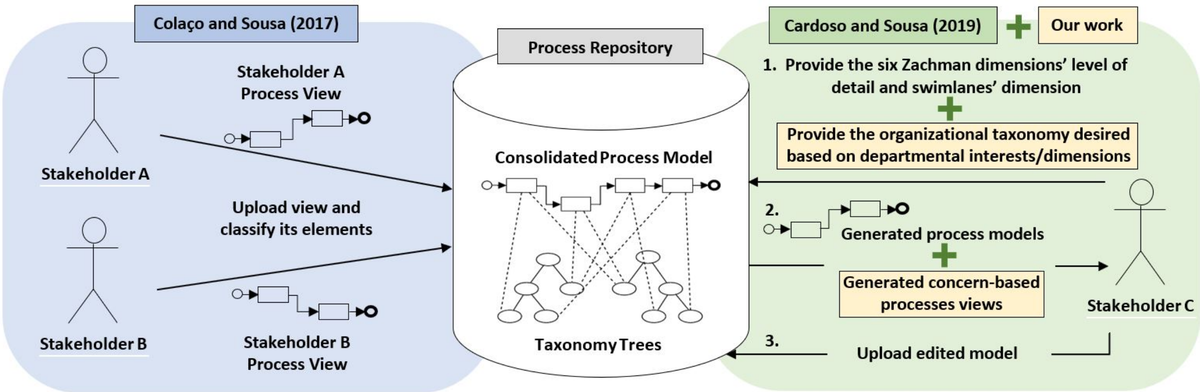

Figure 4.1: Illustration of the relation between [8] (in blue) and [9] (in green) works and our research (emphasized in yellow).

Notwithstanding the above, aiming to meet organizational stakeholders' needs, our solution goes further to present them with a method that enables the generation of departmental business process views such as HR, IT, Risk, and Auditing. For that purpose, our approach considers each department as a dimension, and departmental concerns such as departmental functions, roles, and areas, as the criteria for process decomposition instead of the six Zachman contextual dimensions. This means each decomposition step separates a different departmental concern from the other concerns that specify the activity. Hereupon the activities' classification performed by the stakeholders is made according to departmental interests, and the decomposition steps are automatically performed by choosing the level of detail desired for each dimension (i.e. department).

4.2 Components

This section explains in further detail all the components of our solution, how they support it and how they work together to allow its proper functioning.

4.2.1 Atlas Tool Support

In Section 2.5 we present and clarify the two major components of the *Atlas* [13] tool, and more precisely, the tree main elements of the Process Modeler component: a **Retriever**, a **Generator**, and a **Designer**.

Our method introduces the pseudocode that, together with the already existent algorithms that comprise the *Atlas* tool and retrieve the process data from the **Process Repository**, is part of the main steps the **Process Modeler** carries out to generate and grant a view.

The role of the user is just to choose as inputs the process name, the desired levels of detail, and the dimension that shall be depicted in the swimlanes. It is noteworthy that our method is directly related with the **Generator** component of the Process Modeler that also assigns each process activity to the concept in the chosen level of the taxonomy trees of each dimension. A practical example is the *Bank Credit Granting* process (see Fig. 4.3) that in a view with Risk at level 1 and HR at level 2, associates the *Evaluate the procedures against illegal acts* activity with *Bank Risk (Risk)* and *Strategic (HR)* taxonomy concepts. If no dimension is specified the user is presented with the consolidated process model that already contains the associated taxonomy trees. In other words, the Generator component implements the view generation algorithms that our method is part of.

Thereupon, once the generation of the new process model data is concluded, the **Designer** performs the remaining steps to present the business process model in the canvas through the use of the *bpmn.io* library to design all the graphical BPMN elements and constructs that concern it.

4.2.2 The Process Repository

As a crucial component of our solution, there is a need to disclose the content of the *Atlas*' repository that is relevant to our work. It is structured as it follows:

- the **dimensions** that allow the visualization of different views;
- an **organizational taxonomy** for each dimension, which contains a collection of concepts organized into a hierarchical structure - **taxonomy tree** - and consequently a level of depth that increases proportionally with the level of detail desired;
- the **consolidated BPMN process models**;
- the **mapping** between the activities of the consolidated process models and the leaf nodes of the taxonomy trees.

The existing *Atlas*' repository metamodel is shown in Fig. 4.2 through a simplified UML class diagram. As shown, a Process is composed of Flow Elements that can be Activities, Gateways, or Events. Flow Elements are bidirectionally connected by sequence flows, making these connections represent the position of a Flow Element relative to another. A Process also has organizational taxonomies represented by Taxonomy Nodes whose aggregation with each other conceptually creates a taxonomy tree, illustrating a Dimension. Each organizational taxonomy has a single Taxonomy Root to which all the respective Taxonomy Leaves are attached as it is elucidated in the Taxonomy Node class's self-association. The leaves of the taxonomy trees classify each Activity of the Process.

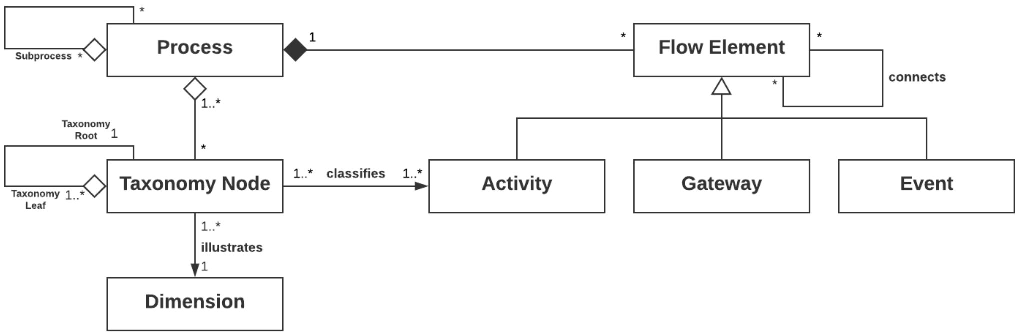

Figure 4.2: Unified Modeling Language (UML) class diagram of the *Atlas* tool's process repository metamodel.

However, the current repository's state dictates a few modeling **constraints**:

1. a small subset of BPMN elements such as activities, gateways, non-boundary events, and swimlanes is supported. Both pools and lanes are inferred from the associations between the taxonomy trees' leaf nodes and the process activities. The correspondent taxonomy tree root is depicted in the pool whereas its descendants in lanes;

2. only well-structured consolidated models are allowed. The splits and joins should be paired into single-entry-single-exit (SESE) blocks, respectively;

3. a standalone process activity appears in all views unless it is aggregated with other activities, thus forming a different activity.

To elucidate the readers, an example of a process model based on the repository metamodel is shown in Fig. 4.3 which states the information that the process repository contains for the *Bank Credit Granting* process introduced in Section 1.3.1. For the sake of simplicity, the associations between Process and Flow Element objects are not depicted. In given situation, the *Bank Credit Granting* process is only connected with two dimensions: *HR* and *Risk*, with 2 levels of detail each. For instance, the *HR* dimension has the concept *Bank HR* as Taxonomy Root Node at level 1 and the concepts *Functional*, *Administrative*, and *Strategic* at level 2. As expected, the consolidated process model shows the links between the Flow Elements accordingly with the associations made within the Business Process Model. Also, each activity, if applicable, is linked with one of the Leaf Nodes for each Organizational Taxonomy. For example, the *'Evaluate the Efficiency of Workflows'* activity is linked with the *Functional* leaf node as regards to the *HR* dimension and is not linked with any leaf node as regards to the *Risk* dimension,

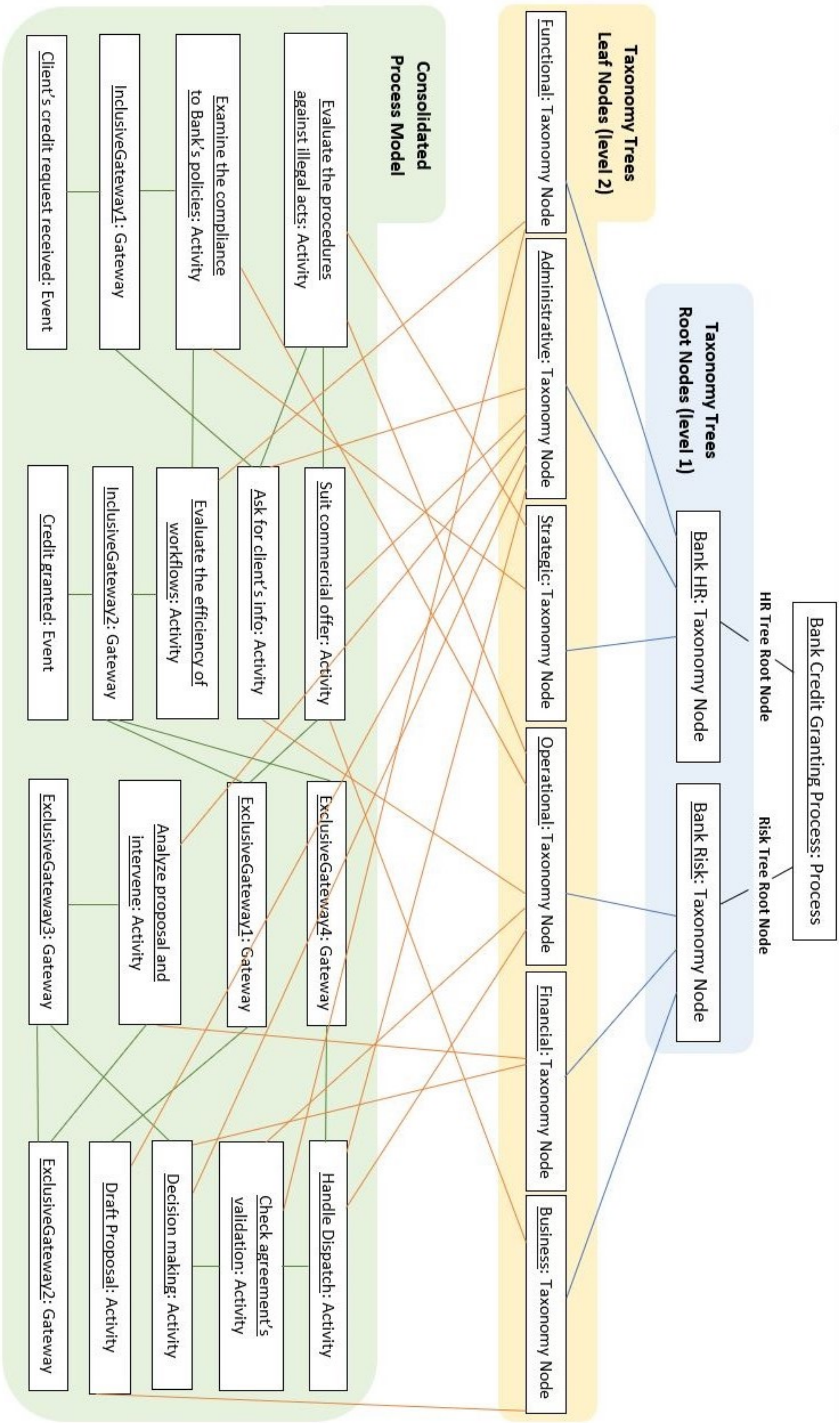

Figure 4.3: UML object diagram of the repository content for the *Bank Credit Granting* process.

once that activity is not a concern for the Risk stakeholders. These results can be visually understood in Fig. 1.1 where we can observe the only appearance of the aforementioned activity in the *HR* view and mapped into the *Functional* lane.

4.3 The Generation Method

Our solution is somehow related to business process variability modeling since more and more process variants are created to portray stakeholder's distinct concerns of the same process. According to [45] a process variability modeling approach is classified based on how it captures the relation between a set of elements of a process and the corresponding elements in its variants. Then, the *activity specialization* classification is the one that most nearly resembles the approach outlined here, since it only allows variants in process activities and not in other types of elements, which is aligned with the hierarchical abstraction technique that will be used: *functional decomposition*.

Our view generation approach is based on stakeholders' concerns by doing business process decomposition according to the concerns that are involved in the specification of its activities. **Decomposition** deals with breaking down a system into progressively smaller subsystems that are accountable for some part of the problem domain [46]. Thus, the *functional decomposition* of a process entails its recursive separation into progressively detailed activities. The lowest level of decomposition consists of indivisible atomic activities. Furthermore, the concerns, which have an associated dimension, are shaped by departmental interests and mapped to each of the process activities, making it possible to assign to each activity, its level of HR, IT, Risk, and Auditing. Along with it, there are various levels of detail in which the activities can be decomposed. This is accomplished through the taxonomy trees associated with each dimension. It is the tweaking of the dimensions and respective taxonomies that allows the generation of different views out of a consolidated business process model.

The current repository algorithm supports the generation of views based on the criteria for activity decomposition presented in [6]. Those criteria have one aggregation condition for each Zachman contextual dimension, yet the set of conditions is not fixed to those six dimensions. The choice of dimensions and their respective structure is configurable, then since there are as many conditions in the repository as there are dimensions, stakeholders can easily define new ones. However, in our approach, we concentrate on departmental dimensions, and our rule for decomposing process activities given a consolidated process model is presented below:

One activity δ can be decomposed into two activities α and β if and only if the activity δ is not deemed atomic, meaning it can be further decomposed. Once atomic, and given 2 dimensions 'd1' and 'd2', the activity δ is decomposed if and only if one of the following two conditions applies:

- *the activity δ has different taxonomy concepts within dimension 'd1' at a specific level of detail;*

- *the activity δ has equal taxonomy concepts within dimension 'd1', but different taxonomy concepts in other dimension 'd2' at the chosen level of detail of the latter.*

For instance, given a consolidated process model of a *Bank Credit Granting* process, if one chooses the HR dimension at level of detail 3 and the Risk dimension at level of detail 1, a given activity δ is decomposed if it is performed by different stakeholders at level 3 of the HR organizational taxonomy. However, if another chooses the HR dimension at level of detail 3 but the Risk dimension at level of detail 2, the activity δ could be even more decomposed if it has different types of Risk associated at level 2 of the Risk organizational taxonomy.

