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Business Process Modeling: how CMMN and DMN complement BPMN

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Abstract

The business world's current markets are characterized by higher levels of competition, forcing organizations to adopt IT solutions that can provide them with a competitive advantage. Thus, they continuously search for approaches that can facilitate the development and maintenance of their Information Systems. To accomplish that, modern organizations increasingly focus on their business processes, as these are considered a main factor for their success. Organizations use a set of approaches to ensure greater control, flexibility and ability to manage their business, while aligning their processes with the organizational strategy. Among these, the hybrid process modeling approach, which combines the Business Process Model and Notation (BPMN), Case Management Model and Notation (CMMN) and Decision Model and Notation (DMN) to model business processes, is gaining momentum. This approach helps to define organizational processes in a more efficient, structured and realistic way, while making them much simpler. In this paper, we begin to explore the combination of the recent CMMN and DMN proposals with the widely used BPMN language, trying to understand the benefits that the integration of these three notations bring to the modeling of business processes.

Keywords: Business Process Management (BPM); Business Process Model and Notation (BPMN); Case Management Model and Notation (CMMN); Decision Model and Notation (DMN).

1. INTRODUCTION

This paper is intended to demonstrate how some coexisting business process model languages can improve *Business Process Management* (BPM) implementation. This subject has been having a lot of attention because companies are trying to improve their business processes, therefore ensuring business strategies operationalization, a better alignment between strategies and information and technology systems, while promoting an overall improvement of business management capabilities.

One of the process modeling languages that can help to improve BPM is the *Business Process Model and Notation* (BPMN). It has been proposed by the OMG (*Object Management Group*) and is considered today the standard language for the modeling of business processes. Its main purpose is to represent the most procedural parts of any process, that is, the set of tasks whose execution logic is pre-defined and repetitive. This type of language is less appropriate in situations of greater variability, in which the execution logic needs to be more flexible and even defined during the actual execution of the process. For these situations declarative process modeling approaches are more convenient as they are able to produce "open" models. In this context, languages such as the *Case Management Model and Notation* (CMMN) and the *Decision Model and Notation* (DMN) have appeared in order to help BPMN to operate at that level.

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Moreover, in the same business process there are, sometimes, both procedural and declarative parts. In this context, CMMN might be used to complement BPMN, because it has the capability to represent much of the flexibility and adaptability required by the more declarative parts. With an identical purpose in mind, the DMN has been proposed, which can represent complex business decisions embodied in the BPMN models.

Regarding the structure of this paper, we begin with a brief introduction to the topic of process modeling. In this context, the BPMN and, particularly, the CMMN and DMN techniques are introduced and complemented with examples. In the following section, some issues around the integration of CMMN and DMN with BPMN are discussed and a representative example is presented. Finally, we discuss some issues that our study has already allowed us to conclude and we identify the difficulties we have come across during this study.

2. PROCESS MODELING

Process modeling is typically used to describe a workflow, so we can understand, analyze and make improvements to it. The usage of diagrams helps to visualize business processes, facilitating their analysis, in order to make better change decisions. Business process modeling can also help group similar processes together and anticipate how they should operate. Some benefits commonly recognized to business process modeling include:

• Gives everyone a clear understanding of how the process works;

• Provides consistency among the process stakeholders;

• Helps to identify and to eliminate redundancies and inefficiencies;

• Sets a clear starting and ending of the process.

There are many different techniques to model processes, like UML Activity Diagrams, Flowcharts, Data Flow Diagrams (DFD), Role Activity Diagrams (RAD), Role Interaction Diagrams (RID), Colored Petri Nets (CPN), among others. Anyway, as said before, our focus will be on three OMG business process modeling notations - BPMN, CMMN and DMN.

2.1. BPMN

A BPMN model is a collection of graphical objects, representing mainly activities, events and control flow. Its primary purpose is to offer a notation easily understandable by all the stakeholders involved in the management of business processes. Therefore, BPMN 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, to the business people that will manage and monitor those process, to cooperate and work more efficiently. So, BPMN builds a standardized

bridge between the business process design and the business process implementation and later management (Fiol, 2014; White, 2004).

