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Hybrid Business Process Modeling

Projeto de Dissertação

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Abstract

The current situation of the business world it’s in a stage of great competitiveness and this leads current organizations to come up with some kind of strategy that can maintain them in its prowl. They then create and implement mechanisms that quickly and successfully promote the development and optimization of their Information Systems. The more agility and updated an organization is, the more distinction it can be from the other companies. This factor is the most important advantage in giving response in a timely manner to the market pressures, needs and opportunities.

This leads organizations to focus on their business processes to present high levels of competitiveness and realize that these processes can be a main factor for their success. But because this isn’t an easy task, organizations manage their approach through a set of organized activities, to ensure greater control, flexibility and ability to align organizational processes with organizational strategy. One of these activities in this approach is the hybrid process modeling, that has the ability to define and change organizational processes in a more reflected and structured way and also the ability to make them much more simple and easy to make and understand.

This work intends to deepen the knowledge about process modeling and to perform a lithographic review on the various languages of business process modeling, such as BPMN, CMMN and DMN. It is also intended to make a study on how best to combine all these languages to produce an effective and perceptible process modeling.
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1. Introduction

This first chapter will present the problem statement, that includes the motivation for the project realization. Then it will be explained the objectives and the expected outcomes. Finally, the last point being approached will be the document structure with the reference to the chapters studied in the project.

1.1 Problem Statement

BPMN is an important language for the modeling of business processes. It has a great capacity to represent the most procedural parts of any process, that is, tasks that are repetitive or consistent, they are typically suited to business processes characterized by some stability, where the threads and sequences of activities and decisions can be predefined. Its use has been growing day by day due to the need of business studies.

However, this type of language is already less appropriate in situations of greater variability, in which the execution logic needs to be more flexible. For these situations a less procedural and more declarative approach to process modeling would certainly be more appropriate. Compared to procedural process modeling approaches that tend to produce "closed" models, declarative process modeling approaches produce "open" models, and languages such as CMMN and DMN came to complement it with the ability to operate at that level.

Often, in the same business process, there are procedural parts with declarative parts. It is in this context, complementing the BPMN, adequate to the most procedural parts of the processes, that the CMMN proposal is introduced, by being capable of translating much of the flexibility and adaptability required by the more declarative parties, along with the DMN, capable of representing complex business decisions embodied in the BPMN and CMMN models.

Thus, in this work the hybridization of the three languages will be explored to model a passive business process of having all kinds of elements, procedural or flexible, that exist in organizations, exploring the modeling of processes using the conjugation of those three languages.
1.2 Objectives and Expected Outcomes

As we know BPMN (Business Process Model and Notation), currently in its version 2.0. It is considered the standard in terms of organizational process modeling. However, several other modeling languages appeared to complement and support it.

This work has as main objective the modeling of a sufficiently representative hybrid business process, that integrates the languages BPMN, CMMN and DMN. This will require knowledge of business process modeling and the systematization of the current state of BPMN, CMMN and DMN languages.

The expected outcomes of this project are the verification of the possible coordination and compatibility of the three languages, the effectiveness of that hybrid modulation and the advantages it would bring to any organization that would be willing to implement it.

1.3 Document Structure

This document is structured in six chapters.

In this chapter is presented a contextualization of the origin and necessity of the dissertation and investigation realization. Also, a description of the main objectives and expected results of this project.

The second chapter approaches the Business Process Management theme. There is a definition and a presentation of its introduction to the organizational world. A brief passage to its life cycle is studied, because in the future of this project it will be needed for guidance during the process of modeling a business process. There is also an introduction of Business Process Management Systems and what they need to accomplish to be a successful choice. Finally, a brief presentation of business process is explored to give context and connection to the next chapter.

The third chapter presents Process modeling and all three modeling languages BPMN, CMMN and DMN. Within each one it there is an introduction, the elements that constitute them and a small example of how it functions with a small explanation. There is also a demonstration of a business process that utilizes all the three languages together with a explanation of how its conducted.

In fourth chapter the methodological approach used to develop the research project is defined and justified, in this case Design Science Research.
The fifth chapter the planning and schedule of the main activities that cover the entire realization of the research project are introduced.

The final chapter presents some final considerations related to the efforts in this preliminary phase of the research project.
2. Business Process Management

BPM is all about continuous business process improvement and it has two important roles, that are the process identification, that represent the activities and their elements, and the representation of new processes, for performance evaluation. It can be seen as a set of methods and competences, or as an approach that through a relation between management and information technology tries to find and define the best and most reliable process for a certain organization and to improve the optimization on already existing ones (Magalhães, 2008).

Is a discipline that involves any combination between modeling, automation, execution, control, measurement and optimization of business activity flows, to support enterprise goals, spanning systems, employees, customers and partners within and out of the boundaries of the organization. The result of methods, techniques and tools has then to support the design, enactment, management, and analysis of operational business processes.

Is also based on a continuous improvement cycle with the objective of enhancing the strategic alignment regarding the market and the clients. This will bring a competitive advantage, as like the differentiation between products or services. So, the organizations that that constantly seek their process improvement allow an easier integration of the new processes.

So, in a more briefly matter, we can say that BPM comes from two different areas, that are management and information technology and results in a set of methods, techniques and tools for the design, interaction, control and operational analysis of business processes, involving people, organizations applications, documents and other sources of information (Oliveira, 2008; van der Aalst, 2013).

2.1 Business Process Management Introduction

Organizations are interested in understanding, managing and improving their business processes and the set of tools and methods to achieve all these goals is known as BPM.

In recent times BPM has been getting a lot of investigation and development interest, mainly for its ability and potential of productivity improvement and organizational cost reduction, guaranteeing sustainability (van der Aalst, 2013). Currently there is already several BPM systems on the market capable of manage and control organizational business process.
This is an expanding area in the organizational world for the guarantee of improvement in organizational processes of the organizations. It is a way to add value to their business, since it is expected that with a well-organized organizational process there is an identification of activities that should or should not be performed and this gives an improvement on resources, time and costs (Andrade, 2016).

Due to increasing levels of organizational competition and a competitive market, organizations needed to adapt to all the changes that were taking place around them. This capacity was not supported by traditional organizational structures, since these are oriented to functional and hierarchical segmentation, so they represent obstacles to the adaptation that they are exposed.

The main point of BPM is to align business process with client needs and strategic objectives, so it makes the organization change its functional orientation to a process orientation.

When successfully implemented BPM integrates and transforms the culture of the organization, adjusting how the business is conducted. It can be applied to any type and dimensions of organizations, with the primary objective of redirecting the organizational resources.

BPM requires the participation of all the organization, from administration to operational level and everything in between. It reveals a new vision beyond the traditional and functional structures about the business operations. It evolves all the executed work for the delivery of the product or service, no matter what functional areas or locations are involved.

It represents the organizations as a set of linked processes with the objective of accomplishing their proposed services or products. So, the organization politics are still determined on the high hierarchy levels, but the functional work teams are the ones responsible for controlling and redefine the work methods (Davenport, 1992).

In BPM the concept of a process model is fundamental. Process models can be used to configure information systems, but also be used to analyze, understand, and improve the processes they describe. So, by that we have the introduction of BPM technology to the organizations, that has both management and technical ramifications and can provide significant productivity improvements, cost savings, and flow-time reductions.

So, at this point organizations started to adopt business process, that allow them to have a global and integrated view of work, which allows them an ability to adapt in a quicker and faster way to the constant demands they face.
To cope with all these high competitive levels in the organizational world, organizations created a new paradigm where BPM appears as one of the fundamental pillars (Hammer & Champy, 2006; Verner, 2004).

2.2 BPM Life Cycle

Is a discipline that uses various methods to discover, model, analyze, measure, improve, and optimize business processes.

To manage organizational business processes, there are a group of activities that need to be performed. These activities are a part of the process management lifecycle.

Initially is intended to design the process configuration, that is, defining the process activities and tasks, the human and technologic resources to perform those activities, conditions and circumstances.

The design of the business process should be documented using a notation as a purely formal step. Although there are many different process management lifecycles for management and improvement of business processes, the essential BPM lifecycle is demonstrated ahead.

Once a process is in place, it has the necessity to be continually managed. The performance, in terms of critical metrics that are associated to customer needs and company requirements, need to be compared to the targets that were proposed to be meet and if performance does not achieve the expected, the reasons for the flaw must be determined. Once the intervention has been chosen and implemented, the results need to be assessed and the cycle begins again from the start. This cycle of process improvement repeats continuously for as long as process exists. This introduces continual process improvement into organizations in a structured and easy to use way (Morais, Kazan, Pádua, & Costa, 2014; van der Aalst, 2013).
The steps in a BPM Life Cycle (Figure 1) are:

- Process Identification;
- Process Discovery;
- Process Analysis;
- Process Redesign;
- Process Implementation;
- Process Monitoring and Controlling.