Nevertheless, considering the 3^{rd} constraint enumerated in Section 4.2.2, the views obtained from the iterations of the aforementioned rule to the consolidated process models may contain activities that, even though they are correctly mapped into a taxonomy concept (i.e. taxonomy node of an organizational taxonomy) within that view, they may not be needed to represent stakeholders departmental interests. This translates into filtering each activity's concern for a determined view. This filtering step of Algorithm 4.1 is based on the information provided by the stakeholders and uploaded in the modeling phase of a consolidated model in the process repository (left side, Fig. 4.1).

As described in Algorithm 4.1, an activity α is of concern to a view *V* if one of the following two conditions is verified:

- the activity α is performed by *V*;
- the activity α is of interest to *V* because that knowledge is relevant to get other tasks done.

Algorithm 4.1: Ascertain if an activity is a concern of a View.

Data: The view *V* and the activity α.
Result: A boolean that asserts if an activity α is a concern of a View V.

```
procedure IsAConcern(V, α)
begin
    if (α is performed by V) or (α is of interest to V) then
        return true
    else
        return false
```

Hereupon, as an add on to the already existing generation algorithm, Algorithm 4.2 is the pseudocode of a method that uses (1) Algorithm 4.1 as a condition to exclusively pick the required activities to serve the stakeholder's needs regarding a specific view, and for that purpose, the activities also need to (2) find a Taxonomy Node (i.e., departmental function, role, area, or other) in the organizational taxonomy of *V* that suits them. Otherwise, if both conditions are not met, the activities are mapped into a Taxonomy Outsider Node that becomes part of the taxonomy tree of *V* but is not relevant to *V*.

Algorithm 4.2: Picks the relevant activities for a View.

Data: The process *P*, the view *V*, the Taxonomy Trees part of the Organizational Taxonomy of the view *V*, and the activities of the process *P*.
Result: The generated concern-based and filtered view *V* distinguishing the activities that interest from those that do not interest the view *V*.

$P \leftarrow Process$
$V \leftarrow View$
$T \leftarrow TaxonomyTreesOfV$
$A[\,] \leftarrow ActivitiesOfP$

procedure ActivitiesPicker(P, V, T, A[ ])
$AV[\,] \leftarrow ActivitiesOfV$
$O[\,] \leftarrow OutsiderOfV$
begin
    $For\ \alpha\ in\ A[\,]$:
    if $\underline{\alpha\ finds\ a\ T\ node\ where\ it\ fits}$ **and** IsAConcern(V, α) **then**
        $add\ \alpha\ to\ AV[\,]$
    else
        $add\ \alpha\ to\ O[\,]$
    $show\ V \leftarrow AV[\,] + O[\,]$ relevant + irrelevant activities to V

As a result of applying the method, a concern-based and filtered view *V* is generated, distinguishing the activities that are relevant to the view *V* from those that are not.

Finally, Algorithm 4.2 along with Algorithm 4.1 compose a method that we call **solution artefact**. Recalling our hypotheses stated in Section 1.1, we can say with a great level of confidence that **the answer to the hypothesis H1 is 'yes'**. Through the solution artefact that we proposed in this chapter, we realize that the existing view generation algorithm from Cardoso and Sousa [9] is extensible enough to generate BPMN 2.0 concern-based business process views for organizational stakeholders.

However, in the next sections of *Demonstration* and *Evaluation* of the artefact, we present conclusive results of applying our method in two distinct real life cases, which will assist us in answering the hypothesis **H2** and in reaching our initial goals.

5

Demonstration

Contents

This chapter covers the 4^{th} step of the DSRM: *Demonstration*. At this stage, we show and explain the results of applying our proposed concern-based view generation method to two illustrative Real Life Case Studies: a *Bank* and a *Company*, so that we can demonstrate and later test the usefulness of our research while further help the reader's understanding of our solution.

To achieve these results and after we define the underlying business processes in a textual manner, a few steps need to be previously accomplished to provide a full description of each case study:

1. **identify the different concerns** of the departmental stakeholders regarding the business process.

2. **illustrate the consolidated business process model** as a result from the content populated in the Process Repository by the departmental stakeholders of the business process, after following the view integration method provided by Colaço and Sousa [8]. This step is portrayed in blue in Fig. 4.1 and is not described here in further detail because it is out of the scope of our work. The stakeholders create taxonomy trees by classifying each process activity according to their concerns which, in the particular case of our work, are departmental.

3. **list the available generation alternatives and showcase a selection of views** that address the stakeholders' concerns previously identified, through the process view generator represented in green, in Fig. 4.1, and the method we propose in this research, represented in yellow in the same figure.

5.1 Real Life Case Study #1

For this purpose, we recall the *Bank Credit Granting* process whose textual description is provided in Section 1.3.1.

We consider the HR, IT, Risk, and Auditing, as departmental stakeholders with interest in seeing their views depicted in the *Atlas* tool. Nonetheless, to simplify the reader's understanding of the results, in this section we will only demonstrate and cover the HR and Risk departments, contrary to the next chapter where we will examine and explore them all. However, some of the concern-based views generated through our solution are available for consultation in the Section 6.2 of the next chapter, and we represent part of the consolidated business process model with some of the connections between its activities and the taxonomy concepts for each one of the four departments, in Fig. 5.1.

Here, we show an upgrade of the HR and Risk views (earlier represented in Fig. 1.1) with more activities and a higher level of detail (taxonomy level 3) thus taking advantage of the dynamic taxonomies, since the views illustrated in Fig. 1.1 are considered too simple due to practitioners' comments to previous works.

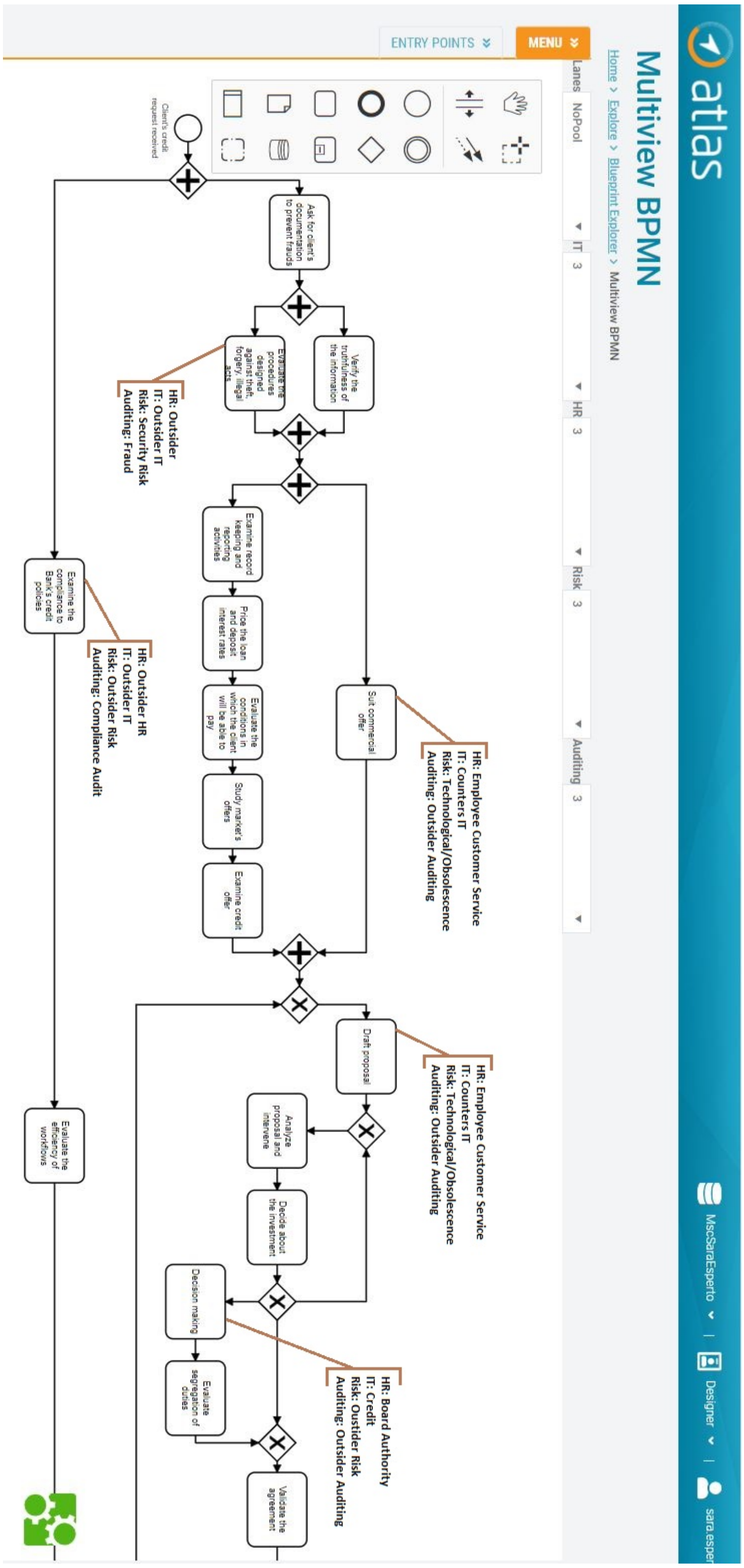

Figure 5.1: Part of the consolidated business process model of Real Life Case Study #1. Observe some associations between the *Bank Credit Granting* process activities and the taxonomy concepts that are represented.

In Fig. 5.2, the swimlanes of the top and bottom views are used to represent the concerns of the HR and Risk dimensions, respectively, and each activity of the *Bank Credit Granting* process is mapped into a taxonomy concept regarding the HR and Risk organizational taxonomies that we present below:

- **HR dimension ⟹ Bank HR (level 1):**
  - Administrative (level 2)
    - Employee Customer Service (level 3)
    - Board Authority (level 3)
    - Financial Advisory (level 3)
    - Maintain Employee Data (level 3)
  - Functional (level 2)
    - Performance Management (level 3)
    - Technology (level 3)
  - Strategic (level 2)
    - Compliance (level 3)
    - External Relations (level 3)
- **Risk dimension ⟹ Bank Risk (level 1):**
  - Strategic/Business (level 2)
    - Technological/Obsolescence (level 3)
    - Commercial (level 3)
  - Financial (level 2)
    - Credit (level 3)
    - Market (level 3)
  - Operational (level 2)
    - BPM – service delivery, client, business practices (level 3)
    - Legal (level 3)
    - Security (level 3)
    - People (level 3)
  - Outsider (level 2)

Bearing these organizational taxonomies in mind, the stakeholders can generate 18 different business process views. There are two dimensions and the swimlanes can portray either or none (2 options),

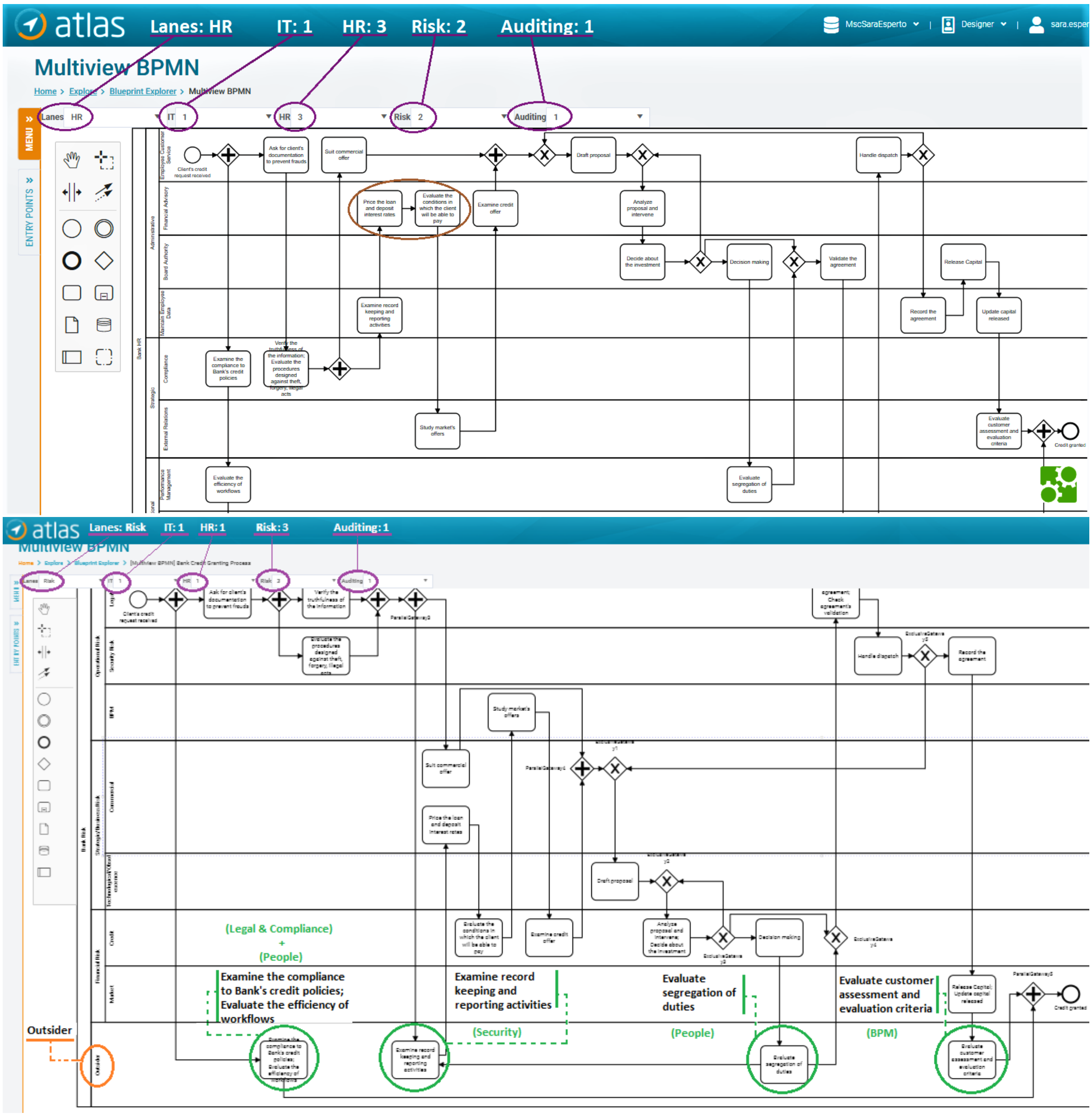

Figure 5.2: Screen of the *Atlas* tool after the generation of HR (top) and Risk (bottom) business process views at level 3 of detail.

the latter corresponding to the consolidated model. Furthermore, each dimension has three levels of detail ($3^2 = 9$ different combinations).