The BPMN proposal became an important factor for reducing the fragmentation that occurs with the countless existing tools and notations for process modeling and implementation. A well-supported standard notation like BPMN makes process modeling and implementation much less confusing for business and IT users. Indeed, without BPMN business process models, developed by business people, are different from the process representations that developed systems require to implement and execute those processes. Thus, there was the need to translate the original business process models for the execution models and such translations might have errors that make it hard to understand the evolution and the performance of processes to the process owners (Bossuyt, 2017).

Due to space constraints and taking into account that BPMN is already sufficiently well-known, in the next section we only present a simple BPMN process example.

2.1.1 Example of BPMN

In this example we have a process to deal with the recruitment of new personnel (Figure 1). 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.
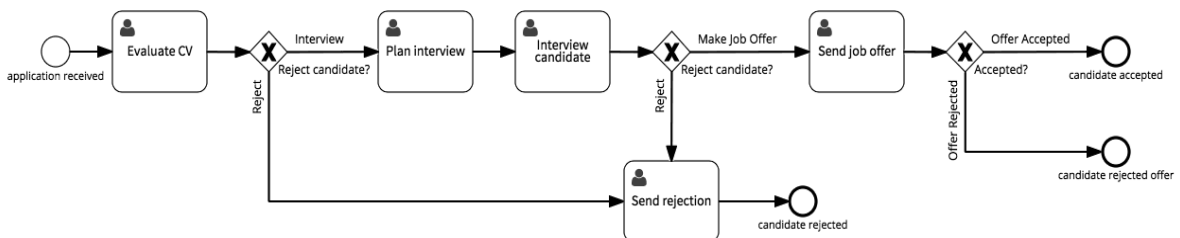

Figure 1 - BPMN example

The present action is a recruitment process that consists of a series of decisions, to reject the candidate or to 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.

2.2. CMMN

The CMMN was also proposed by the OMG which has published it in 2014. It is, clearly, a notation that came to complement the BPMN technique, in order to support the more "flexible" parts of business processes.

In simple words, the CMMN is a type of business process notation 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 about the process. Case management, by definition, provides the workers with discretion and control on how a case evolves. Therefore, it is fair to say that, case management isn't about the process, but about the workers.

As typically happens in regular workflow or process systems, the designer encodes the business goal to be accomplished in the process model. This means that the system is responsible to reach that goal and it merely uses the workers to achieve it. In case management systems it's the other way around. The workers are responsible to achieve the business goal and they use the system as a tool to accomplish that goal. This is the reason why case management relies more on the judgment of workers than in control flow (Marin, 2016).

CMMN is declarative by nature, thus, one should not read any meaning into the relative positioning of graphical shapes and it describes what is allowed and disallowed in the process, as opposite to BPMN that is imperative, as it describes "how" to do the process (OMG, 2014).

2.2.1 Categories of Elements

As mentioned before, 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. In order to save space, in this paper we won't represent the graphical shapes of each element of a CMMN diagram. The CMMN categories of elements are (OMG, 2014):

- **Case Plan Models**: The complete behavior model of a Case is captured in a Case Plan Model. It is represented by using a "Folder" shape. The various elements of a Case Plan Model are represented within the boundary of the Case Plan Model shape;

- **Case File Items**: A Case File Item is depicted by a "Document" shape with a broken upper right corner. 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.;

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

- **Entry and Exit criteria**: Plan Items may have associated Sentries. When a Sentry is used as an entry criterion it is depicted by a halo "Diamond" shape. 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. 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 expanded it is depicted by a "-" sign in the small box;