**Process Identification**

It captures the business processes at a high level and gathers enough detail to understand conceptually of how the process works.

It identifies an organization’s business process and prioritizes their management based on certain criteria, with the objective of getting a broad picture of processes in the organization and to maximize the value of BPM initiatives (Morais et al., 2014).
Process Discovery

Mostly composed by four steps (Morais et al., 2014):

- Defining the setting that is dedicated to assembling a team in a company that will be responsible for working on the process;
- Gathering information concerning with building an understanding of the process. Different discovery methods can be used to acquire information on a process;
- Conducting the modeling task, in that it deals with organizing the creation of the process model. The modeling method gives guidance for mapping out the process in a systematic way;
- Assuring process model quality that aims to guarantee that the resulting process models meet different quality criteria. This phase is important for establishing trust in the process model.

Process Analysis

Is the act of conducting a thorough review and arriving at a complete or portion understanding of a business process, with the goal of maintaining or achieving process excellence, or achieving incremental to transformational improvements in a business process.

Process analysis involves looking at all components of a process, could they be inputs, outputs, mechanisms and controls, inspecting each component individually and as they interact to deliver results. These components can often be categorized into people, processes, applications, data, and technology needed to support a business goal or objective. Analyses cover and uncover quality, time, and costs at all points of a business process, from inception to completion.

Aids to process analysis can include:

- Visual process models, both static and dynamic;
- Data collected at the beginning, duration, and end of key activities, lower level processes, and the entire business process itself;
- Business process analysis methods such as value chain analysis, end-to-end modeling, and functional decomposition.

Some typical process analyses are:

- Resource utilization;
• Distribution analysis;
• Cycle time analysis;
• Cost analysis;
• Software application usage;
• Global/Local process variations.

At this stage of the BPM life cycle it is necessary to observe the processes exactly the way they are happening in the company at the time, only then can you get a “picture” that will help modeling and the evaluation of the organization’s processes. It is with this analysis of the present moment that you can understand what could be improved, targeting the following phases of the BPM lifecycle (Morais et al., 2014).

Process Redesign

Is the act of transforming an organization’s vision, goals, and available resources into a discernible, measurable means of achieving the organization’s vision. It focuses on defining what the organization will do to achieve its financial and other goals and is the time to make decisions about everything that was detected in the previous phases.

Now that there is an awareness of bottlenecks, failures, delays and other shortcomings from the reporting process, with the greatest detail as possible, it is now time to align with the strategic goals of the company and design a new process. For this, it cannot fail to have simulations based on the studied scenarios and include the necessary improvements (van der Aalst, 2013).

The steps of this stage are as follows:

• Analyze gaps and make comparisons;
• Design the process and analyze IT use;
• Model the new process;
• Get new process procedures accepted;
• Deployment Plan Creation.
Process Implementation

Implementation is a phase of the BPM life cycle that can be performed in two ways. Through a systemic implementation, that is with the aid of specific software and technologies, or non-systemic implementation, without these types of BPM tools.

Regardless of which is used, the goal is the same, to enable and put into action process implementation as defined and documented in the form of a workflow previously defined (van der Aalst, 2013).

Process Monitoring and Controlling

Every company has strategic goals and it is at this stage of the BPM life cycle that it can find out if the processes are aligned with these objectives or not, by monitoring appropriate indicators to assess the results obtained.

The most commonly used performance indicators usually involve four dimensions: the length of process time, monetary cost spent on the process, capacity, as in how much can the process actually produce, and quality, which examines whether there are many errors and variations that affect a satisfactory delivery to customers in the process (Morais et al., 2014).

2.3 Business Process Management Systems

For a successfully implementation of BPM in an organization, it’s important to know that on his pillar there will be technology tools. There is already a set of tools designed for that purpose, they are called Business Process Management Systems (BPMS). Its objective is to allow a more efficiently interaction between the organizational and technologic worlds. These tools make possible to execute any necessary operations about business process and monitor a BPM project, form the beginning until the end, trough modelling, implementation, development, execution and process optimization.

With the organization’s complexity increasing, business process has been getting more complicated. This fact made more important the utilization of tools that allow they’re management. These tools were manly based on information technology. It’s also important for these technologies to be able to cover all the BPM lifecycle.
These systems are a set of techniques that seek constant system management optimization and be complementary to the traditional informatic structures in the pursuit of promoting client satisfaction. They promote the constant interaction between people and process, define the information access, support process flow and manage exceptions.

BPMS benefits organizational management, promoting communication and people integration, supporting and simplifying planning, structuring and activities controlling. Also giving better agility and flexibility in functional business changes.

BPMS can also help organizations reduce process response time, reducing errors due to the countless information transitions, reduce the costs and function optimization (Karagiannis, 1995).

These technological tools can be seen as software tools, because they are able to support activities like modulation, analyses and optimization of business process.

The implementation of these tools needs a responsible methodology that incorporates several methods and techniques suited for the support of the various activities that constitute a Business Process Management.

BPMS tools should be able to serve some scenarios:

- Business management critical identification and modulation processes;
- Scheme identification understanding, acceptance and execution, and process interaction and sequencing;
- The creation of pillars for the process management system integration with the information technology environment;
- The acceptance of the criteria and methods proposed by the organization, to ensure the organizational processes effective execution and monitoring;
- Availability of organizational processes information in adequate time;
- Possibility of activities monitoring, by controlling the organizational processes performance and functioning;
- Functionalities for the current structure, simulation and optimization analysis of the organizational processes;
- Resources that gives the possibilities for actions that focus on obtaining planned results and continuous improvement of business processes.

There is also a set of four essential functionalities that BPMS tools must provide to cover the BPM lifecycle of any project.
Process definition by giving supports to the design of the process model, presenting all the information necessary for the system to execute the process, like the rules of the processes, the users covered and the documents that involve each activity (Puntar, Iendrike, & Santoro, 2009).

Control of process execution by letting BPMS control and dictate how the sequence of executions should occur, and consequently their instances activation. The instances can vary in number and be associated to one or several processes and be simultaneously running in a BPMS, being it responsible for how and when the activities execute.

Interaction control by adding elements to the worklist of the workers when there’s an activity forwarded to them. The lists contain several instances of the running processes. The workers responsible have access to their work lists and then can select the tasks they want to perform. Executions of these tasks involve document manipulation, decision making, and data completion. The completion of the task by the responsible worker replaces the process flow and activates new activities according to the expected results.

Management and controlling of the execution processes, by presenting the its own process model, several information about the preformed activity state, either in execution or to be performed and by having resources that allow to make performance measures and produce statistics for projections of the process optimization.

The primary objective of business process modeling tools is to analyze how things are right now and simulate how should they be carried out to achieve better results (Oliveira, 2008; Reijers, 2006).

2.4 Business Process

A business process is a set of related and structured activities that produce a type of service or product for a certain customer. It’s often seen as flowchart of a sequence of activities with interleaving decision points, and in other cases a process matrix of a sequence of activities with rules based on data in the process.

When a business process is too complex it may be decomposed into some sub-processes. These sub-processes have their own attributes, but also aid the super-processes in achieving their goal. The business process analysis usually includes the mapping of processes down to activity or task level.
Business processes are made to add value to the customer and unnecessary activities should be excluded, because the outcome of a well-designed business process is value to the customer, or effectiveness, and less use of resources, or efficiency.

Business processes can be modeled by various methods and techniques, just like BPMN, CMMN and DMN (these will be presented further on), that can be used to draw business process in a workflow (Verner, 2004).

A business process is a set of structured and measurable activities that get a certain input and then develop an output with value for the client. These activities define “How”, “Who”, “When”, and “Where” the process is executed, building a flow of information according to the functioning areas of the organization.

Business process has the objective of establishing how the work should be performed by the participant people, machines and applications to give response to the different phases that constitute the production or realization of a determinate service or product, assuring the best possible performance of the organization. In other cases, a set of miss-structured or wrongly executed business processes may compromise the survival of the organization.

Business process can be arranged in three types:

- **Operational processes**: processes to constitute the core of the entire business and to create the primary value stream. They are responsible for directly guaranteeing value for the customer and involve all the nuclear activities for the survival of the organization. They are present throughout all the procedure and showing a complete vision of all the production or service steps;

- **Supporting processes**: supports the core processes, like accounting, recruitment or technical support. As the name suggests, are made to give support to all other processes in the organization. Its main function is to help other processes raise their capacity in the realization and execution of the objectives. These should also cover all the organization;

- **Management processes**: these are the processes that manage the system’s operation. Usually it includes corporate governance and strategic management. They have the objective of controlling and managing the activities and the hole business. Even though they don’t add direct value to the customer, they are essential for the maintenance of the high level of quality of the organization in the way it accomplishes the work according with the established rules to match its goals and objectives.
In conclusion a business process coordinates the behavior of people, systems, information and things to produce business outcomes in support of a business strategy (Fiol, 2014).
3. Process Modeling

Process modeling is mainly used to map a workflow, so we can understand, analyze and make positive changes to that workflow or process and finding ways to improve them. The usage of diagram helps to visualize this process and make better decisions. Business process modeling can also help you group similar processes together and anticipate how they should operate.