As required, the higher the dimension's level of detail, the more the process activities are decomposed, so if the lowest level of detail is chosen for all dimensions, there is no activity decomposition. The composed activities' name is simply the aggregation of the names of the activities that originated it.

On the one hand, at the top of Fig. 5.2, the HR view shows a scenario where all the activities (1) have a taxonomy node (in the HR organizational taxonomy) where they fit and (2) are a concern of the HR department who is interested in knowing all the parties and knowledge needed to perform each activity of the process. Also, as level 2 of Risk was chosen in the HR View (highlighted in purple as Risk: 2), activities like the ones highlighted in brown: *'Price the loan and deposit interest rates'* and *'Evaluate the conditions in which the client will be able to pay'* are decomposed because even if mapped into the same taxonomy concept at level 3 (Financial Advisory) within the HR dimension, they are part of different taxonomy concepts at level 2 of the Risk dimension (Business and Financial, respectively).

On the other hand, at the bottom of Fig. 5.2, the Outsider lane in the Risk view (highlighted in orange) represents the taxonomy node where all the activities that are not relevant to the Risk view will be mapped. Hereupon, by applying our method we conclude that all the activities highlighted in green (1) have a taxonomy node (in the Risk organizational taxonomy) where they fit and that relation is written in green brackets, and (2) are not a concern of the Risk department since those activities are mostly performed by the Auditing department, and they are not of interest to Risk because the knowledge they provide is not relevant to get Risk activities done. Nevertheless, those activities are necessary to keep the process' flow and in case that process fails, the stakeholders are easily aware of the problem's origin.

Then, reducing the number of relevant process activities is fundamental, especially when stakeholders are dealing with intricate processes like this. Afterwards, HR and Risk departmental stakeholders are presented with more enriched but less complicated views that better suit them by concentrating and only showing the concerns stated by them in the first instance.

5.2 Real Life Case Study #2

This Case Study #2 is also based on real life events but in this case of a Company. It represents a *Purchase Order and Reimbursement Expenses* process which was created and mostly modeled by us and based on the information provided on the Chapters 3 and 4 from Dumas et. al [3] book. The process' scenario is described below:

"This is an Online Sales Company that sells different kinds of products and has good reviews based on the way they deal with reimbursing their customers when something goes wrong. This process starts whenever a purchase order has been received from a customer. The first activity that is carried out

is understanding if the Company is dealing with a new customer. Next, it is necessary to check stock availability and, if the products of the order are available, the shipment address is received so that the product can be shipped to the customer and an invoice is emitted. Once the payment is received the order is archived, thus completing the process if the customer doesn't need reimbursement. If there is a need for reimbursement the employee fills an expense report and he is later notified of the receipt of it. Then, a new account must be created if the employee does not already have one. Amounts under a specific price are automatically approved while others require manual approval. In case of rejection, the employee must receive a Rejection notice by email."

Similar to the Real Life Case Study #1, we also considered the HR, IT, Risk, and Auditing departments as stakeholder groups. Following the application of the view integration method, the Process Repository is left uploaded with the consolidated business process model portrayed in Figures 5.4, 5.5. Again, we present some of the connections between its activities and the taxonomy concepts for each one of the four departments.

Once we have already explained and presented through textual descriptions the concerns of the HR and Risk dimensions in the Real Life Case Study #1, in this Case Study #2 we introduce the other two departments, IT and Auditing, by showing their organizational taxonomy in Fig. 5.3 through visual trees instead of textually. Note that both dimensions have 3 levels of detail and neither of the two trees has all the leaf nodes at the same level of detail.

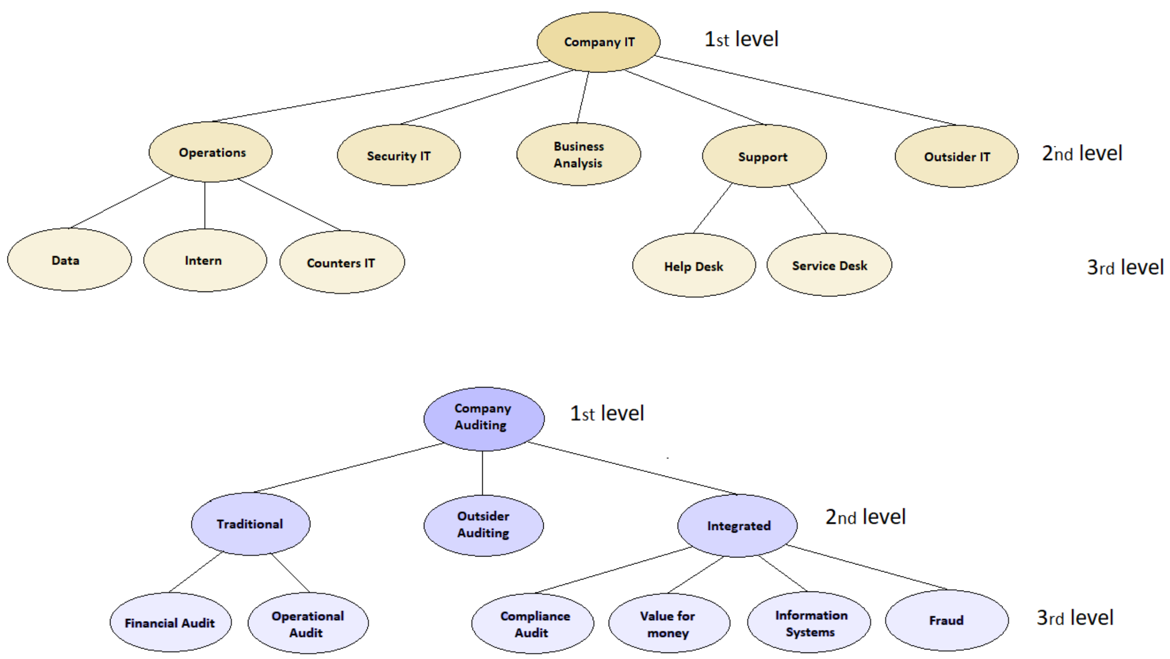

Figure 5.3: Organizational taxonomy for the Real Case Study #2 regarding the IT dimension in the gold tree (top) and the Auditing dimension in the blue tree (bottom).

However, following the same line of reasoning of the Case Study #1, these two organizational taxonomies allow the generation of 18 different process views, but if we consider the 4 dimensions (HR, IT, Risk, and Auditing), each one with 3 levels of detail, we are able to generate $3^4 = 87$ different combinations. Once we are also able to choose what dimension we want to see depicted in the lanes (4 options/4 dimensions), we have $87 * 4 = 324$ views available, with varying levels of detail yet a maximum of three degrees according to the taxonomies presented.

In table 5.1 we share some examples of concern-based generated views for this Case Study #2, by choosing different generation options with distinct levels so that we can see the multitude of choices we can model. At least, it was our intention to include in the demonstration examples each departmental view with a level of detail of 3 (maximum) while others with a level of detail of 1 (minimum), to see the decomposition of the *Purchase Order and Reimbursement Expenses* process through a recursive separation into progressively fine-grained activities which makes possible to notice all the details for each specific organizational department.

Table 5.1: Examples of concern-based generated views regarding the Company Real Life Case Study #2.

Stakeholder	**HR**	**IT**	**Risk**	**Auditing**	**Model**
HR department	3	1	1	1	Figures A.1, A.2
IT department	1	3	1	1	Figures A.3, A.4
Risk department	1	1	3	1	Figures A.5, A.6
	1	1	2	1	Figure A.7
Auditing department	1	1	1	3	Figure A.8

Also, this kind of departmental views with fine-grained activities is the one used in the next chapter, in Section 6.2.2, for the *Evaluation* of the solution regarding this process.

Hereupon, contrary to the previous Real Life Case Study #1 we made an effort towards always keep in mind an Outsider lane by including it in the taxonomy tree of each department, meaning in this case we have at least one activity, in all the views, that is not a concern of that specific department considered at each time, since that or those activities are mostly performed by other organizational stakeholders. Fig. 5.3 portrays the visual examples of including the Outsider taxonomy node, where all the activities that are not of interest to the departments will be mapped, in the organizational taxonomies of IT at the top, and Auditing at the bottom. This node is always included in the 2^{nd} level of detail because level 1 fundamentally neglects the dimension in the sense that there is no decomposition of activities concerning that dimension.

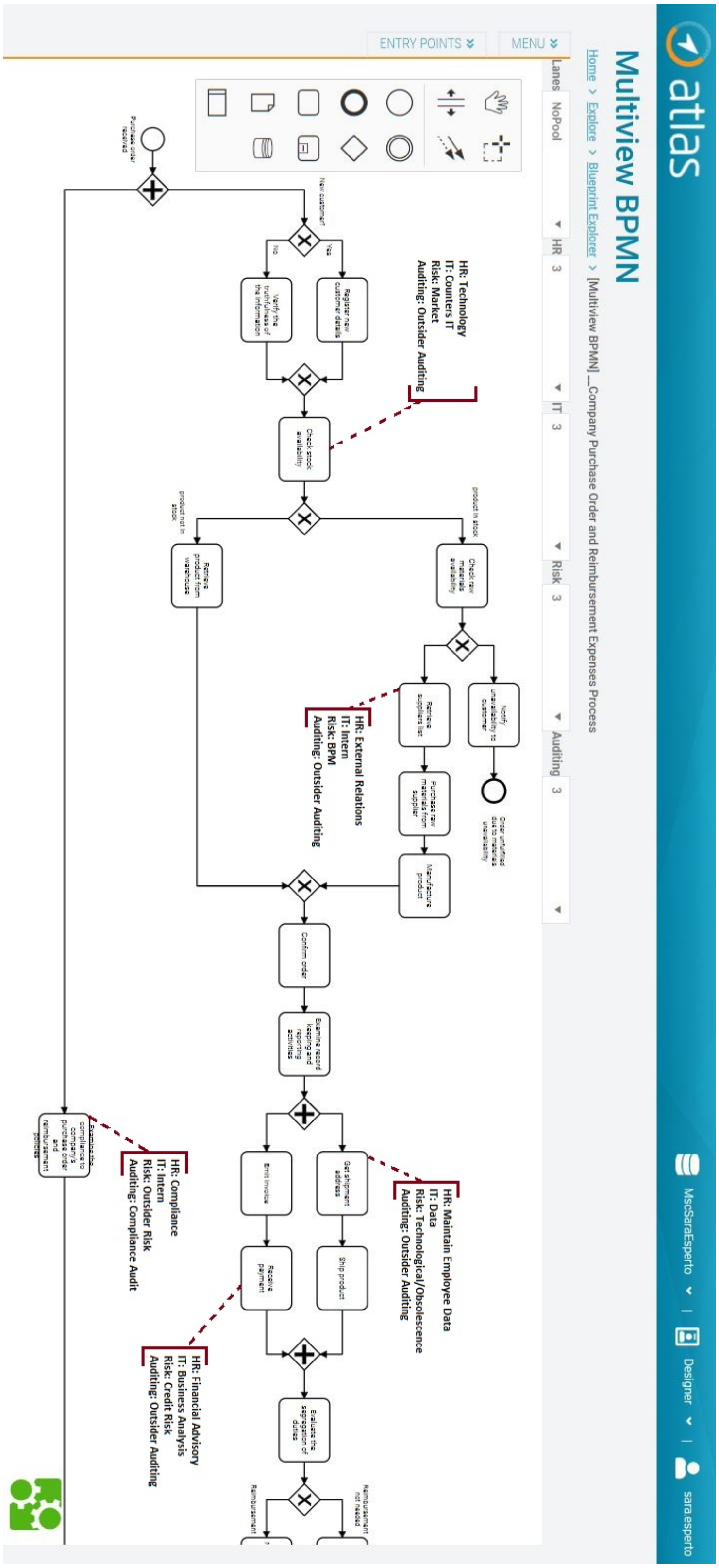

Figure 5.4: Part 1 of the consolidated business process model of Real Life Case Study #2. Observe some associations between the *Purchase Order and Reimbursement Expenses Process* activities and the taxonomy concepts that are represented.