- **Tasks**: A Task is depicted by a rectangle shape with rounded corners. 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 associated with one or more entry or exit criteria Sentries. 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. 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. If the Human Task is blocking, it is represented by a rectangle with rounded corners and a "User" symbol in the upper left corner. Blocking Human Tasks are executed by a case worker and they must be explicitly completed by the worker. A Case Task is represented by rectangle shape with rounded corners with a "Folder" symbol in the upper left corner. A Process Task is depicted by a rectangle shape with rounded corners with a "Chevron" symbol in the upper left corner. A Decision Task is depicted by a rectangle shape with rounded corners with a Decision Table symbol in the upper left corner;

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

- **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. Events Listeners are similar to events in other workflow or BPMN notations. A Timer Event Listener is represented by double line circle shape with a "Clock" marker in the center. As the name suggest it is regulated by the time. A User Event Listener is represented by double line circle shape with a "User" symbol marker in the center. In this case it is regulated by users;

- **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. 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;

- **Connector Usage**: There are certain situations where a task can only be activated if both previous tasks are complete, this is called a "and" situation. Another situation occurs when a task can be activated if either previous task is completed, in other words a "or" situation;

- **Planning Table**: 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 they are not visualized, a marker in the form of a "+" sign is present in the bottom center cell, otherwise the marker is in the form of a "-" sign. The Planning Table shape can only be placed as a decorator on the boundary of a Stage or a Human Task;

- **Decorators**: The AutoComplete Decorator is a small black square. It indicates that the stage or case (case plan) will complete when all the required case plan items are completed. 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. A task with a manual activation decorator means that a case worker must decide if the task should be executed or not. The Required Decorator is a bold black "Exclamation" symbol and is visible when a Required Rule is defined for Plan Item or Discretionary Item. It indicates that a stage, task, or milestone must be executed for the stage or case to complete. 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. It indicates the stage, task, or milestone can be repeated multiple times;

- **Artifacts**: An Association is a dotted connector used to link a Text Annotation to a CMMN Element. Is line must be drawn with a dotted single line. If there is a reason to put directionality on the Association, then an arrowhead may be added to the Association line. The directionality of the Association can be in one direction or in both directions. Text Annotation objects can be used to display additional information about a Case or attributes of the objects within a CMMN diagram. A Text Annotation is an open rectangle that must be drawn with a solid single line. It can be connected to a specific object on the Diagram with an Association but does not affect the execution of the model.

2.2.2 Example of CMMN

The following example represents a CMMN diagram containing a case plan model, which is the essential part of any CMMN case definition (Figure 2).
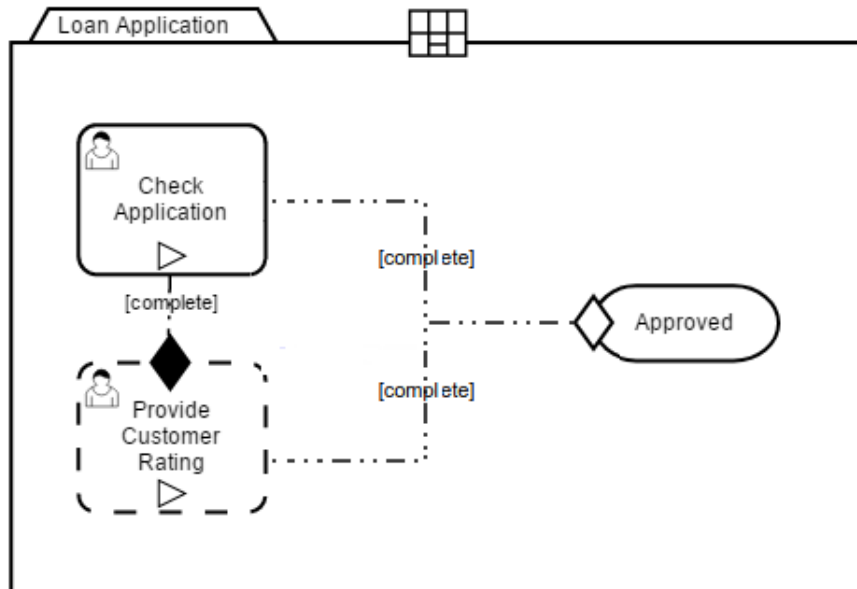

Figure 2 - CMMN example

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

Next its 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.