There are many benefits to business process modeling:

- Gives everyone a clear understanding of how the process works;
- Provides consistency and controls the process;
- Identifies and eliminates redundancies and inefficiencies;
- Sets a clear starting and ending to the process.

There are a lot of different techniques to model processes, like UML Diagrams, Flowchart Technique, Data flow diagrams (DFD), Role Activity Diagrams (RAD), Role Interaction Diagrams (RID), Gantt Charts, Integrated Definition for Function Modeling (IDEF), Colored Petri Nets (CPN) or Workflow Technique, but in this project, we will focus on three OMG business modeling notations that are Business Process Management and Notation (BPMN), Case Management Model and Notation(CMMN), and the Decision Model and Notation (DMN).

3.1 Business Process Management and Notation

A Business Process Model is a network of graphical objects, where there are activities and flow controls that define how they operate and the order of performance.

BPMN’s development is an important for reducing the fragmentation that occurs with the countless of process modeling tools and notations. This fragmentation has stopped the adoption of inter-operable business process management systems. So, a well-supported standard modeling notation will make it less confusing among business and IT users.

Another factor brought the development of BPMN is that business process models developed by business people have been different from the process representations that designed systems require to implement and execute those processes. Also, there was the need to translate the original business process models for the execution models and such translations can have errors that make it hard to understand the evolution and the performance of the processes to the process owners (Bossuyt, 2017).
BPMN as its primary goal set to offer a notation easily understandable by business users. Therefor it will make it simpler for business analysts, who create the initial draft of the processes, to the technical developers, who implement the technology that will perform those processes, and to the business people that will administrate, manage and monitor those process, to cooperate and work more efficiently. So, BPMN builds a standardized bridge between the business process design and the process implementation.

To make an easy development of simple diagrams that will be simple to understand by most of business analysts, there were made up a set of graphical elements. The chosen elements were selected to give the user a distinguishable feel from each other and to use shapes more familiar to the greatest number of modelers (Fiol, 2014; White, 2004).

One of the main reasons for the development of BPMN was to create an easy mechanism for the creation of business process models and at the same time the ability of being able to handle the complexity of business process. The best solution fund to handle these conflicting requirements was to organize graphical aspects of the notation into specific categories, so that the reader can easily recognize the basic types of elements and get a better understand of the diagram. The four basic categories of elements are:

- Flow Objects;
- Connecting Objects;
- Swimlanes;
- Artifacts;

3.1.1 Categories of Elements

Flow Objects

The Flow Objects are a set of only three core elements, so that modelers don’t have to learn and memorize many different shapes. The three Flow Objects are:

- Event: Is represented by a circle and is something that “happens” during the course of a business process. These Events affect the flow of the process and usually have a cause or a trigger and an impact or result. Events are circles with open centers to allow internal markers to differentiate different triggers or results. There are three types of Events, based on when they affect the flow: Start, Intermediate, and End (respectively in the order of the image) (Figure 2).
Activity: Is represented by a rounded-corner rectangle and is a generic term for work that company performs. An Activity can be atomic or non-atomic. The activities have two types that can be Tasks or Sub-Process. The Sub-Process is distinguished by a small plus sign in the bottom center of the shape (Figure 3).

Gateway: Is represented by the shape of the diamond and is used to control the divergence and convergence of Sequence Flow and will determine traditional decisions, as well as the forking, merging, and joining of paths. The type of behavior control will be indicated by Internal Markers (Figure 4).

Connecting Objects

The Flow Objects are connected in a diagram to create the basic skeletal structure of a business process. There are three Connecting Objects that provide this function. These connectors are:

- Sequence Flow: Represented by a solid line with a solid arrowhead and is used to show the sequence that activities will be performed in a Process (Figure 5).
• Message Flow: Represented by a dashed line with an open arrowhead and is used to show the flow of messages between two separate Process Participants, like business entities or business roles, that send and receive them (Figure 6).

Figure 5 - Sequence Flow

• Association: Represented by a dotted line with a line arrowhead and is used to associate data, text, and other Artifacts with flow objects. Associations are used to show the inputs and outputs of activities (Figure 7).

Figure 6 - Message Flow

Figure 7 - Association

SwimLanes

Many process modeling methodologies utilize the concept of swimlanes as a mechanism to organize activities into separate visual categories in order to illustrate different functional capabilities or responsibilities. BPMN have swimlanes with two main constructs that are:

• Pool: Represents a Participant in a Process. It is also acts as a graphical container for partitioning a set of activities from other Pools. They are used when the diagram involves two separate business entities or participants and are physically separated in the diagram. The activities within separate Pools are considered self-contained Processes, so for that reason the Sequence Flow may not cross the boundary of a Pool. Message Flow is defined as being the mechanism to show the communication between two participants (Figure 8).
• Lane: Is a sub-partition within a Pool and with the extend of the entire length of the Pool, vertically or horizontally. Lanes are used to organize and categorize activities. Lanes are often used to separate the activities associated with a specific company function or role. Sequence Flow may cross the boundaries of Lanes within a Pool, but Message Flow may not be used between Flow Objects in Lanes of the same Pool (Figure 9).

Artifacts

BPMN was designed to allow modelers and modeling tools some flexibility in extending the basic notation and in providing the ability to add context appropriate to a specific modeling situation. Any number of Artifacts can be added to a diagram, as appropriate for the context of the business process. The current version of the BPMN specification only defines three types of Artifacts, which are:

• Data Objects: Is a mechanism to show how data is required or produced by activities. They are connected to activities through Associations (Figure 10).
- **Group**: Represented by a rounded corner rectangle drawn with a dashed line. The grouping can be used for documentation or analysis purposes but does not affect the Sequence Flow (Figure 11).

```

Figure 11 – Group
```

- **Annotations**: Is a mechanism for a modeler to provide additional text information for the reader of a BPMN Diagram (Figure 12).

```

Figure 12 - Annotations
```

### 3.1.2 Example of BPMN

![BPMN example](image)

```

Figure 13 - BPMN example
```

In this example we can see a process that was is goal as sending a job offer letter to a successful job applicant (Figure 13). The context is that recruiting an employee requires a long-elapsed time to complete and involves a certain number of people. Unless very few people apply for jobs, the recruitment will have to handle many cases at the same time. This process requires someone to
assign tasks to the people who do different types of work, such as interviewing or preparing a contract.

The present action is a recruitment process that consists of a series of decisions, to reject the candidate or continue. This simplified process has these decision points after evaluating the applicant’s CV and a single interview.

If the hiring manager rejects the applicant at any stage, it sends a standard rejection email.

There are also a series of roles that must be present for the process to function properly. They are the hiring manager, that is the person who takes responsibility for assessing a candidate and whether to reject the candidate or proceed and the recruiter, that is a human resources assistant who coordinates the recruitment process.

3.2 Case Management Model and Notation

The Case Management Model and Notation was created by the Object Management Group and has published in 2014. It is a notation that came to complement the Business Process Model and Notation.

The Case Management Model and Notation is a type of business process technology that doesn’t use control flow to describe the process. The case file or case folder is the main concept that has all the data and information about the process. Case management has the function of providing the workers with discretion and control on how a case evolves, therefore, case management isn’t about the process, but about the workers.

As mostly appends in regular workflows or process systems, the designer encodes the business goal to be accomplished in the model, so this means that the system is responsible for the that goal and it uses the workers to achieve it. But in case management systems it’s the other way around, the workers are responsible for the business goal and they use the system as a tool to accomplish that goal. This is the reason that case management relies more on the judgment of workers than ins control flow (Marin, 2016).

CMMN is declarative by nature, thus one should not read any meaning into the relative positioning of shapes and describes what is allowed and disallowed in the process as opposite of BPMN, that is imperative, as in, it describes “how” to do the process (OMG, 2014).
The case is the main concept in CMMN, and it is like a process. A case has a case file that is described by a case plan. The categories of elements are:

- Case Plan Models;
- Case File Items;
- Stages;
- Entry and Exit criteria;
- Plan Fragments;
- Tasks;
- Milestones;
- Event Listeners;
- Links;
- Connector Usage;
- Planning Table;
- Decorators;
- Artifacts.

3.2.1 Categories of Elements

Case Plan Models

The complete behavior model of a Case is captured in a case Plan Model. Its represented by using a “Folder” shape (Figure 14).

The various elements of a case Plan Model are represented within the boundary of the case Plan Model shape.