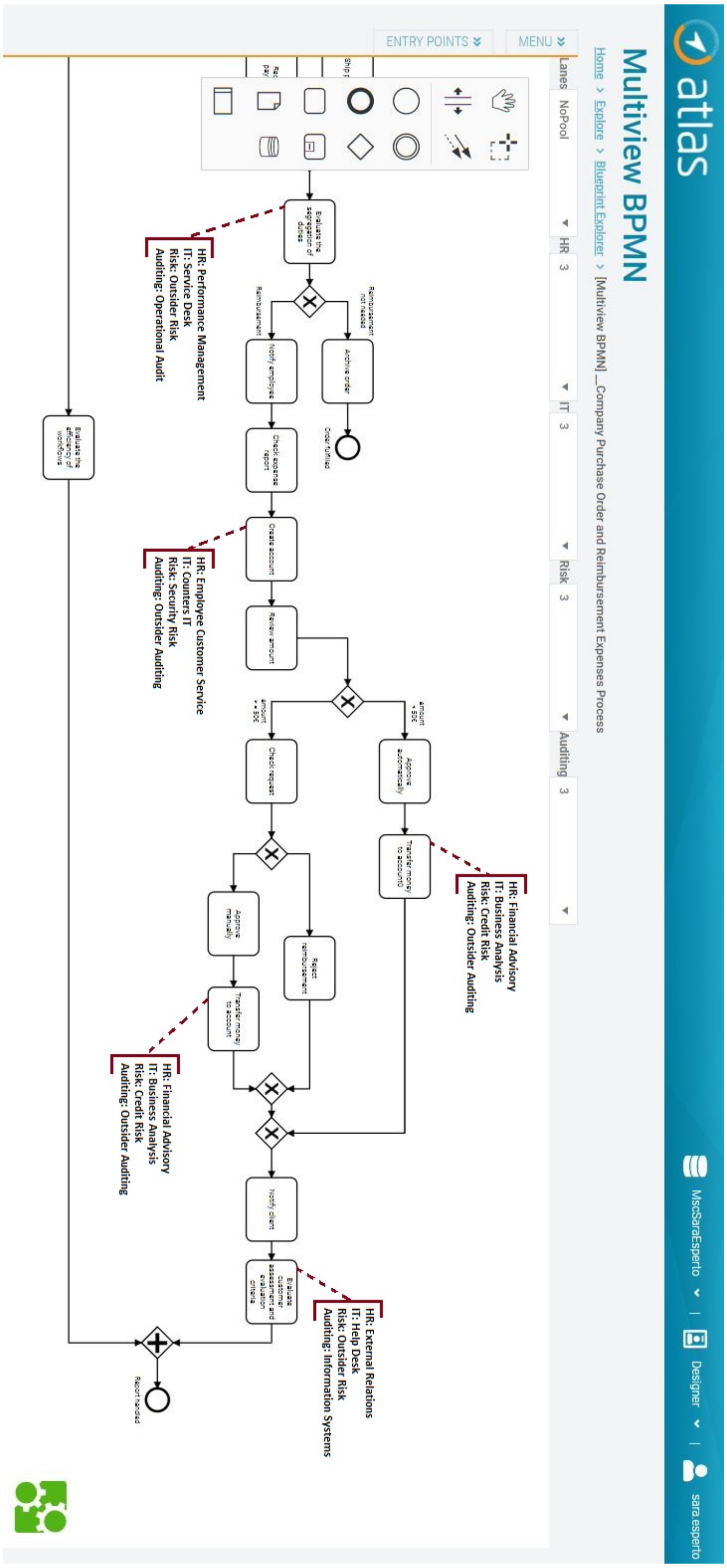

Figure 5.5: Part 2 of the consolidated business process model of Real Life Case Study #2. Observe some associations between the *Purchase Order and Reimbursement Expenses Process* activities and the taxonomy concepts that are represented.

6

Evaluation

Contents

This chapter covers the 5^{th} step of the DSRM: *Evaluation*. Here we aim to measure and validate how well the artefact we propose in Chapter 4 sustains a solution to the problem presented in Chapter 1. For that purpose, we divide the *Evaluation* step in two, meaning it will exist two different evaluation methods according to the real life case studies mentioned in the previous chapter:

1. **Case Study #1:** on the one hand, our main goal was to improve Cardoso and Sousa [9] approach to easily generate BPMN concern-based business process views, which benefit specific organizational stakeholder viewpoints. In order to achieve that, a Bank institution from Portugal made us available 4 different views from 4 distinct departmental stakeholders. Aiming to accomplish those views with our solution, we will now validate our research by making a comparison between the results collected and observed from the use of our artefact and those 4 views which are our point of arrival and a real life case study to solve.

2. **Case Study #2:** on the other hand, in order to understand if we developed a useful method for the stakeholders and if it enables to portray their concerns shaped by departmental interests, we made a survey about the views obtained from the Company's *Purchase Order and Reimbursement Expenses* process, presented in the *Demonstration* (Chapter 5), to get feedback from practitioners and to understand the impact of our solution on a daily basis. The feedback will also help to answer the **H2** hypothesis.

The *Evaluation* step ends with a discussion on the results we obtained.

6.1 Definition of Evaluation Methods

The assessment of our proposed artefact is made through the use of Design Science Research (DSR) evaluation methods already established in the literature. In particular, Prat et. al [10] recognize seven usual evaluation practices, such as practice-based evaluation of usefulness or ease of use, and demonstration.

Furthermore, Prat et. al particularly suggest making use of a taxonomy of evaluation methods for IS artefacts, composed of six dimensions: criterion, evaluation technique, form of evaluation, secondary participants, level of evaluation, and relativeness of evaluation. Then, an evaluation method is a unique combination of characteristics for the six dimensions. In Table 6.1, we benefit from this taxonomy and from the characteristics that apply to detail the two evaluation methods for the **Case Study** #1 and **Case Study #2**, which are **Demonstration/Comparison** and **Practitioners Feedback**, respectively. The Case Studies are explained in further detail in the previous Chapter 5, and the evaluation methods are described in this chapter, in Sections 6.2.1 and 6.2.2.

Table 6.1: Specification of the evaluation methods using the taxonomy defined in [10].

	Demonstration/Comparison	Practitioners Feedback
Criteria	Effectiveness Technical Feasibility	Efficacy Usefulness Operational Feasibility
Evaluation Technique	Illustrative Scenario	Survey
Form of Evaluation	Analysis	Analysis
Secondary Participants	CGD Bank of Portugal	Practitioners
Level of Evaluation	Real World Example	Real World Example
Relativeness of Evaluation	Absolute	Relative

In Table 6.1 we outline the five evaluation criteria used in this chapter to validate our research. Thereafter, we define each criterion followed by an elucidation of their significance in the context of our research.

- **Effectiveness:** "the degree to which the artefact achieves its goal in a **real** situation". In our approach, it is the degree of similarity obtained when comparing the four business process views modeled by the stakeholders of CGD Bank of Portugal (Case Study #1) with the four departmental concern-based business process views generated through our method in the *Atlas* tool.

- **Technical Feasibility:** "evaluates, from a technical point of view, the ease with which a proposed artefact will be built and operated". This criteria measures how easy is to develop a method and tool that supports the proposed solution.

- **Efficacy:** "the degree to which the artefact achieves its goal considered narrowly, without addressing situational concerns". In this context, it is the degree to which the concern-based business process views generated by our approach in the Case Study #2 are relevant for the process stakeholders.

- **Usefulness:** "the degree to which the artefact positively impacts the task performance of individuals". It is the degree to which the solution positively impacts the task of modeling business processes.

- **Operation Feasibility:** "evaluates the degree to which management, employees, and other stakeholders, will support the proposed artefact, operate it, and integrate it into their daily practice". Self-explanatory.

6.2 Case Studies

This section presents the *Evaluation* and consequently validation of this dissertation for the two case studies that the proposed solution aims to solve.

6.2.1 Case Study #1: Demonstration/Comparison

The **Demonstration** component of this evaluation method is somehow already proved through the use of the *Atlas* tool to execute our solution, which we thoroughly delineate in Chapter 4. Subsequently, a glimpse of the results captured by the tool is earlier shown using two Real Life Case Studies: a Bank (#1) and a Company (#2), in Chapter 5.

Below, regarding the **effectiveness** evaluation criterion, we will evaluate our solution by comparing the initial four departmental views provided by CGD Bank of Portugal stakeholders with the views obtained through the *Atlas* tool.

At the bottom of the Fig. 6.1, we have the automatically generated HR view by choosing the HR dimension to be represented in the lanes with a level of detail of 3. When comparing with the initial HR view from the Bank, we notice that all the activities that are of interest to this view (highlighted in violet) are mapped in the lanes where they are supposed to be. Also, as predicted, the stakeholders are presented with an Outsider lane where all the activities that didn't concern them in the first place are mapped. However, if they change their mind, it is always possible to generate the HR view of the Fig. 5.2 where all the activities find a taxonomy node (in the HR organizational taxonomy) where they fit and then enabling the Bank to know all the parties involved to perform each activity of the *Credit Granting* process.

Fig. 6.2 shows, at the bottom, the *Atlas* generated view high-lightening in green the activities of interest to the Risk stakeholders and modeled by the Bank stakeholders in the view at the top of the same figure. Alike the previous comparison, the activities were mapped to the taxonomy node/lane where they fit and according to the organizational taxonomy provided by the stakeholders at a level of detail of 3. However, unlike the HR view, some *Credit Granting* process activities that weren't considered in the Risk view provided by the Bank were maintained in the lanes other than the Outsider lane since those activities were considered to also have a Risk associated. The only activities mapped in the Outsider lane are the ones directly and only related with the Auditing view, therefore not being very relevant to the Risk department. The interactions with the Human pool and the pool itself are replaced with more general activities that represent those interactions since the solution we present is narrowly defined to work with single pool process models.

The comparison results of Fig. 6.3 for the IT view are quite similar to the ones obtained for the HR view. All the activities in which the IT departmental stakeholders are interested are highlighted in brown

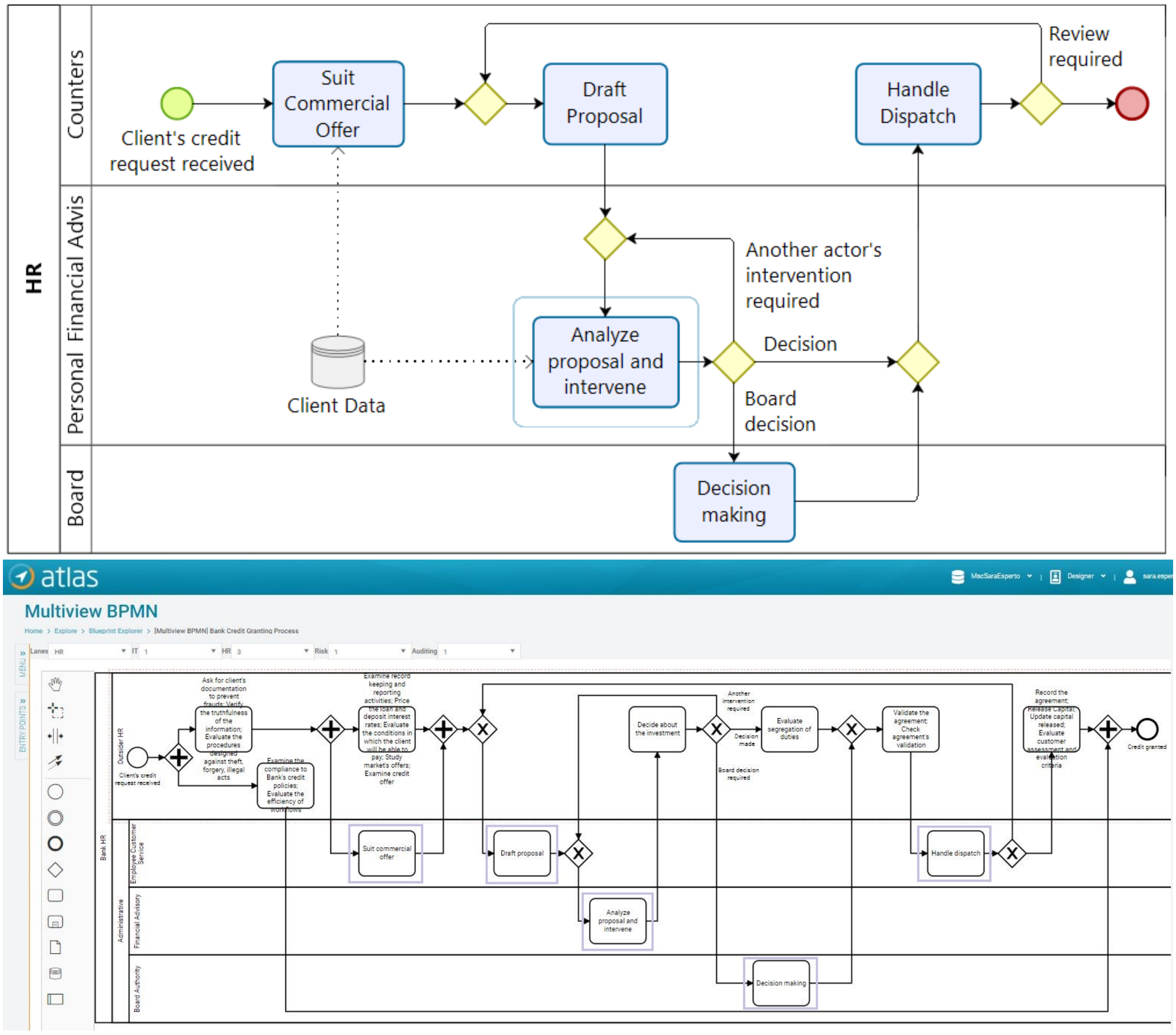

Figure 6.1: HR View of the *Bank Credit Granting* process, manually modeled by the HR stakeholders (top) and automatically modeled in the *Atlas* tool at level 3 of detail (bottom).

and mapped in the lanes where they are supposed to be. Even if not mapped to the exact taxonomy concept that they were in the first place in the view provided by the Bank, that is not a problem, because when considering an organizational taxonomy tree with more concepts and levels, stakeholders can find sharper fits for their activities.

Also, not all the activities of the view provided by the Bank can find a level of detail of 3 in the IT taxonomy, which is the case of the *'Analyze proposal and intervene'* and *'Check agreement's validation'* activities, that both in level 2 and 3 of detail are mapped in the *Business Analysis* and *Security IT*, respectively.

Similarly to the Risk view, some interactions with a *Human* pool represented by exchanges of messages, are replaced with more general activities like *'Ask for client's documentation to prevent frauds'*.

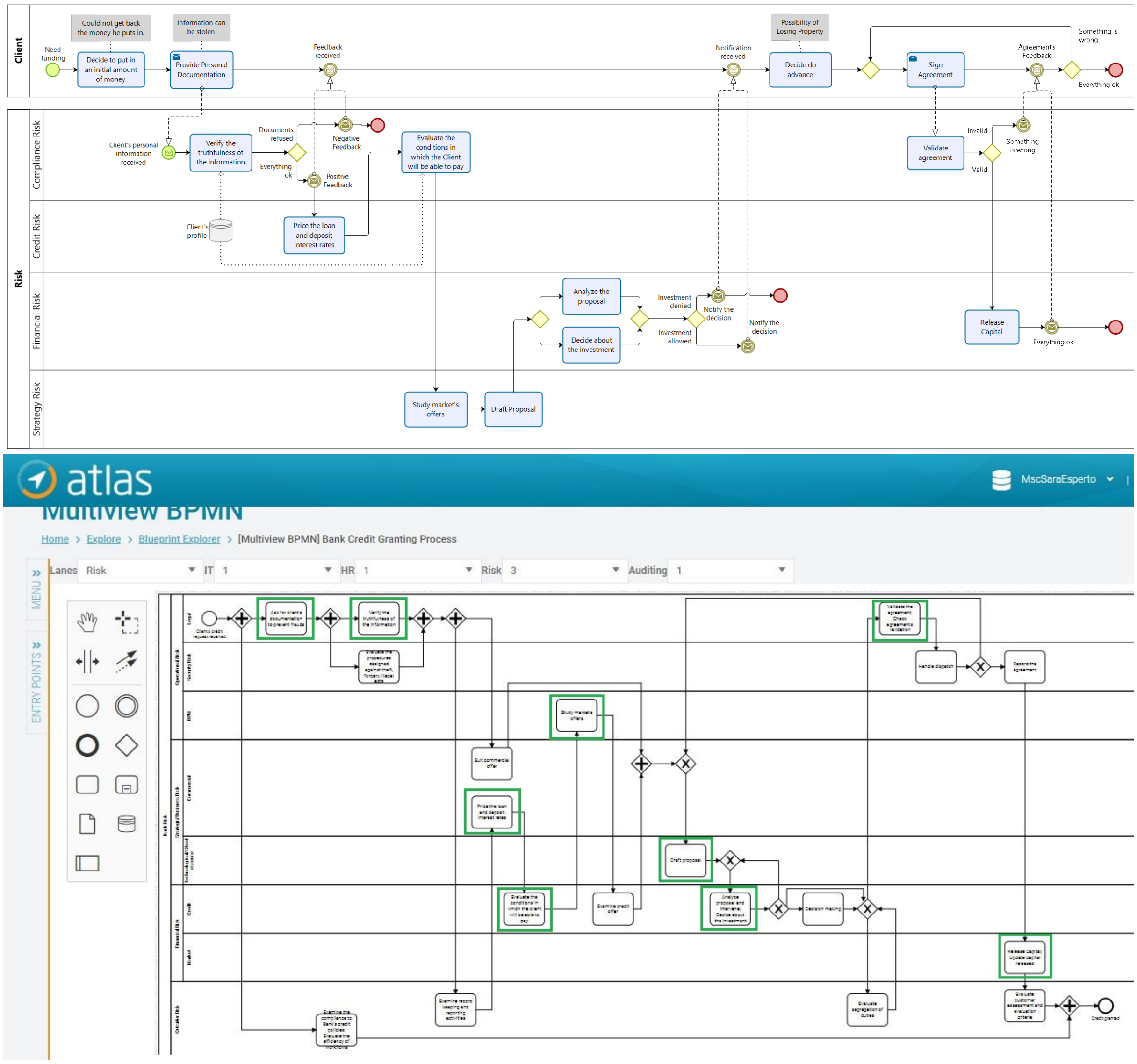

Figure 6.2: Risk View of the *Bank Credit Granting* process, manually modeled by the Risk stakeholders (top) and automatically modeled in the *Atlas* tool at level 3 of detail (bottom).

Finally, although there is an Outsider lane where all the non relevant activities for the IT stakeholders are mapped, it is always possible to generate an IT view where some other activities also find a taxonomy node (in the IT organizational taxonomy) where they fit and then enabling the Bank to know all the IT systems involved to perform each activity of the *Credit Granting* process, if applicable.

Last but not least, the comparison of the Auditing views is one of the most important, once it allows us to see the prominence of keeping in mind the flow of the processes. Through the Fig. 6.4, we notice that most of the Auditing activities are a consequence of other activities in the sense that those activities need to occur to be "Examined" and "Evaluated" by the Auditing stakeholders that mostly do their job in parallel. 7 out of 8 activities modeled in the view provided by the Bank were also modeled and generated

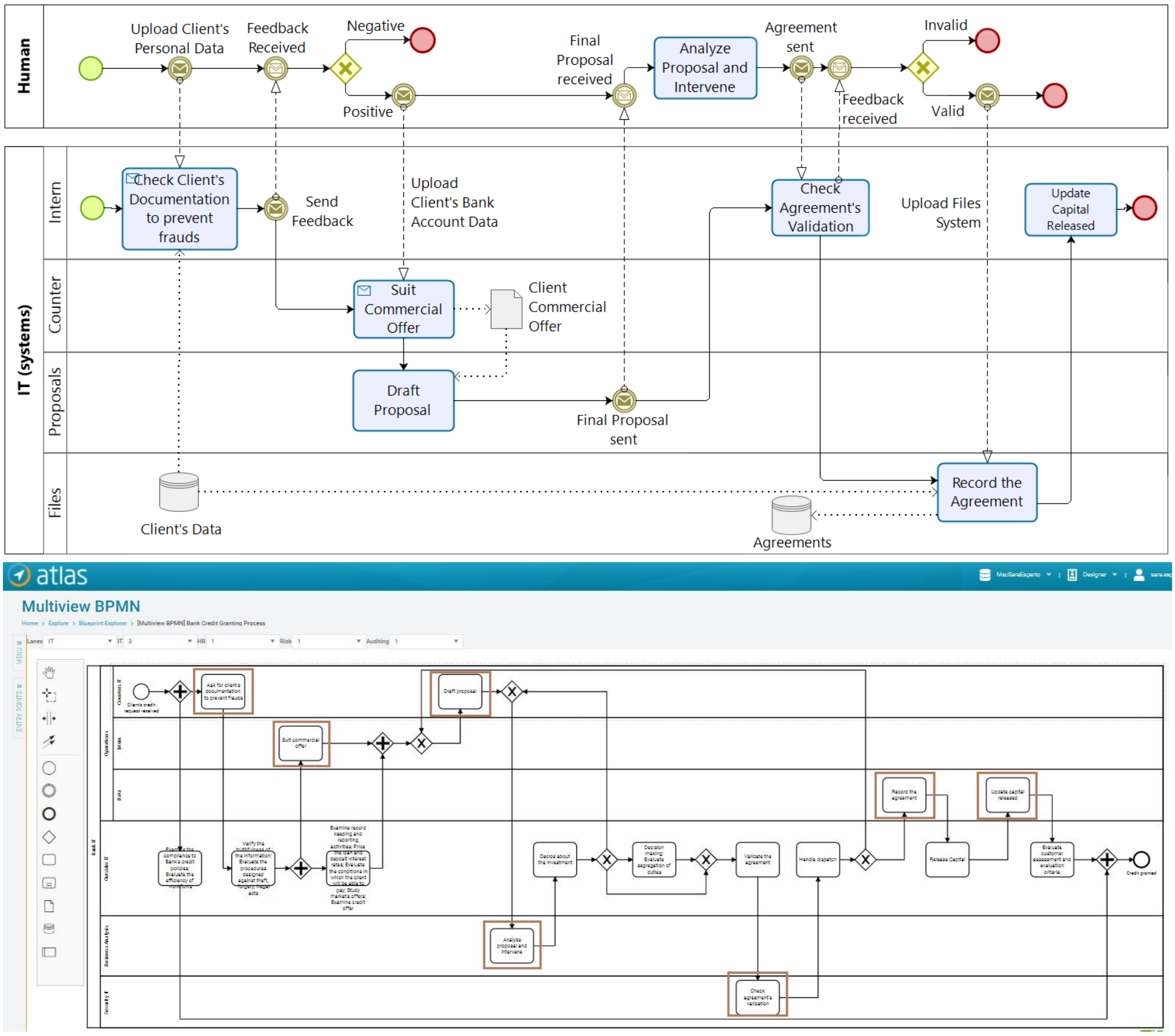

Figure 6.3: IT View of the *Bank Credit Granting* process, manually modeled by the IT stakeholders (top) and automatically modeled in the *Atlas* tool at level 3 of detail (bottom).

by the *Atlas* tool view and mapped to the corresponding lanes. Those activities are highlighted in blue.

Next, we evaluate the 2^{nd} Life Case Study and in the last section of this chapter, we discuss the results obtained for the chosen evaluation criteria.

6.2.2 Case Study #2: Practitioners Feedback

As a litmus test for our solution, we recruited leaders of the business process industry to participate in a small survey[1] (documented in Appendix B) with the objective of gathering feedback from practitioners that deal with the challenges of business process modeling and related documentation, on a daily basis.

[1] https://forms.gle/kgcomj12yjEPRTrR8

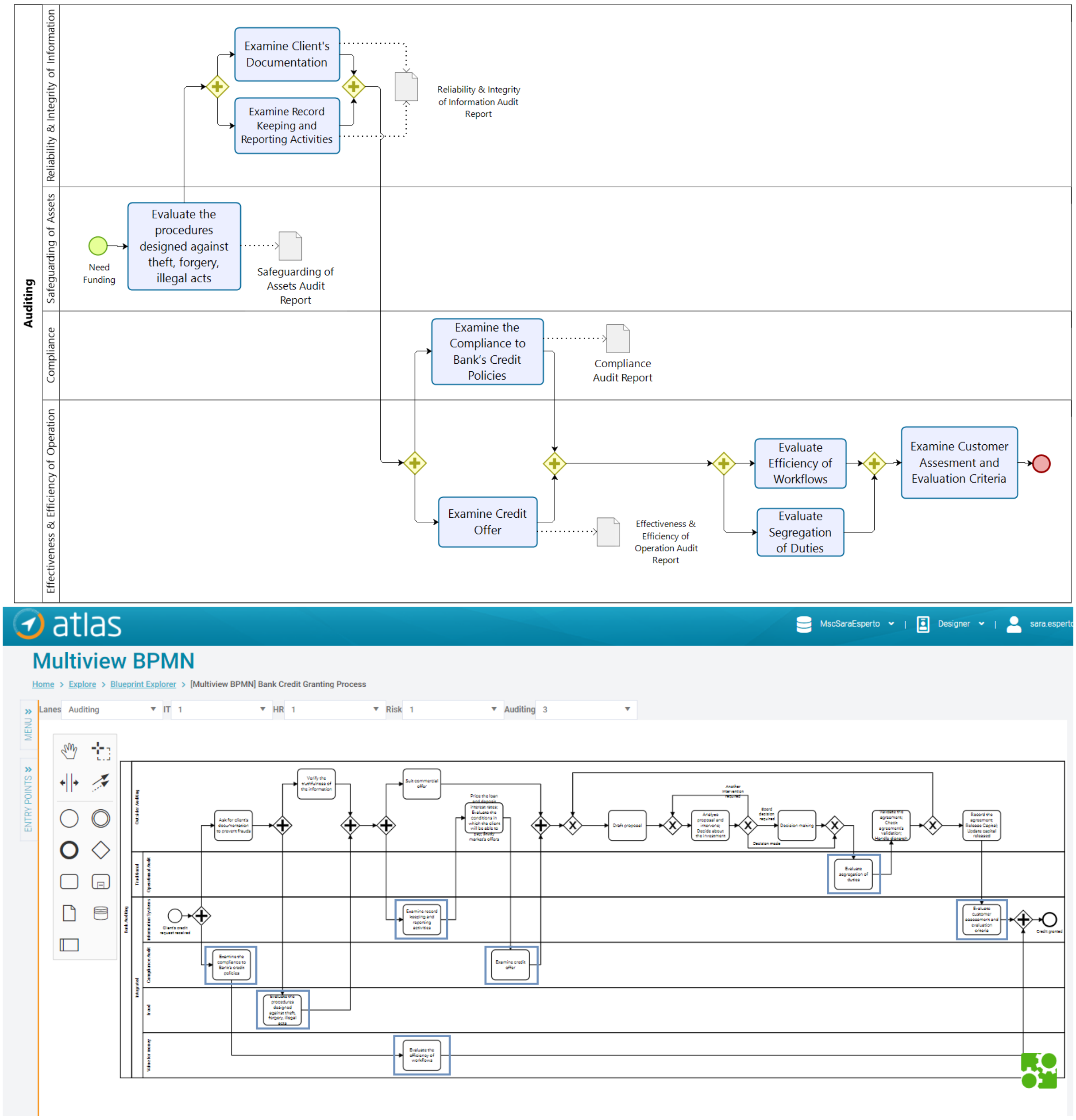

Figure 6.4: Auditing View of the *Bank Credit Granting* process, manually modeled by the Auditing stakeholders (top) and automatically modeled in the *Atlas* tool at level 3 of detail (bottom).

The participants were previously asked to sign a consent form where we also elucidate that their involvement presented no potential risks and no anticipated benefits to them. The survey was online and it was made available after an explanation and a whole demonstration of the solution in the *Atlas* tool. However, for those participants who didn't have the chance to see the demonstration, we provide a YouTube video[2] in order to clarify possible existing doubts. The goal of the survey was to evaluate

[2] https://youtu.be/04UkcwuPS5Q

and obtain feedback from the views generated regarding the Real Life Case Study #2 presented in Section 5.2.

The survey consists of 4 sections. In the first one, we aim to explain the role of the practitioners by inviting them to put themselves in the position of a stakeholder of one of the 4 departments of our research (IT, HR, Risk, and Auditing). Later, they are presented with a few statements about the concern-based views of the Table 5.1 and they are asked to evaluate the proposed solution in terms of Efficacy, Usefulness, and Operational Feasibility which are the selected evaluation criteria for this evaluation method (see Table 6.1). More precisely, the survey is composed of a few statements for each criterion and the practitioners need to pronounce their agreement with each statement in a five-point scale ranging from strong disagreement to strong agreement, and then justify their answer.

In terms of **efficacy**, one of the respondents neither agrees nor disagrees that the IT view expresses his concerns while agreeing and strongly agreeing that the remaining views model his concerns in a relevant way, encouraging stakeholders to better figure out business processes' reality. Overall, the respondent considers that the proposed solution is capable of modeling concern-based business process views that simplify the interests that each stakeholder wants to see depicted, rather than having a single complex view that aims to satisfy all the stakeholders at the same time.

Regarding the **usefulness**, the respondents agree that the proposed solution is geared towards to provide automatic assistance to stakeholders for obtaining concern-based business process views, once it adjusts the views' complexity to the needs of each moment. For example, in some circumstances, general views fit better than detailed ones. However, the statement about our works' positive impact in the task of modeling business processes is more contested, since the practitioners consider that it does not necessarily impact modeling, but certainly the visualization, exploration, and analysis of business process models.