Figure 14 - Case plan
Case File Items

A Case File Item is depicted by a “Document” shape that consists of a rectangle with a broken upper right corner (Figure 15). Case file items are used to represent all kinds of data, including a data value in a database, a row in a database, a document, a spreadsheet, a picture, a video, a voice recording, etc. In addition to basic data, case file items can also represent containers, including, a directory, a folder, a set, a stack, a list, etc.

![Figure 15 - Case file item](image)

Stages

A Stage is depicted by a rectangle shape with angled corners and a marker in the form of a “+” sign in a small box at its bottom center. When the Stage is expanded it is shown with the marker in the form of a “-” sign in the same small box (Figure 16).

A Stage may be discretionary, that has the shape of a rectangle with short dashed lines and angled corners and a marker in the form of a “+” sign in a small box at its bottom center, while a discretionary expanded Stage has a “-” sign in a small box at its bottom center.

When a Stage is expanded, elements that are contained in it become visible.

![Figure 16 - Stage](image)

Entry and Exit Criterion

Plan Items may have associated Sentries. When a Sentry is used as an entry criterion it is depicted by an allow “Diamond” shape (Figure 17). Describes the condition that must be satisfied for the stage, task, or milestone to be available for execution.
When a Sentry is used as an exit criterion it is depicted by a solid “Diamond” shape (Figure 18). Is similar to an entry criterion, but it is used to stop working on the stage, task, or case plan when it is satisfied.

Plan Fragments

A Plan Fragment is depicted by a rectangle shape with dashed lines and softly rounded corners and a marker in the form of a “+” sign in small box at its bottom center. When the it is expanded it is depicted by a “-” sign in a small box at its bottom center (Figure 19).

Tasks

A Task is depicted by a rectangle shape with rounded corners (Figure 20). A task represents the execution of actual work. There are four types of tasks, namely non-blocking human task, blocking human task, case task, and process task.
A Task may be discretionary, that is represented by a rectangle shape with dashed lines and rounded corners.

A Task may be associated with one or more entry or exit criteria Sentries.

Human Task

A Human Task has two possible depictions. If the Human Task is non-blocking, it is represented by a rectangle with rounded corners and a “Hand” symbol in the upper left corner (Figure 21). Non-blocking human tasks are handed out to a case worker and as soon as it is claimed by a case worker, it will be considered complete.

![Figure 21 - Non-blocking human task](image)

If the Human Task is blocking, it is represented by a rectangle with rounded corners and a “User” symbol in the upper left corner (Figure 22). Blocking human tasks are executed by a case worker and they must be explicitly completed by the worker.

![Figure 22 - Blocking human task](image)

A Human Task may also be discretionary and by then represented by a rectangle shape with dashed lines and rounded corners with the appropriate marker depending if it is blocking or not.

Case Task

A Case Task is represented by rectangle shape with rounded corners with a “Folder” symbol in the upper left corner (Figure 23).
A Case Task may also be discretionary and is represented by dashed lines.

Process Task

A Process Task is depicted by a rectangle shape with rounded corners with a “Chevron” symbol in the upper left corner (Figure 24).

A Process Task may also be discretionary and is represented by dashed lines.

Decision Task

A Decision Task is depicted by a rectangle shape with rounded corners with a Decision Table symbol in the upper left corner (Figure 25).

A Decision Task may also be discretionary and is represented by dashed lines.

Milestones
A Milestone is portrayed by a rectangle shape with half-rounded ends and may have zero or more entry criteria (Figure 26). Represent accomplishments during the execution of the case instance.

![Milestone](image)

*Figure 26 – Milestone*

Event Listeners

An Event Listener is represented by a double line circle shape with an open center so that markers can be placed within it to indicate its variations (Figure 27). Events listeners are similar to events in other workflow or BPM notations.

![Event Listener](image)

*Figure 27 - Event listener*

A Timer Event Listener is represented by double line circle shape with a “Clock” marker in the center (Figure 28). As the name suggest it regulated by the time.

![Timer Event Listener](image)

*Figure 28 - Timer Event Listener*

A User Event Listener is represented by double line circle shape with a “User” symbol marker in the center (Figure 29). In this case is regulated by the user.

![User Event Listener](image)

*Figure 29 - User Event Listener*
Links

Certain dependencies between elements that are shown inside expanded Stages or Plan Fragments are connected by using links. These connector’s shape object is a dash-dot-dot line that must not have arrowheads (Figure 30).

![Dependency link](image)

*Figure 30 - Dependency link*

The other type of dependency that is visualized is the dependency between a Human Task and Discretionary Items in its Planning Table. When the Human Task is shown with its Planning Table expanded, these dependencies are depicted with a discretionary association that is a dashed line and it must not have arrowheads (Figure 31).

![Discretionary dependency link](image)

*Figure 31 - Discretionary dependency link*

Connector Usage

The following picture illustrates a situation where task can only be activated if both previous tasks are complete, in other words a “and” situation (Figure 32).

![Example of an "and" situation](image)

*Figure 32 - Example of an "and" situation*

In this picture is illustrated a situation where a task can be activated if either previous task is completed, in other words a “or” situation (Figure 33).
Planning Table

A Planning Table may exist in a Stage or a Human Task. It is represented by a “Table” shape composed of six cells with the center bottom cell containing a marker indicating if the Discretionary Items are visualized or not. When there are not visualized a marker in the form of a “+” sign is present in the bottom center cell (Figure 34), otherwise the marker in the form of a “-” sign (Figure 35).

![Figure 34 - Collapsed planning table](image)

The Planning Table shape can only be placed as a decorator on the boundary of a Stage or a Human Task object.

When a user expands a Planning Table, its contained Discretionary Items become visible within the Stage (Figure 36).
Decorators

For the CMMN notation to be as expressive as possible, different shape decorators are introduced. These decorators are useful to visually indicate some behavior patterns of Plan Items and Discretionary Items.

AutoComplete Decorator

When a Stage Auto Complete attribute is set to “True”, then an AutoComplete decorator is added to the bottom center of the Stage shape. The AutoComplete Decorator is a small black square (Figure 37). It indicates that the stage or case (case plan) will complete when all the required case plan items are completed.

Manual Activation Decorator

The Manual Activation Decorator, representing a Manual Activation Rule, is a small white-filled triangle pointing to the right, and is visible when a Manual Activation Rule is defined for the Plan Item or Discretionary Item (Figure 38). A task with a manual activation decorator means that a case worker must decide if the task should be executed or not.
Required Decorator

The Required Decorator is a bold black “Exclamation” symbol and is visible when a Required Rule is defined for Plan Item or Discretionary Item (Figure 39). It indicates that a stage, task, or milestone must be executed for the stage or case to complete.

Repetition Decorator

The Repetition Decorator, portraying a Repetition Rule, consists of two bold vertical bars crossed by two bold horizontal bars (identical to ASCII # symbol), and is visible when a Repetition Rule is defined for a Plan Item or Discretionary Item (Figure 40). It indicates the stage, task, or milestone can be repeated multiple times.

Artifacts

Case Models may also contain any number of artifacts representing annotations of the diagram. There are two types of artifacts:

• An Association: is a dotted connector used to link a Text Annotation to a CMMN Element;

• A Text Annotation: is entered text used for comment or to give an explanation.
Association

An Association is a line that must be drawn with a dotted single line (Figure 41).

![Figure 41 - Association](image1)

If there is a reason to put directionality on the Association, then an arrowhead may be added to the Association line (Figure 42). The directionality of the Association can be in one direction or in both directions.

![Figure 42 - Directionality association](image2)

Text Annotation

Text Annotation objects can be used by the modeler to display additional information about a Case of attributes of the objects within a CMMN Diagram. A Text Annotation is an open rectangle that MUST be drawn with a solid single line (Figure 43).

The Text Annotation object can be connected to a specific object on the Diagram with an Association but does not affect the execution of the model. Text associated with the Annotation can be placed within the bounds of the open rectangle.

![Figure 43 - Text annotation](image3)
3.2.2 Example of CMMN

This example demonstrates a CMMN diagram containing a case plan model, that is the essential part of any CMMN case definition (Figure 44).

In the first part of the case, the loan application should be reviewed for any formal errors, so it’s used a human task. Additionally, the customer’s creditworthiness must also be assessed. In this case is defined that the human tasks don’t need manual activation.

Next it’s added a milestone. The condition(s) defining when the milestone is reached are modeled using Sentries. Sentries are used to capture conditions within a case and can trigger other events to occur. In this case the Approved milestone is reached when both tasks have successfully completed, if the application was sufficient and if the customer received a good rating for creditworthiness. But when a loan application is not sufficient, there is no need to provide a customer rating any longer and this is express by adding a sentry which acts as exit criterion.
3.3 Decision Model and Notation

Decision Model and Notation was published by the Object Management Group in 2015 and its main purpose is to become a common notation, just like BPMN. Trying to make so that it is understandable by all business users, to will ensure interchangeability of decision and process models across organizations.