Finally, in the last statement which is intended for evaluating the **operational feasibility** of our work, there is consensus that if integrated into the daily practice of an organization, the proposed solution would probably get the support of management, employees, and other relevant stakeholders, anywise one can not absolutely assure, but the guess is that people would approve such concern-based views.

6.3 Discussion

Based on the results reached in both the implementation and integration of our method in the *Atlas* tool and later through its demonstration in Chapter 5 and comparison with a Real Life Case Study #1 of a Bank, we feel confident in saying that our solution is **technically feasible** to handle and implement, once it can be easily integrated with an already existing artefact and then effortlessly operated.

Also, given the results of the comparisons made between the views provided by the Bank and the concern-based business process views generated by the *Atlas* tool, we can conclude that the solution also achieves its evaluation criterion of **effectiveness** by generating correct and also consistent business process views with various levels of detail and by portraying different stakeholders' concerns.

Then, through the evidence we were able to extract from practitioners survey about the Real Life Case Study #2 of a Company, we can conclude that the **efficacy** and the **usefulness** criteria were satisfied, yet we can not effectively conclude that the solution is **operationally feasible** since the respondents did not take a position of strong agreement about that topic. Their explanations lead to the idea of the need for accurate process support and evidence to help integrate our solution into the daily practice.

Even though we achieved quite profitable results, we believe that the deployment of the solution in a real organization would be of great value, since only the widespread and intensive use would allow a better validation of what we discuss here. This use would not only allow a better evaluation of the operation feasibility criterion but also determine, with a higher level of confidence, the achievement of the other criteria.

Finally, after answering in Section 4.3 to the hypothesis **H1** stated in Section 1.1, we recall the **hypothesis H2, which answer is 'no'**. The results achieved in this chapter and the previous one lead us to assert that even if extensible, the existing view generation algorithm from Cardoso and Sousa [9] is not viable and easy handling in real life contexts, once it didn't aim at offering to stakeholders the views that better fit their interests and represent their concerns like we did in our proposal. Through the practitioners' feedback, we discern that mapping stakeholders' concerns with the six dimensions (5W1H) of the Zachman Framework is not as viable and useful to organizations' as mapping them into organizational departments. Stakeholders are more interested to know who in the HR department is in charge of a specific activity and what are the risks associated when performing it. Only answering to 5W1H is too simple, seldom adequate, and not of great value to organizations. Their processes are more complex and cross inter-organizational boundaries and multiple departments, then requiring improvements of understanding and communication among them.

7

Conclusions and Future Work

Contents

Views address a set of related concerns and are tailored to particular stakeholders. The decomposition of business processes, when keeping stakeholder's concerns in mind, makes concern-based views an excellent mechanism to consciously convey details about an architecture and, in our particular case, to an organization that wants to see their departmental interests modeled.

Once we support the answers to the hypotheses **H1** and **H2**, in Sections 4.3 and 6.3, respectively, with evidence we can conclude that **our 1^{st} goal of giving results-based answers to both hypotheses was achieved.** In summary, the existing view generation algorithm from Cardoso and Sousa [9] is extensible enough to allow the generation of BPMN 2.0 concern-based business process views for organizational stakeholders, yet not viable and easy handling in real life contexts, leaving room for improvement, such as researches like ours.

This research aimed to expose the problem of the nonexistence of an approach that represents and benefits the multiple organizational stakeholder's needs, always remembering the required consistency. Our contribution to this problem is grounded on the development of a method, that supported by a business process repository, offers to the research community a solution that can be applied to tackle those organizational needs making it possible to obtain concern-based views based on existing consolidated models and organizational taxonomies. By continuing to use the organizational taxonomies together with the proposed dimensions and the possibility of choosing different levels of detail, we also expect to aid departmental stakeholders in communicating and expressing their distinct concerns when engaging in business process design. Moreover, the solution was intended to allow stakeholders to convey their concerns in a structured manner. That was accomplished by proposing an interactive solution in which the user is able to provide some inputs used to choose the dimensions and to create the organizational taxonomies, and consequently to model the final results. Hereupon, our method consists of a solution artefact that improves Cardoso and Sousa approach [9] by allowing the easy generation of more complex views that benefit specific organizational stakeholder viewpoints while addressing their concerns. Then, **we achieved our 2^{nd} goal.**

Despite some limitations that are intended to be extinguished in future work, this method differentiates itself from the other proposals as it consists of an incremental approach that can adapt to the growth of organizations and their business, by embedding time into the business process models. As far as we know, there are no other techniques or proposals to business process design that fulfill the requirements that our solution fulfills.

Finally, through this dissertation **we consider to have addressed our research problem once we validated and improved an already existing view generation approach**, allowing it to address the stakeholders' concerns and generate more complex views like the ones shaped by departmental interests as HR, IT, Risk, and Auditing. Beyond the method and the answers to the hypotheses, our developed work resulted in a set of three main contributions that we specify in the next section.

7.1 Contributions

This dissertation aims to tackle organizational needs by providing useful inputs about the generation of concern-based business process views supported by a business process repository with existing consolidated models and organizational taxonomies. More precisely, we contribute with:

- An algorithm to pick the relevant activities of a view based on stakeholders' concerns;
- A mapping between the set of departmental interests and the organizational stakeholders' concerns, and between those concerns and the corresponding dimensions;
- A concern-based rule for decomposing business process activities given a consolidated process model.

7.1.1 Research Communication

To *Communicate* the research problem and its importance, as well as its usefulness and novelty to relevant audiences, is the last step of the DSRM. Thus, considering our contributions to be relevant to the field of study, we communicated them to the scientific community by writing and submitting a scientific paper [47] in the proceedings of the Practice of Enterprise Modeling (PoEM) International Conference 2020 where, after being accepted, we were able to present it. All the practitioners' comments to the document and corresponding presentation triggered a useful discussion that significantly assisted us in the improvement of our work.

In addition, the submission and the public defense of this dissertation to a panel of judges and recognized industry experts can be considered another means of communicating our research. Lately, this work will be freely accessible to the research community or any other interested people.

7.2 Limitations

As a work in progress, the main limitations are imposed on the consolidated business process models that have some known constraints (presented in Section 4.2), which means that even if still compliant with BPMN 2.0 [12], the represented views assume various simplifications.

First of all, only a small subset of BPMN sequence flow elements, such as activities, gateways, and non-boundary events (start, intermediate, and end) is supported, discarding the use of elements like data objects, data stores, message flows, boundary events, transactions, cancellations, and compensations, etc. Also, the proposal we present is narrowly defined to work with single pool process models, yet with any hierarchy of swimlanes that always portray one of the stakeholders' uploaded dimensions in the process repository. Moreover, although it is not necessarily a limitation since all the activities are important to bring a wider perspective of the process, a standalone process activity appears in all views unless it is aggregated with other activities, thus forming a different activity.

Furthermore, as previously mentioned in the *Background* chapter, our research focuses on one of the phases of the BPMN Lifecycle: Process Discovery, aiming to improve documentation of conceptual AS-IS business processes models and smooth the communication and results amongst relevant stakeholders, that must be understandable, intuitive, and may leave room for interpretation. At this point, it is not our intention to generate executable and machine readable process models.

Lastly, only well-structured consolidated process models are allowed, as such, they must comply with some modeling restrictions: they must have only one start event, but can have multiple named differently end events; splits and joins should be paired into Single-Entry-Single-Exit (SESE) blocks, respectively; and activities and events have exactly one outgoing and one incoming arc (except for the start that does not have any incoming arc, and for the end event that does not have any outgoing arc).

7.3 Future Work

As future work, the aforementioned limitations should be mitigated through the following considerations:

1. increase the number of supported BPMN flow elements with a focus on data and message flows, and more than a pool per process, then improving the communication of the generated business process models and bearing in mind the real world users' interests portrayed in the views of the Real Life Case Study #1, emphasized at the top of Figures 6.2 and 6.3;
2. embody the generation of executable BPMN process models;
3. improve the business process design in order to remove some of the modeling restrictions imposed on the consolidated process models. Also, do some research work about open source BPM platforms to solve the placement of the gateways. A bad placement sometimes leads to the overlay of the sequence flow symbols. *Camunda* BPM platform appears to be a good answer once it is a native BPMN 2.0 process engine that can be embedded inside *Java* applications and it is flexible enough for workflow and process automation.

Besides handling our proposal's limitations, future work involves creating a higher number of case studies with a larger number of practitioners involved and industries other than banking and sales. This way we could not only obtain a higher accuracy on the results but also raise some interesting challenges we have not addressed like finding edge cases in which the solution is not a sharp fit.

Apart from that, it would be interesting to bring other phases of the BPM lifecycle to this research and also imagine the benefits and emerging constraints brought up for the business process orchestration subject.

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A

Examples of Concern-based Generated Views

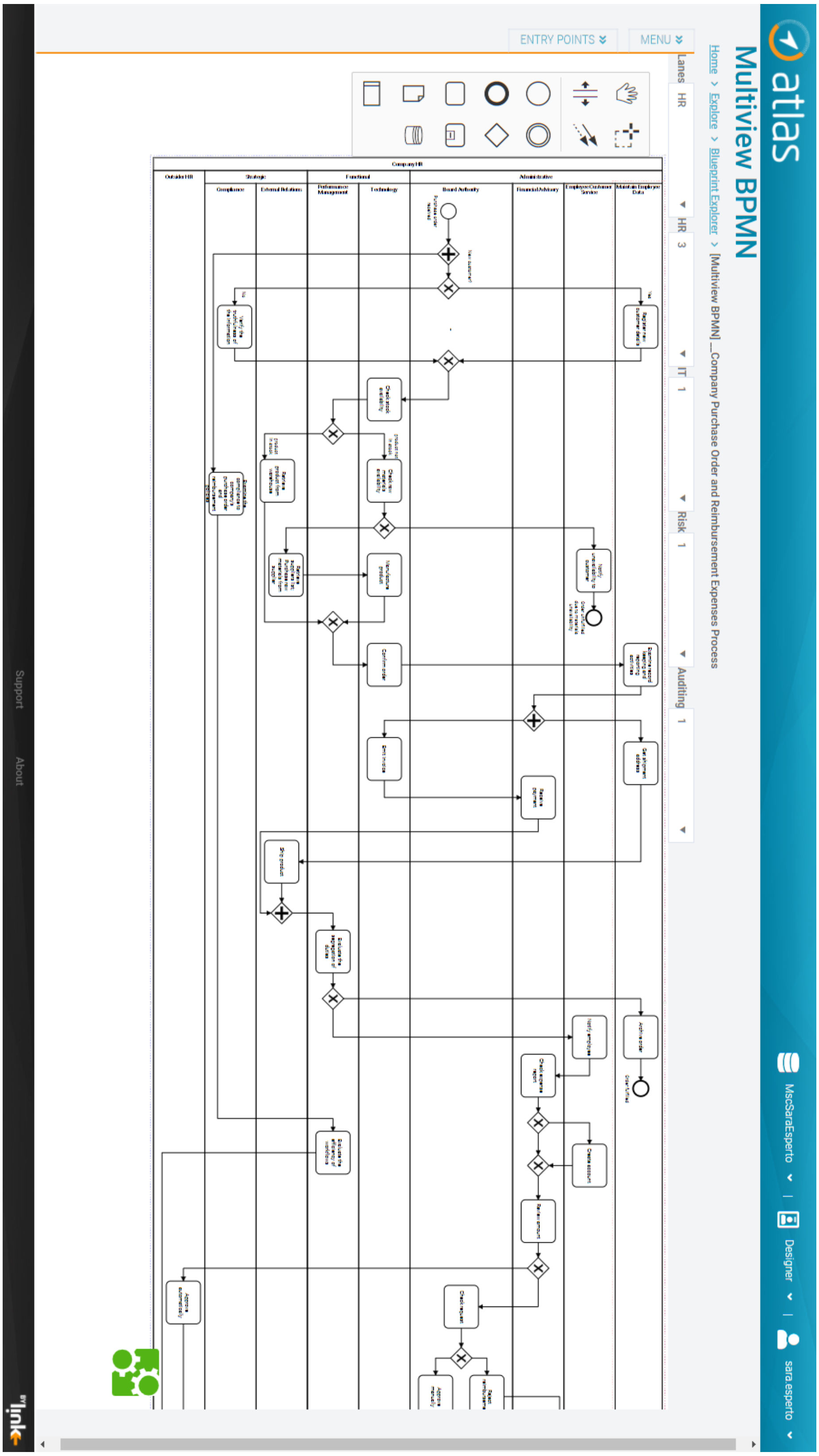

Figure A.1: HR View (Part 1) of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: HR — *HR*: 3 — *IT*: 1 — *Risk:* 1 — *Auditing:* 1.

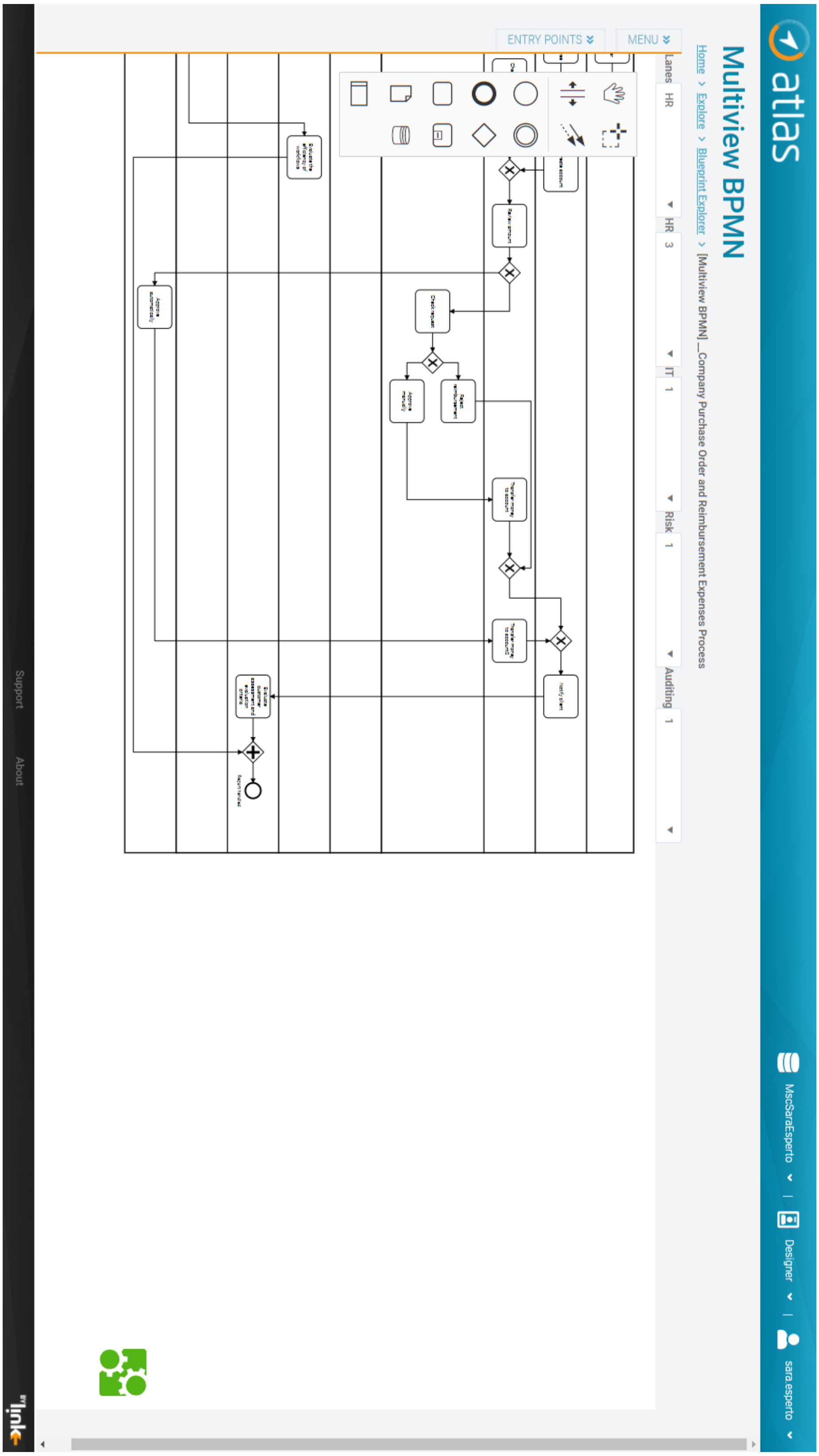

Figure A.2: HR View (Part 2) of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: HR — *HR*: 3 — *IT*: 1 — *Risk:* 1 — *Auditing:* 1.

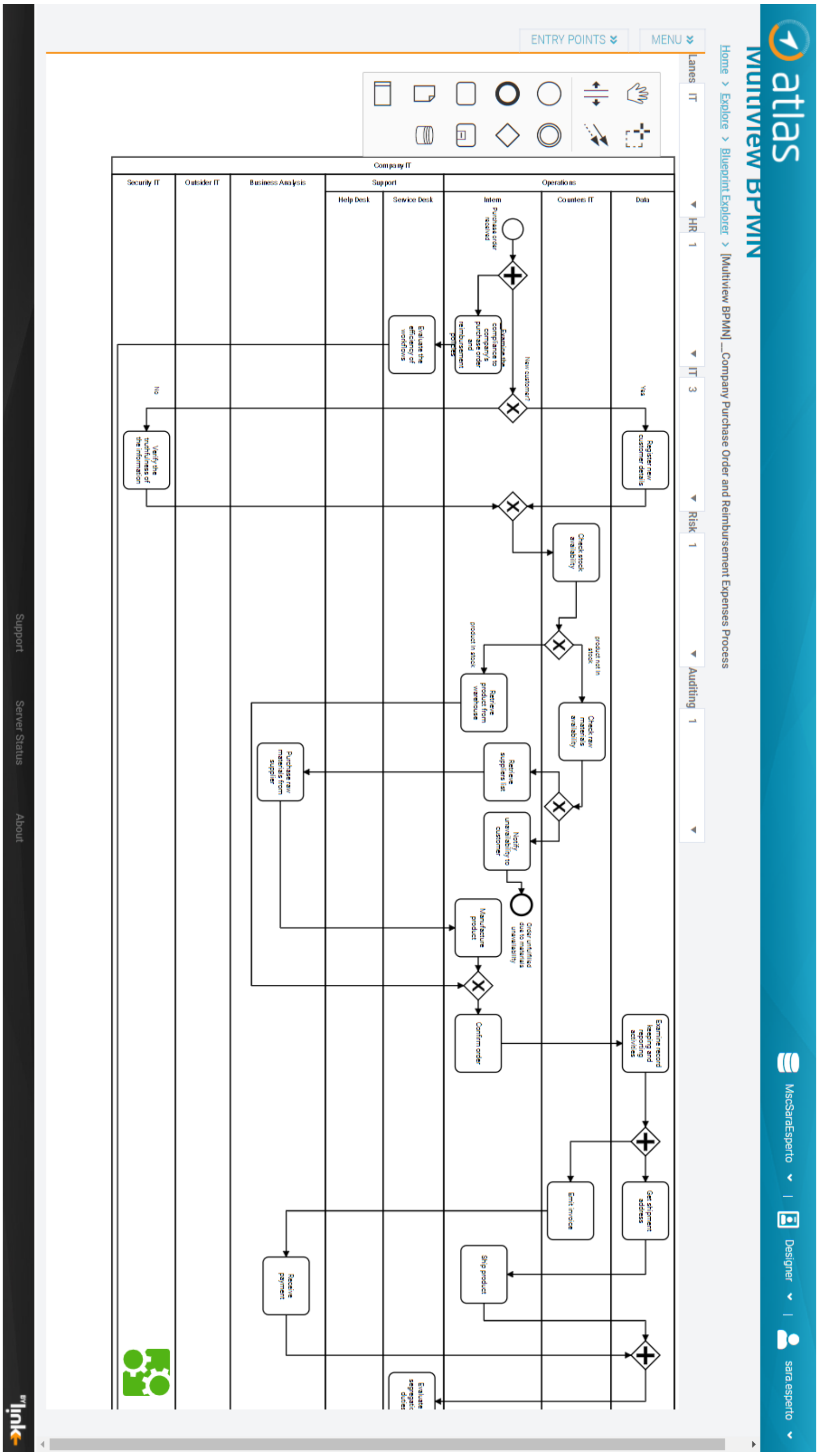

Figure A.3: IT View (Part 1) of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: IT — *HR*: 1 — *IT*: 3 — *Risk:* 1 — *Auditing:* 1.

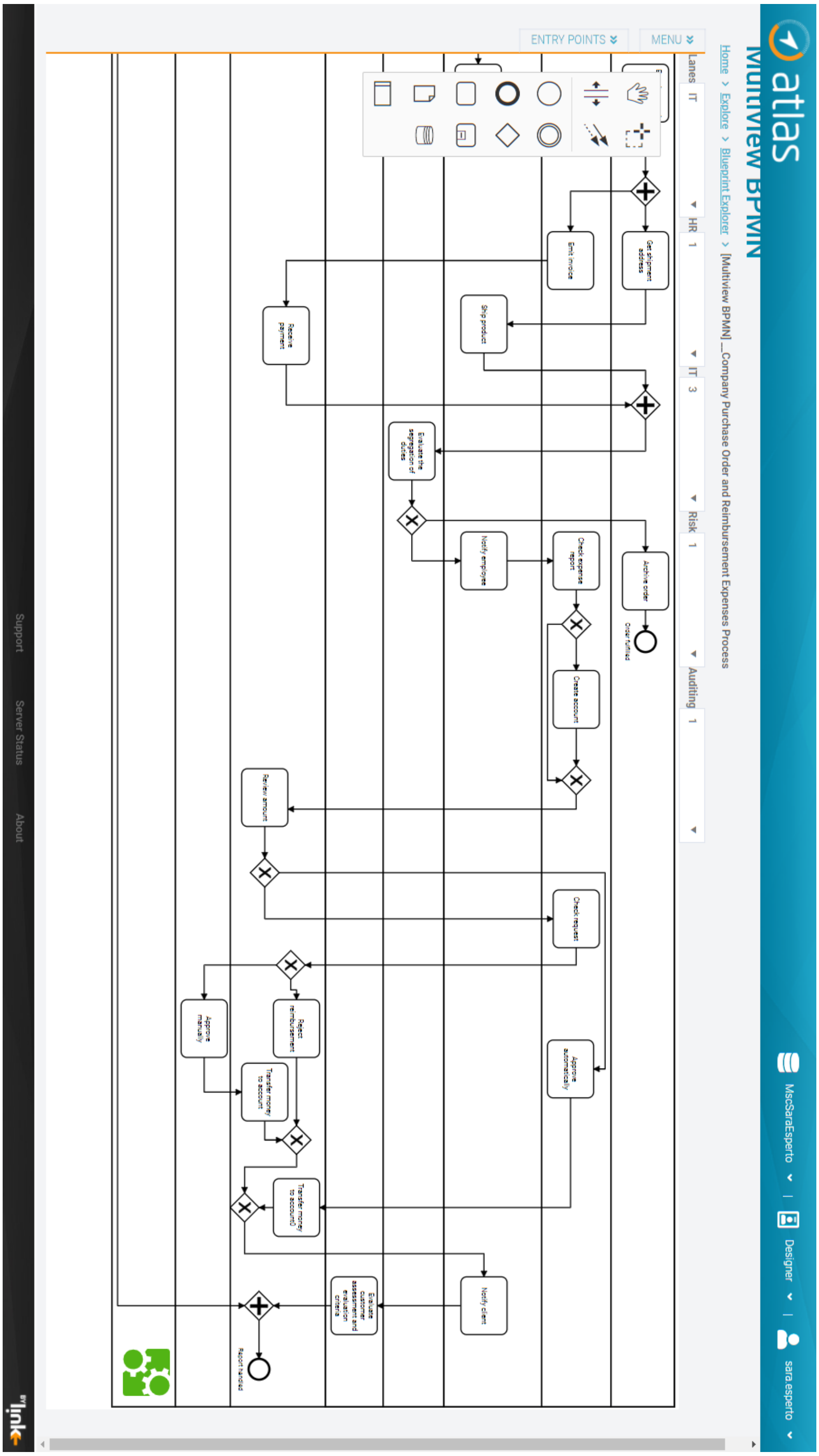

Figure A.4: IT View (Part 2) of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: IT — *HR*: 1 — *IT*: 3 — *Risk:* 1 — *Auditing:* 1.

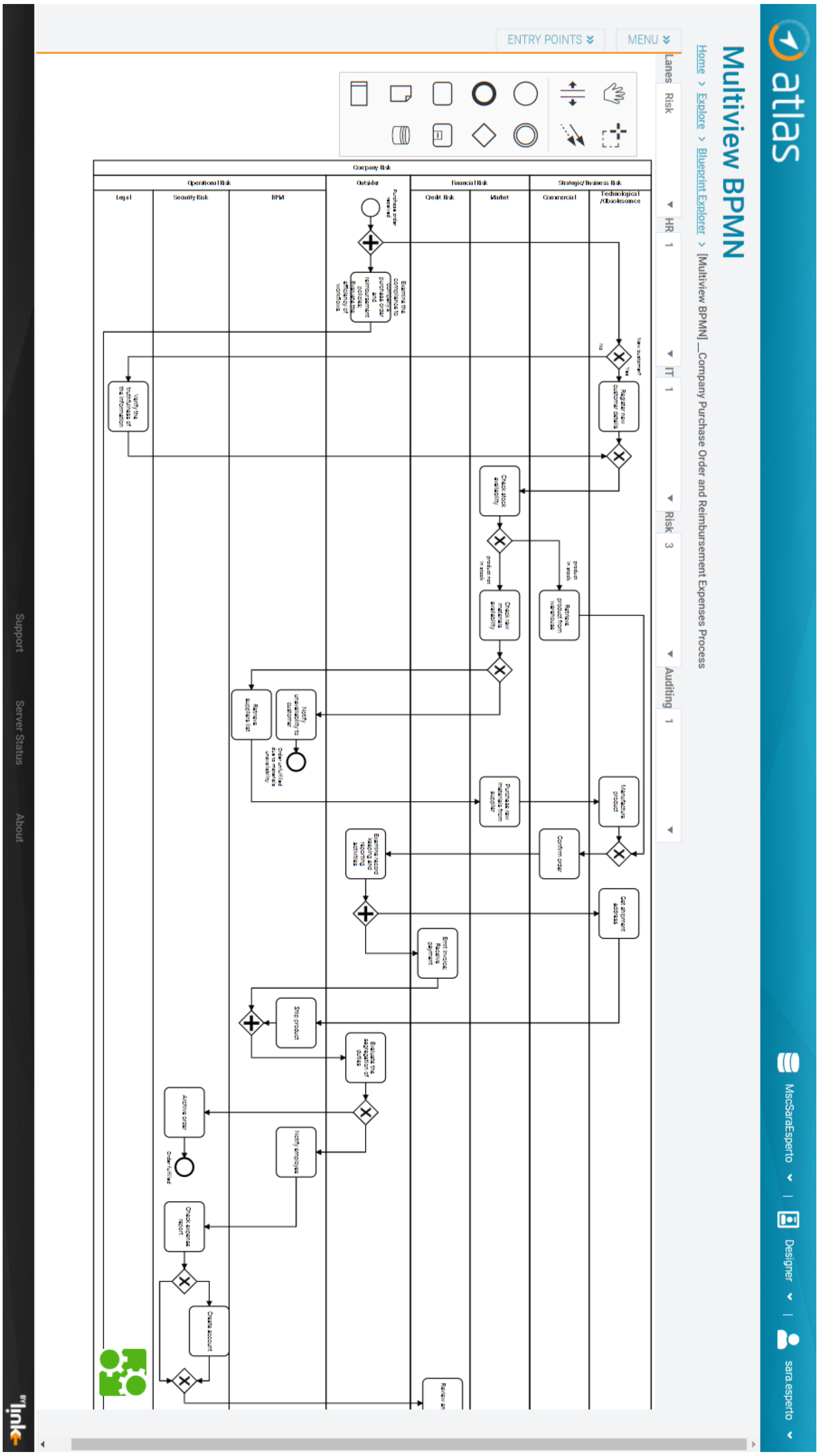

Figure A.5: Risk View (Part 1) of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: Risk — *IT*: 1 — *HR*: 1 — *Risk:* 3 — *Auditing:* 1.