The primary goal of Decision Model and Notation is to provide a common notation for decision logic that is understandable for business users, business analysts and technical developers.

It allows designers to model decision logic independently, or in combination with the already established standard BPMN.

In most process models with a lot of detailed decision logic, the result ends up in a complex and confusing spaghetti-like models. So, the primary objective is to separate decision logic from the process model to improve simplicity, precision, readability and maintainability of both models. A simplified business process model is easier to read and maintain and any change is necessary to make it doesn’t impact the whole process model (Bossuyt, 2017).

Another benefit DMN is that a detailed decision logic leads to opportunities regarding automated decision-making, and there for automated processing, that would lead to the least necessity for human intervention during the process, freeing up expensive resources to other activities with more value. Because DMN allows for explicit decision modelling, it becomes clear to where exactly the decision could be improved.

A company is only as agile as its business processes, there for a simplification will leads to a more agile business. The purpose of adding DMN to an already existing business process is to facilitate interchangeability and reusability of decision models and adding this to the fact that business process models are the most important part in designing information systems, development and maintenance costs have the chance to be reduced significantly (“DMN Tutorial,” n.d.).

The Decision Model Notation can be modelled using a combination of four elements and three requirements.
3.3.1 Categories of Elements

Elements

- Decision: A decision denotes the act of determining an output from a number of inputs, using decision logic which may reference one or more business knowledge models (Figure 45).

![Decision](image)

*Figure 45 – Decision*

- Business Knowledge Model: A business knowledge model denotes a function encapsulating business knowledge (e.g., as business rules, a decision table, or an analytic model) (Figure 46).

![Business knowledge](image)

*Figure 46 - Business knowledge*

- Input Data: An input data element denotes information used as an input from one or more decisions. When enclosed within a knowledge model, it denotes the parameters to the knowledge model (Figure 47).

![Input data](image)

*Figure 47 - Input data*
• Knowledge Source: A knowledge source denotes an authority for a business knowledge model or decision (Figure 48).

![Knowledge source](image)

*Figure 48 - Knowledge source*

Requirements

• Information Requirement: An information requirement denotes input data, or a decision output being used as one of the inputs of a decision (Figure 49).

![Information requirement](image)

*Figure 49 - Information requirement*

• Knowledge Requirement: A knowledge requirement denotes the invocation of a business knowledge model (Figure 50).

![Knowledge requirement](image)

*Figure 50 - Knowledge requirement:

• Authority Requirement: An authority requirement denotes the dependence of a DRD element on another DRD element that acts as a source of guidance or knowledge (Figure 51).

![Authority requirement](image)

*Figure 51 - Authority requirement*
3.3.2 Example of DMN

![DMN Example](https://www.camunda.org)

This table contains the decision logic about the desired dish for a given season and guest count (Figure 52).

To begin, the fields are filled in to set the conditions and the results of the decision, then the rules that specify what desired dish for each season and the guest count are inputted. In this case, the ruling process is that the season and the guest count are the conditions or input entries of the rule and the dish is the conclusion or output entry of the rule. There is also a Hit Policy (in this case a “UNIQUE” type) that dictates that only one option can be the final result.

3.4 BPMN + CMMN + DMN

This example demonstrates a car insurance application process (Figure 53). Its function is to allow to see the viability of the usage of the three OMG business modeling notations that are Business Process Management and Notation (BPMN), Case Management Model and Notation (CMMN), and the Decision Model and Notation (DMN) and how they can serve a much better understanding of a complex process.
In this case there is received a car insurance application and a process to determine if its passive of being accepted or not. It starts by determining the risks, so DMN is used to prevent a large cascade like set of gateways and for that is inputted a set of conditions to get an output of results, that can be decisive or inconclusive. When the process results are conclusive BPMN sends the results of the application and ends the process, but when the process is inconclusive there is the need for the utilization of CMMN to manually check the application and then proceed by providing BPMN with the final decision, so it send the result and end the process.
4. Methodological Approach

To carry out this project, the methodological approach followed will be the Design Science Research (DSR), that according to Vaishnavi e Kuechler which are cited by (Da Silva, J. V. V. M.; Da Costa, R. M.), is an analytical set of techniques and perspectives (complements the positivist and interpretative perspectives) to carry out studies in Information Systems. It involves the analysis of the use and performance of artifacts designed to understand, explain and improve the behavior of the aspects under study (Vaishnavi and Kuechler, 2006). Wang and Wang (2003) refers DSR to a set of specific guidelines and methods for the process of creating, constructing and validating an artifact in the context of IT innovation. These artifacts are usually designed to satisfy a need or to serve a purpose (Simon, 1996).

This methodology (Figure 54) is summarized very quickly in 6 steps, the first being the "Identify Problem and Motivate", the second the "Define Objectives of a Solution", the third is the "Design and Development", the fourth is the "Demonstration", the fifth is the “Evaluation”, and final one is the "Communication".

1) Identify Problem and Motivate: in this step, the important thing is to specify the research problem and justify the value of a solution.

2) Define Objectives of a Solution: the important thing is to review the objectives and definition of the problem and present objectives that can be quantitative as a desirable solution would be better than the existing, or qualitative ones as a description of how a new artifact should support solutions for problems not solved until now.

Figure 54 - Design science research process model by Peffers et al. ([15], p. 54)
3) Design and Development: the important thing in this step is the creation of the artifact that can be constructs, models, methods or instantiations. This task includes determining the desired functionality of the artifact and its subsequent creation.

4) Demonstration: In this step, demonstrate the functions of the artifact to solve one or more instances of the problem. This may involve the use of the artifact in case studies, experiments, and simulations.

5) Evaluation: observe and measure the impact and success that the artifact has on the problem. This activity involves the comparison of the objectives with the actual results obtained in the use of the artifact.

6) Communication: in this step it’s important to communicate a set of facts such as the problem and its importance, the artifact, its usefulness and novelty and its effectiveness for future researchers and to contribute to relevant future works.

During this project I will follow an exploratory approach, since in this area there is still little knowledge and information available. So, I will explore the various existing solutions and choose the best.
5. Study of Business Process Management Software

Business Process Management Software is not simply about the drawing of flowcharts and process maps, it’s about supporting the whole process of BPM and the continuous improvement of the business process to boost the organizations. BPM Software helps businesses perform a better BPM, in order to achieve better business results. BPM Software significantly improves the chances to increase process performance, compliance, and grab opportunities for innovation by allowing organizations to optimize the way they manage their processes and improvement initiatives.

After all the investigation and the notation studied the next step has the prof of concepts of the cooperation and integration of the three languages. So, there has the need to find a Business Process Management Software, or also called a “BPM Tool” or a “BPM Suite”, capable of supporting all these languages and provide the means for that integration.

Three tools were then evaluated to find the best one that would be able to operate with the efficiency required by the complexity of the integration, in other words, a tool capable of support all the languages, integrate them and have the availability of demonstrate its performance.

So, the three explored tools were the “Camunda”, “Signavio” and “Trisotech”. For each one a series of tests were conducted with the objective of understanding how all the platforms operate at the required levels of modeling. Therefore, the tests of comparative nature were made to figure out the best one to utilize. At the end of each tool description has created a table that compares the most important aspects on the components of BPMN, CMMN and DMN to a successful integration of the languages. The selected aspects are:

- Does it support it;
- Does it integrate any of them;
- Does it enable to see its animation and performance.

Support it: Some of these tools don’t give access to some of the business notation required by this project. In other words, if there is no access to all the notations the project would be out of the possibility of realization.

Integrate it: It’s required the ability for the tools to integrate all the notations, or in other words, to cooperate and communicate within to build a hybrid business process.
Animate it: After the integration there is the need to prove that they actually can integrate, so the animation is required to show the performance of the business process.

5.1 Camunda

Camunda BPM is a light-weight, open-source platform for Business Process Management developed in JAVA with the main objective of automating business processes, based on the business process modeling language, Business Process Model and Notation (BPMN 2.0). Also, a platform for workflow and decision automation that brings business users and software developers together.

The main components are written in Java and have a general focus on providing Java developers with the tools they need for designing, implementing and running business processes and workflows on the Java virtual machine (JVM). Also, the process engine technology available to non-Java developers and a REST API which allows to build applications connecting to a remote process engine.

BPMN 2.0 Core Engine is the core of the process engine. It features a lightweight execution engine for graph structures (PVM - Process Virtual Machine), a BPMN 2.0 parser which transforms BPMN 2.0 XML files into Java Objects and a set of BPMN Behavior implementations (providing the implementation for BPMN 2.0 constructs such as Gateways or Service Tasks).

![Process Engine Architecture](https://docs.camunda.org)
The core of the Camunda goes through an execution mechanism for BPMN, CMMN and DMN and presents benefits such as:

- Allows your running templates to be light in disk space. It can run on any Java virtual machine (JVM).
- Provides the ability to access the engine through the REST API, or through the JAVA API and uses existing integrations such as Spring and JAVA EE.
- The ability to implement BPMN service tasks in code or make use of integrated REST and SOAP connectors.
- An engine that is fast and highly scalable, because it allows multiple instances to share the same database with no execution problem.

5.1.1 Camunda Aspects

With the Free Trial Modeler provided by Camunda, there is access to a desktop application for modeling BPMN, DMN and CMMN. It allows you to model files located directly on local file system.

The workspace for the Camunda is simple and easy to utilize, but the major step back is that it only allows to model the notation separately, or in other words, one notation is no able to invoke another one.

![Camunda Modeler](image)

*Figure 56 – Camunda Workplace*
For the BPMN model, all the desired elements are on the palette on the left-hand. It has a side by dragging and dropping them onto the diagram canvas or a click on the element and then on the canvas mechanism to perform the process. Alternatively, it is possible to add new elements by using the context menu that appears when you select an element in the diagram. Using the wrench icon in the context menu, it can change the type of an element in place.

![Figure 57 – Camunda BPMN Modeler](image)

In the CMMN model the situation is the same as before. All the desired elements are on the palette on the left-hand. Using the wrench icon in the context menu, it can change the type of an element in place.

![Figure 58 – Camunda CMMN Modeler](image)
Finally, the DMN model stands as the previous ones. The different situation in this model is that when the decision table icon on the task is pressed the decision table opens and the conditions can be applied.

![Camunda DMN Modeler](image)

**Figure 59 – Camunda DMN Modeler**

Opened the Decision Table there is the ability to add Inputs, Outputs and Rule elements by clicking the plus signs. Also, to edit a table cell by clicking on it and the tabulator key can be used to walk through the table cells. Finally, to delete, copy or insert a rule or a column by right clicking in the cell.

![Camunda DMN Decision Table](image)

**Figure 60 – Camunda DMN Decision Table**
So, in the end, although is an easy and simple tool to utilize, it doesn’t cover the aspects need to successfully produce the wanted hybrid business process. The final aspects stand in the table 1:

<table>
<thead>
<tr>
<th>Camunda</th>
<th>BPMN</th>
<th>CMMN</th>
<th>DMN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Communicates/Integrates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animate/Demonstrates</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 – Camunda Aspects

5.2 Signavio

Signavio was born out of the need for a more collaborative and accessible approach to process management.

Finding the process management was either nonexistent or completely unmanageable for many companies, there was no way to share knowledge between employees or departments, and although there might be theoretical or academic ways to study and implement process management, businesses weren’t benefitting from it because it didn’t exist in any sort of accessible platform, such as a software solution.

Addressing this issue and what started out as a research project to create a modeling tool with collaborative functions, turned into a prototype for the Signavio software that appeared in 2006. After the tool was refined, Signavio was founded in 2009 and introduced the first completely web-based collaborative BPM software.

The Signavio Process Manager is an intuitive BPM solution for professional process modeling. Whether to create current-state documentation or target concepts, the Signavio Process Manager is a choice for process modeling. It also enables business people to capture, design, and improve their business.

It has created to be a modern solution designed to leverage the interfaces, devices, and working practices of today with the future of your business in mind.

Whether to create current-state documentation or target concepts, Signavio Process Manager is valid choice for process and decision modeling.
As part of the Signavio Business Transformation Suite, Process Manager captures, connects, and communicates how work is done and where decisions are made, allowing to create new workflows, while gaining insights into the consistency and efficiency of business practices.

5.2.1 Signavio Aspects

With the Free Trial Modeler provided by Signavio, there is access to a modeling environment for BPMN and DMN, but it doesn’t support CMMN and that’s where it majorly will fall short of the requirements needed for the hybrid business process. It allows you to model processes located directly on their servers.

The workspace for the Signavio also is simple and easy to utilize tool. It allows to model BPMN and DMN with a collaborative manner, this meaning that a BPMN process is able to invoke DMN for the decision-making processes, in an intuitive way.

![Figure 61 – Signavio Workspace](image)

The BPMN model in Signavio has all the elements located on the left-hand of the workspace. It has a side by dragging and dropping them onto the diagram canvas mechanism to perform the process. Alternatively, it is possible to add new elements by using the context menu that appears when you select an element in the diagram. Using the wrench icon in the context menu, it can change the type of an element in place and for more advanced attributes options a right-hand side bar can be popped up.
On this bar the invocation of the DMN occurs, by linking the selected task to an existing DMN process or by creating a new DMN process. In this situation the task is linked to an existing DMN process called Decision 1.

The DMN model also has all the elements located on the left-hand of the workspace. It has a side by dragging and dropping them onto the diagram canvas mechanism to perform the process. Alternatively, it is possible to add new elements by using the context menu that appears when you select an element in the diagram. Using the wrench icon in the context menu, it can
change the type of an element in place and for more advanced attributes options a right-hand side bar can be popped up.

Figure 64 – Signavio DMN Modeler

Opened the Decision Table there is the ability to add Inputs, Outputs and Rule elements by clicking the plus signs or by clicking on the elements on the top of the table. Also, to edit a table cell by double clicking on it.

Figure 65 – Signavio DMN Decision Table
Although this is a well-functioning tool, it falls short to cover the aspects need to successfully produce the wanted hybrid business process. It’s on his way to be a successful tool, but it doesn’t reach it yet. The final aspects stand in the table 2:

<table>
<thead>
<tr>
<th>Signavio</th>
<th>BPMN</th>
<th>CMMN</th>
<th>DMN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Communicates/Integrates</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animates/Demonstrates</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 2 – Signavio Aspects*

5.3 Trisotech

Trisotech’s Digital Enterprise Suite is a complete cloud-based visualization, transformation, innovation and improvement software to improve organizations. Combining concepts of simplicity, usability and collaboration in the cloud, Trisotech’s Digital Enterprise Suite is a highly visual and interactive software suite that enables non-technical business people to innovate, transform and improve their business.

It brings strategy, design and technology together providing organizations with insight for gaining competitive advantage.

More than just modeling, the Digital Enterprise Suite ensures the achievement of desired business outcomes. The Digital Enterprise Suite provides an intelligent fabric that empowers organizational analysis and decisions via visualization from business discovery through to transformation, innovation and improvement.

The Digital Enterprise Suite enables non-technical business people to participate in enterprise and business architecture discovery and modeling and gain unique insights into relationships between models created using the Suite and other tools.

It provides Visual Modeling, by using diagrams to capture and communicate organization’s essential processes, cases and decisions, specify how thing should get done using BPMN process models, describe how to react in specific contexts using CMMN case model and stipulates the requirements and logic of business decision using DMN decision models.

Also provides Verification and Validation, ensuring early detection of errors in operational models by verifying the structure and validating the syntax of BPMN, CMMN and DMN.
Finally gives access to Animation, validating the behavior of your operational models by stepping through each activity with multimedia elements presented at each step, animating integrated BPMN, CMMN and DMN models.

5.3.1 Trisotech Aspects

Lastly, as said before, the Free Trial Modeler provided by Trisotech gives access to a modeling environment for BPMN, CMMN and DMN, with the possibility to integrate all of them and with the capability of animating the process, giving a real perspective of said integration. The Trisotech Workspace also allows you to model processes located directly on their servers.

![Figure 66 – Trisotech Workspace](image)

The BPMN model in Trisotech have their elements located on the left-hand and on the top bar of the workspace. It has a side by dragging and dropping them onto the diagram canvas mechanism to perform the process. Alternatively, it is possible to add new elements by using the context menu that appears when you select an element in the diagram. Using the left-click in the context menu, it can change the type of an element in place.
On this bar the invocation of the CMMN or the DMN occurs, by linking the selected task to an existing respective notation process.

In the CMMN model the situation is the same as before. All the desired elements are on the palette on the left-hand or on the bar on the top. Using the double click in the context menu, it can change the type of an element in place.
The DMN model also has all the elements located on the left-hand or the top bar of the workspace. Also, a side by dragging and dropping mechanism. Alternatively, it is possible to add new elements by using the context menu that appears when you select an element in the diagram. Using the double click in the context menu, it can change the type of an element in place.
Opened the Decision Table there is the ability to add Inputs, Outputs and Rule elements by clicking the plus signs. Also, to edit a table cell by double clicking on it. Additionally, provides a Quick Guide for assistance on the added conditions.

![Figure 71 Trisotech DMN Decision Table](image1)

The Process Animator is found on the top bar of all the modelers. Clicking the start button, it will go to the animator environment and the evolution of the process can be seen as it unrolls. When reaching one of the invoking of other model tasks, it automatically opens their animators. Once finished it returns to the original process animator and continues until it reaches an end event.