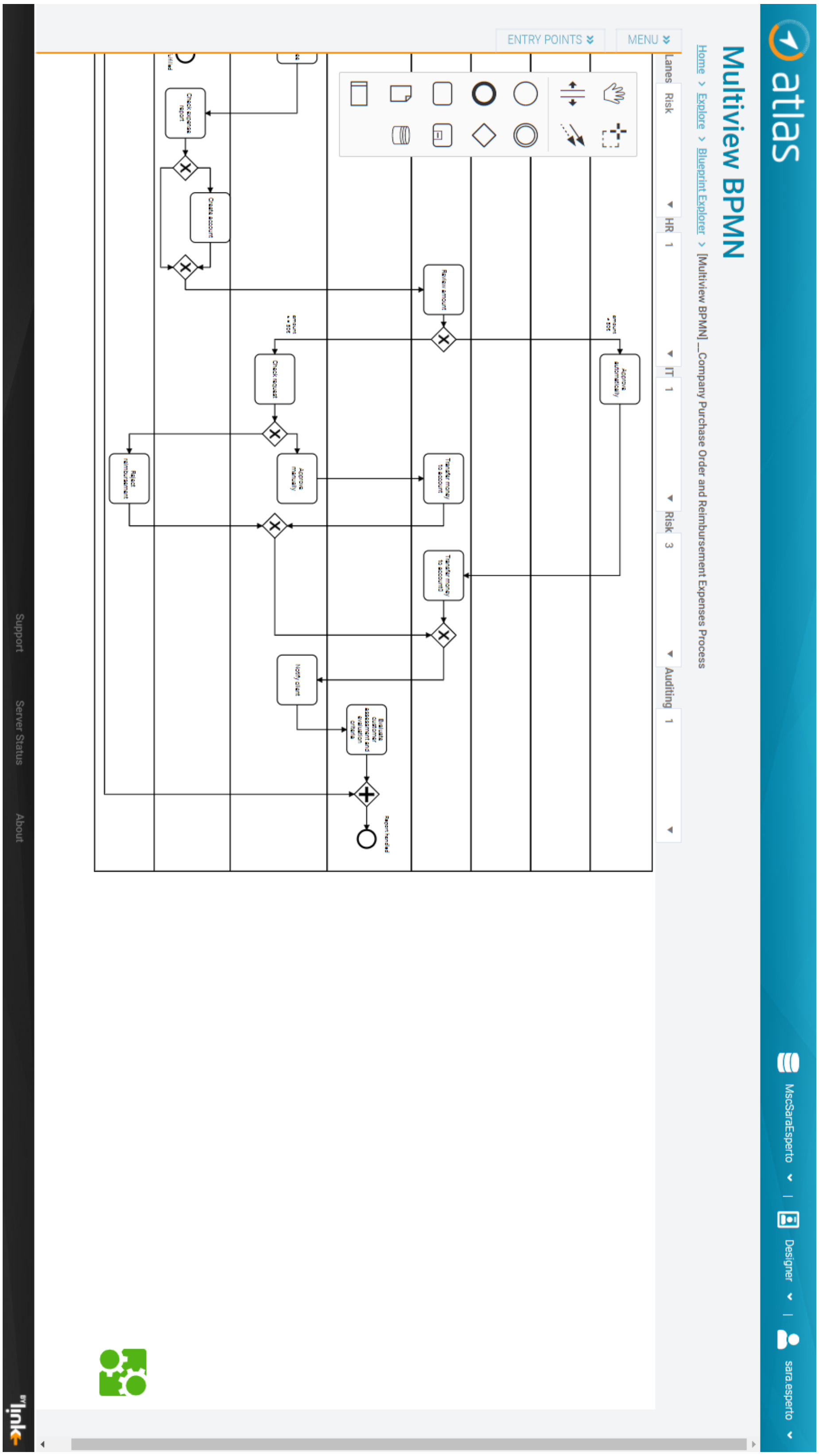

Figure A.6: Risk View (Part 2) of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: Risk — *IT*: 1 — *HR*: 1 — *Risk:* 3 — *Auditing:* 1.

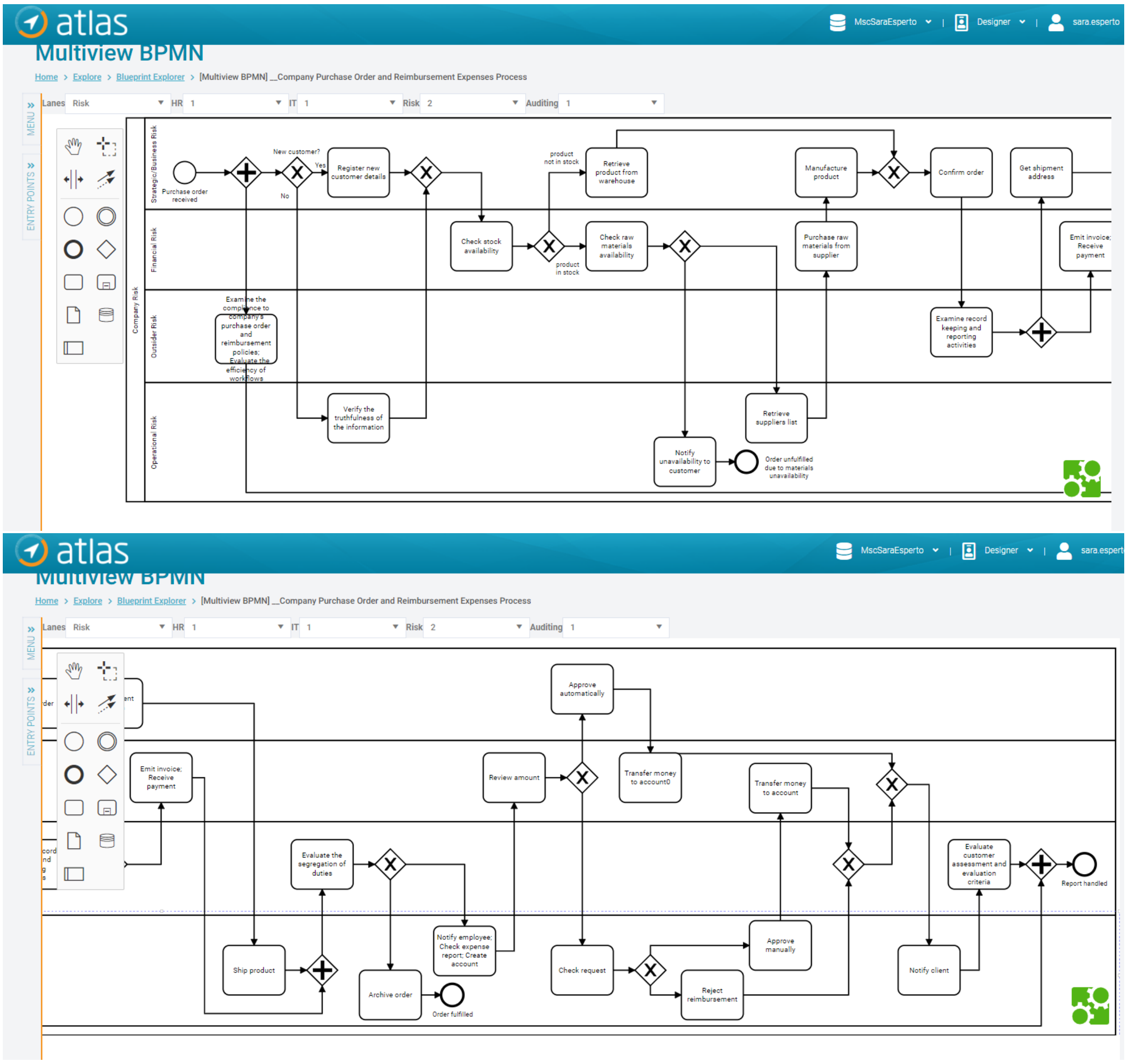

Figure A.7: Risk View of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: Risk — *IT*: 1 — *HR*: 1 — *Risk:* 2 — *Auditing:* 1.

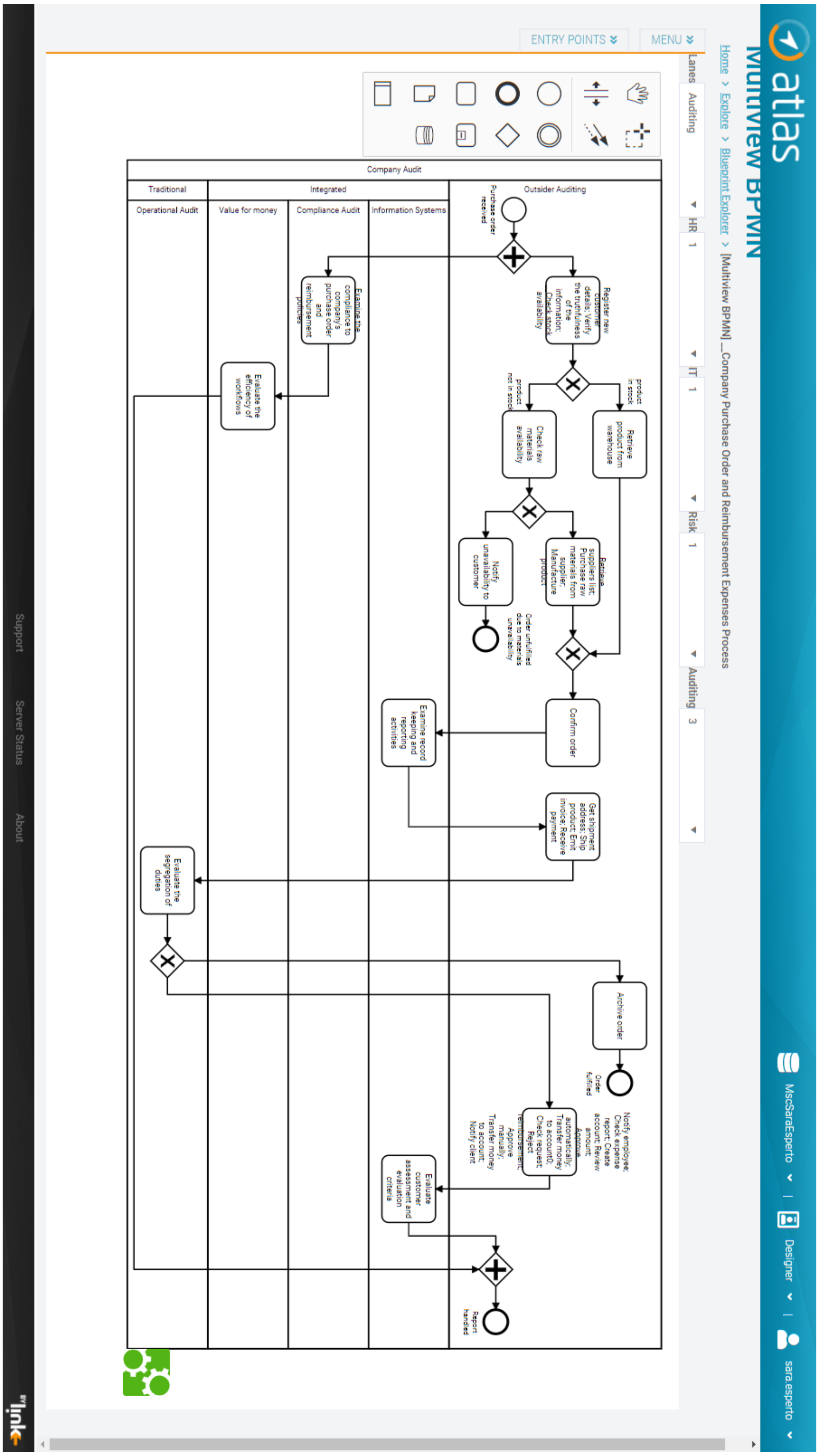

Figure A.8: Auditing View of the *Company Purchase Order and Reimbursement Expenses* process (Real Life Case Study #2), by setting the options *Swimlanes*: Auditing — *IT*: 1 — *HR*: 1 — *Risk:* 1 — *Auditing:* 3.

B

Practitioners Survey

Practitioners Survey: 'Generation of Concern-based Business Process Views'

Name: ___________________________________

Function/Job: ___________________________

Institution/Company: ____________________

Your role

Firstly, we invite you to visualize our solution in this video: https://youtu.be/O4UkcwuPS5Q . Take your time to see the concern-based generated views and how the solution was made.

Then, during this survey, we invite you to put yourself in the position of a stakeholder of one of the following departments, one at a time, accordingly:

- Human Resources (HR), Information Technology (IT), Risk, Auditing.

After, you will be asked to evaluate the proposed solution in terms of Efficacy, Usefulness, and Operational Feasibility. To answer the following questions, please consider that a relevant organizational taxonomy and a consolidated process model are already present in the repository.

Efficacy

See Figures A.1, A.2, A.3, A.4, A.5, A.6, A.7, A.8.

1. On a scale from 1 to 5, as a stakeholder of each one of the departments, evaluate the following sentence: 'The proposed solution generates business process views that express my concerns'.

	1	2	3	4	5
HR	☐	☐	☐	☐	☐
IT	☐	☐	☐	☐	☐
Risk	☐	☐	☐	☐	☐
Auditing	☐	☐	☐	☐	☐

2. 'The proposed solution generates business process views that are relevant to the process stakeholders'.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Justify your answer.

Usefulness

3. 'The proposed solution was demonstrated as being useful since it provides automatic assistance to the stakeholders for obtaining concern-based business process views'.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Justify your answer.

4. 'The proposed solution positively impacts the task of modeling business processes'.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Justify your answer.

Operational feasibility

5. 'If integrated into the daily practice of an organization, the proposed solution would get the support of management, employees, and other relevant stakeholders'.

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Justify your answer.