![Figure 72 – Trisotech Process Animator](image2)
Finally, produced all the tests on Trisotech, all the aspects needed to successfully produce the hybrid business process are found, so is an extremally reliable tool. The final aspects stand in the table 3:

<table>
<thead>
<tr>
<th>Trisotech</th>
<th>BPMN</th>
<th>CMMN</th>
<th>DMN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supports</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Communicates/Integrates</td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>Animates/Demonstrates</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3 – Trisotech Aspects

5.4 Conclusion

After the analysis and evaluation of all the tools, it’s clear that all of them have good competences and abilities to provide a fine workspace for process modeling. But for this work there has the need to a special and specific type of requirements to produce a functional and reliable hybrid business process.

The Camunda and Signavio tools didn’t fill those requirements and by that they had to be excluded from possible to utilize. They have great possibility to be a utilizable tool down the line when more evolved and complemented, but at the current point don’t present a valid choice for the necessary job.

The end results show that the Trisotech tool is the most complete of all the tools. It contains the most elements and options of any of them. It’s capable of supporting all the notations, to integrate and animate them, thus proving its effectiveness, make it the eligible one to conduct this work. So, the following work on the process has all made using the Trisotech tool.
6. The Development of the Process and the Integration of the languages

For the proof of concepts, the chosen model was a hypothetical process cable of integrating the languages BPMN, CMMN and DMN. So, the process is based on a banking interaction with a possible client, by a request for a loan to a business or a material good.

6.1 BPMN

The process starts when the bank initiates contact with the client, for the receiving of the loan request.

![BPMN Process Diagram](image)

*Figure 73 – BPMN Process*

Once the bank has the request it will be analyzed and processed according to the specifications requested by the client.

This analysis is conducted by a task that calls the DMN language to simplify the figuring out of how the process will carry on. After the task “Type of Loan” that uses the DMN concludes, the process will proceed with a gateway that can advance through an automatic “Denial Loan” when the amount requested doesn’t fall in any of the categories of acceptance from the bank or the Financial Stability of the client doesn’t give the bank guaranties to provide some sort of requested loan.
When the amount requested is within the rules of the bank and the Financial Stability falls in the acceptance stated obligated by the bank than the process will advance accordingly of what the client requests the loan for.

In this stage of the process there is the need to give a further analysis of the requested loan and that demands the calling of CMMN in the tasks “Access Material Loan” and “Access Business Loan”.

Those are the tasks that ultimate will decide if the loans are possible of being accepted or not. Accepted or denied following task will send the decision to the client and the process then terminates.

6.2 DMN

When DMN is invoked there will be a decision, that in this case is “Type of Loan”, with three data inputs, that are the “Amount Requested”, “Financial Stability” and “Type”.

Starting with the inputs, in the case of the “Amount Requested”, it’s where the client will say the amount of money that he wants the bank to loan him.

This input needs to be of the numeric type. For the “Financial Stability” the bank needs to find out the financial state of the client. As for this input the clients can be divided in three categories stipulated by the bank that are “Low Income”, “Average Income” and “Large Income”.

Finally, the “Type” represents at the client wants the loan for, where two situations can be fund, these are the “Material” or “Business”, that going forward will determine how the process will advance.
These are the set of rules predetermined by the bank for the decision-making process and consequentially the evolution of the process itself. There are four rules in total, three for the “Material” type and one for the “Business” type.

As for the “Material” type rules the bank doesn’t take micro loan, so anything lower than 5000 currency is automatically declined. Also, in this type for clients with the financial stability of “Low income” only have the rage up until 10000 currency, for the ones of “Average income” it’s up until 15000 and for the “Large income” ones it goes until 30000 currency. If the requests are in order with all the input conditions it will have an output of “Advance for Material Loan”, otherwise the requests that don’t respect the conditions are automatically denied by default.

In the “Business” type the only clients that can request this type of loan are the ones with the financial stability of “Large income” and their rage goes from 20000 to 50000 currency. If the requests are in order with all the input conditions it will have an output of “Advance for Business Loan”, otherwise the request not respecting the conditions get automatically refused by default.

6.3 CMMN

In this process CMMN can be invoked in two separate occasions. One situation occurs when the output of the DMN is “Advance for Material Loan” that leads to the task “Access Material Loan” which invokes CMMN. The other situation occurs when the output of the DMN is “Advance for Business Loan” that leads to the task “Access Business Loan” which invokes a different CMMN.
The CMMN Case Plan begins with a non-blocking human task “Check Availability” that as soon as it is claimed by a case worker it’s complete and the Stage “Decision Stage” with the blocking human tasks can start.

The tasks on this Stage are “Evaluate Material Risk” that has a Manual activation decorator, which means that the case worker must decide if the task should be executed or not, and the “Decide Loan Request” executed by a bank employee with a Required Decorator that indicates that the task must be executed for the Stage to complete.

The next steps constitute the official decision by advancing either to the “Loan Denied” or “Loan Accepted” milestones. If the path goes through the “Loan Denial” milestone the decision process reaches its exit criterion to stop the work on the case plan. Otherwise by the “Loan Accepted” milestone the path leads to another blocking human task “Manager Final Decision” performed by the manager of the bank that ultimate determines if the loan is accepted or not. If accepted, it goes to the “Loan Accepted” milestone and the then its exit criterion and if denied it goes to the “Loan Denied” milestone and the its exit criterion.

For the Case Plan to be completed there is also the need for the blocking human task “Write Document” to be executed, because it also has a Required Decorator.
The CMMN Case Plan begins with a Stage “Decision Stage” that incorporates another stage and a blocking human task. The Stage within called “Analysis Stage” has three blocking human tasks, “Analyze Demand”, “Analyze Environment” and “Analyze Population”, performed by the bank employee that have a Required Decorator.

Once all three tasks are completed the Stage concludes and advances for the blocking human task “Decide Loan Request”. The next steps are the same as the previous CMMN Case Plan with the official decision by advancing either to the “Loan Denied” or “Loan Accepted” milestones and the rest maintains same course as before.

Also, like in the previous Case Plan for it to be completed there is also the need for the blocking human task “Write Document” to be executed, because it has a Required Decorator.
7. Performance and Results of the Integration

The process animation is the demonstration of the actual process running, to demonstrate the interaction that these three modeling notations go through. As seen before the base for the process is the BPMN that sequentially then call out the other notation. So, this is how the process operates:

7.1 Animation/Demonstration

Once the contact with the client is established the task to be performed is the “Receive Loan Request”. For it to happen the client needs to send his loan request information and when is received by the bank that task can be fulfilled.

![Figure 78 - Process Initiation](image)

After the request is received the process will analyze it. So, the process advances to task “Type of Loan”, in which for the analysis the BPMN process will invoke the DMN to provide an easier and more efficient decision-making process. Then the BPMN process will remain on hold until the DMN concludes, and therefore provides an output for type of loan assessment.
Next the DMN opens and the type of loan assessment process will begin. The decision task “Type of Loan” will start with all the input data supporting it. This stage is where all the information provided by the client will be introduced and an output resulting from the bank loan rules will give an outcome that is going to serve as the decision for how the process is going to unroll.

When the task is initiated the decision test will begin. As seen before the three inputs of information required by the bank to analyze the loan request are the “Financial Stability”, “Type” and the “Amount Requested”. In this case there is a loan request form a client with “Low Income”, the type is “Material” and the amount requested is “4000”. As previously mentioned, any loan requests below 5000 currency are automatically refused, so as seen in the final end of the picture the output given by the bank is a “Denial”.
In this situation the loan request is for the “Material” type as well, but from a client with the financial stability of “Average Income” and the amount requested is of “12000”. According to the bank rules, this scenario fits in the conditions and the resulting outcome is an output of “Advance for Material Loan”.

For the last possible outcome, the situation stands as a loan request for the “Business” type, for only a client with a financial stability of “Large Income” and an amount form “20000” to “50000” currency can get approved. In this particular case the “Amount Requested” is of “40000” and according to the bank rules, this scenario also fits in the conditions and results in an output of “Advance for Business Loan”.

Picking up from the situation here there as an “Denial” outcome, the process then continues and goes through the exclusive gateway “Type of Loan” to the “Denial Loan” task by the sequence flow “Amount Requested Not According to Company Rules” route.

Once the business process reaches the “Denial Loan” task, a message is sent back to the client with the denial decision for the requested loan and the process terminates in the “Denied” end event.
Another situation happens when the outcome provided previously to the gateway is “Advance for Material Loan”. This will lead the process to the task “Access Material Loan”, a task that is a Case type, so it means that it will invoke the CMMN.

After the CMMN invocation, the process opens the Case Model Plan “Access Material Loan”. When started the required “Check Availability” non-blocking human task it’s promptly executed and as completed the process advances to the stage “Decision Stage”.

In CMMN the Animation Trace keeps a continuous update and gives a sort of summary of what is happening through the case plan process. At the end it will give a representation of the course everything took and what tasks that were completed.
Reaching this stage, the process can go in two ways. The “Decision Stage” is constituted by two tasks, being one the Blocking Human task “Evaluate Material Risk” with a Manual Activation decorator representing when the employee thinks that there is the need for an evaluation of the risks that represent the client acquiring it to prevent problems. The other task that is the Blocking Human task “Decide Loan Request” with the Required Decorator represents the actual decision that the employee is going to make. For the completion of the stage, only the deciding task needs to be completed, leaving the other task up to the employee judgement.

After the “Decision Stage” is completed the employee decision for the requested loan is indicated by the selection of one of the optional milestones that are the “Loan Denied” and the “Loan Accepted”, each one representing an accomplishment during the execution of the case instance. In this case the decision has of denial, meaning that once reaching the milestone an exit criterion is activated representing that if there were no more required pending tasks the case could be terminated in that instance with a final output regarding the decision.
For this situation, it happens that the employee decided to accept the loan, reaching then the “Loan Accepted” milestone. In this circumstance the case isn’t set to terminate as before, because when the loan is accepted by the employee the loan request as to go through a final validation by the manager.

So, the task “Manager Final Decision” is executed, resulting in a final decision about the loan request. This decision is about the acceptance or denial of the loan, just like the employee one and has the function of representing a second and more responsible decision by the bank when it comes to accepting loan requests.
After the manager makes its decision is represented by reaching one of two milestones, that are the “Loan Denied” and the “Loan Accepted”. This situation reflects the acceptance of both the employee and the manager, meaning that again if there are no more required pending tasks the case could be terminated in that instance with a final output regarding the decision.

![Figure 92 – Manager Directing to Loan Acceptance Milestone](image)

The other situation reflects the acceptance of the employee, but the denial of the manager, showing that after a second evaluation a change in the decision and a final output of denial of the loan. So, with no more required pending tasks the case could be terminated in that instance.

![Figure 93 – Manager Directing to Loan Denial Milestone](image)

When the loan decision making process ends and an exit criterion reaches the case plan is necessary that all the required tasks that might not be executed to do so. Only then, when all the elements in the case plan that have required decorators are executed, the case plan can terminate and send the information back to the BPMN. In this situation the only missing required
task to be executed as the “Write Document”, so after the employee performs that task the case plan terminates with the output to send to the next step of the process.

![Diagram of process workflow](image)

*Figure 94 – Finish of Material CMMN*

Finalized the CMMN case plan the process returns to BPMN. Then the task “Access Material Loan” is executed and the process goes to the “Decision” gateway, that according to the output provided by the CMMN forwards the process to the correct task. In this case it goes to the “Denial Loan” task and, as seen previously it sends a message back to the client with the denial decision for the requested loan and the process terminates in the “Denied” end event.
The final situation happens when the outcome “Advance for Business Loan” provided by DMN directs the process by the gateway to the task “Access Business Loan”, a task that is a Case type, meaning that it will again invoke the CMMN.

Invoked the CMMN, the process opens the Case Model Plan “Access Business Loan”. When started the stage “Decision Stage” begins. Inside this stage there is another stage, the “Analysis Stage” with three tasks, that once completed goes to a Blocking Human task “Decide Loan Request”.

Figure 95 – Result of Material CMMN

Figure 96 – Result of DMN's Scenario 3
So, the first thing happening in this process is the “Analysis Stage”. Inside there are the required tasks “Analyze Demand”, “Analyze Environment” and “Analyze Population”. For the stage to be completed all three of the tasks need to be executed because of their required decorators, but because CMMN doesn’t use flow control, the employee responsible for executing them as the control to choose when to execute each one. When all the tasks are completed the stage is finalized and the process can continue.

After the employee executed all the “Analysis Stage” tasks, so that he would have a better understanding of the risks associated to that loan request, this stage will be completed and the process advances to the Blocking Human task “Decide Loan Request”, where he will make the
decision for the loan, either accepting or denying it. When doing so the task will also terminate
the “Decision Stage”.

Following the “Decision Stage”, same as with the other case plan the employee decision for the
requested loan is indicated by the selection of one of the optional milestones that are the “Loan
Denied” and the “Loan Accepted”. In this case the decision has of denial, meaning that once
reaching the milestone an exit criterion is activated representing that if there were no more
required pending tasks the case could be terminated in that instance with a final output
regarding the decision.

In this situation the employee decided to accept the loan, reaching then the “Loan Accepted”
milestone. In this circumstance the case isn’t set to terminate as it as to go through a final
validation by the manager.

The manager makes its decision, represented by reaching the “Loan Accepted” milestones. This
situation reflects the acceptance of both the employee and the manager, meaning that, like
before, if there are no more required pending tasks the case could be terminated in that instance
with a final output regarding the decision.
Exactly as in the case before, when the loan decision making process ends and an exit criterion reaches the case plan, it is necessary that all the required tasks that might not be executed to do so. As in the previous situation the only missing required task to be executed as the “Write Document”, so after the employee performs that task the case plan terminates with the output to send to the next step of the process and going back to BPMN.

With CMMN case plan finalized the process returns to BPMN. The task “Access Business Loan” is executed and the process goes through another “Decision” gateway, forwarding the process to the correct task with the provided output. In this case it goes to the “Accepted Loan” task.
Same as the “Denial Loan” task, this “Accept Loan” task will send a message back to the client with the acceptance decision for the requested loan and the process terminates in the “Accepted” end event.
8. Conclusion

In this chapter a summarization of the efforts and work made towards each of the defined objectives is expressed. Also, there is a presentation of the main conclusions of the accomplished work.

8.1 Summary of the work

The literature review made me expand the range of knowledge regarding the BPMN, CMMN and DMN languages, as in, all the languages were explored in its elements, methods and functionalities. This explorational phase was meant to find fundamental roles for these languages in improving the management of business processes, and consequently in increasing the efficiency of the organizations, so they can be able to keep up with the new requirements of its surroundings. It is also important to define new organizational processes that in the future can bring added value to the organization.

If the modeling phase of any BPM approach is not well structured, reflected, defined and modeled, or in other words, correctly carried out by the project team or the organizations, there is a big chance that this type of projects will be condemned to failure. So, in process modeling the use of a specific notation is crucial. Some business process can get too extensive and long using the most common notation that is BPMN, but with the addition of these other two languages, business process can become much more simple, comprehensive and easy to modify, making this hybrid use of the languages a great possibility of becoming the common modulation way.

There has the need to find a BPMS capable of supporting all the three languages, that allows to model them together in the same process. Not many tools capable of this feature at the moment, but with all the research three tools were evaluated and tested. It has clear that only one of them, the Trisotech tool, has capable of operate at the required level for the realization of this project. Although the other ones, Camunda and Signavio, are tools that have a good working platform, they don’t reach the essential standards for this work. But, is believable than as soon as this hybrid modulation becomes more common there will be an evolution of the current existing tools and an increase of offering new tools for this purpose.
Once these requirements are met, a hypothetical hybrid business process modeling has created, integrating all the three notations and a simulation of the process has made, proving the efficiency of the hybridization of the notations.

All these facts raised it’s believed that business process modeling will be reinvented, and all the processes will become more efficient and simpler. If adopted it’s possible that this will bring great success to the organizations, by saving them time and facilitating their process complexity, there for help them grow and achieve success.

8.2 Difficulties and limitations

Throughout the development of the dissertation some difficulties were encountered in the obtaining of information, the selection of a reliable BPMN and on the development of a process involving three notation languages. But, with all the efforts put on the project, they were surpassed.

The biggest challenges came when it has the time to select a BPMS. When selecting a tool to explore and try to model a process. Founded the two first tools there has a period of testing to explore the depth to which they could go to. Those tools turning out to not be adequate for the work, the attentions turn to Trisotech.

The Trisotech tool hasn’t easy to get to either. Although it had all the potential of all the explored tools, some functionalities were disabled for free trial users. So, a contact had to be made with the company to see if they would be open to enable those functionalities for the length of this project. Luckily, they responded affirmatively and then the functionalities could be utilized.

The final step back has finding a business process sufficiently representative to be modeled that could have all the characteristics to use all the notations. The solutions finish being the creation of a hypothetical business process.

8.3 Future Work

For the future work of this project there is the possibility to deepen the knowledge about how to model a hybrid business process and to create a scenario here that could include an actual business company.
For the scenario that would include an actual business company, an analysis could be made to a complex business process of a company. If that analysis showed that could be need the use of different notations to make an improvement, a redesign, model and implementation would be conducted, so that a real feedback could come out of the experiment and find out if in the real world of business this hybridization could give companies a competitive advantage.
References


Fiol, M. B. (2014). Identificação de problemas em processos de negócio usando a modelagem de processos em BPMN e a árvore de realidade atual da TOC.