2.3. DMN

DMN was also published by the OMG, in 2015, and its main purpose is to provide a common notation for decision logic that is understandable for business users, business analysts and technical developers, just like BPMN. Thus, using BPMN and DMN, which both are understandable by all organizational users, will ensure interchangeability of decision and process models across organizations.

DMN 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 of DMN is to separate the decision logic from the process model, in order to improve simplicity, precision, readability and maintainability of both models. A simplified business process model is easier to read and maintain, as a change doesn't impact the whole process model (Bossuyt, 2017).

Another potential benefit brought by DMN is that a detailed decision logic leads to opportunities regarding automated decision-making, and therefore automated processing, that would lead to the least necessity for human intervention during the process, freeing up expensive resources to other more value-added activities.

A company is only as agile as its business processes. Therefore, a simplification will lead 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.).

2.3.1 Categories of Elements

With DMN a decision can be modelled using a combination of four elements and three requirements (Teniente & Weidlich, 2017):

- 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;

- A business knowledge model denotes a function encapsulating business knowledge (e.g., as business rules, a decision table, or an analytic model);

- An input data element denotes information used as an input for one or more decisions. When enclosed within a knowledge model, it denotes the parameters to the knowledge model;

- A knowledge source denotes an authority for a business knowledge model or decision;

- An information requirement denotes input data, or a decision output being used as one of the inputs of a decision;

- A knowledge requirement denotes the invocation of a business knowledge model;

- An authority requirement denotes the dependence of a Decision Requirement Diagram's element on another Decision Requirement Diagram's element that acts as a source of guidance or knowledge.

2.3.2 Example of DMN

The following table contains the decision logic needed to decide about the desired dish for a given season and number of guests (Figure 3).

Dish				
decision				
U	Input +		Output +	
	Season	How many guests	Dish	
	season	guestCount	desiredDish	Annotation
	string	integer	string	
1	"Fall"	<= 8	"Spareribs"	-
2	"Winter"	<= 8	"Roastbeef"	-
3	"Spring"	<= 4	"Dry Aged Gourmet Steak"	-
4	"Spring"	[5..8]	"Steak"	Save money
5	"Fall", "Winter", "Spring"	> 8	"Stew"	Less effort
6	"Summer"	-	"Light Salad and a nice Steak"	Hey, why not!?
+	-	-	-	-

Figure 3 - DMN example (from www.camunda.org)

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 of the rule. There is also a Hit Policy (in this case is a "UNIQUE" type) that dictates that only one option can be the final result.

3.   BPMN + CMMN + DMN

This section aims to demonstrate the combined use of the three OMG business process modeling notations - BPMN, CMMN and DMN, and how they can deliver a much better representation and understanding of a complex process.

In order to experiment the combined use of the three business modeling notations in the realm of a business process we had to select a *Business Process Management System* (BPMS). These are special SW platforms whose objective is to allow a more efficient and effective interaction between the business and IT worlds. These platforms support all the BPM life-cycle concept, from the beginning to the end, trough process modeling, implementation, development, execution, monitoring and optimization (Karagiannis, 1995). In our work, only the process modeling feature of BPMS is relevant for the time being.

We also had to identify a "proper" business process. One whose modeling could really benefit from the combination of the three notations. So, after seeking in the literature and in the web, our process example was borrowed from a BPMS producer – Camunda, as we thought it is a simple business process but, simultaneously, illustrative of the benefits gained from the three notations combination.

Regarding the tool used in the experiment, after exploring a few options, such as the ones available from the BPMS producers Camunda, Signavio and Trisotech, our choice fell on the Trisotech family of process modeling products. The reasons behind this choice are very down-to-earth. Camunda remains unavailable to us due to its high costs. Besides that, at this stage. it only provides access to the BPMN and the DMN modeler, separately, and no access at all to CMMN. As for Signavio, even though it allows access to an integrated BPMN and DMN modeler, it does not grant any access to a CMMN modeler. Trisotech was the only one who gave us access to all three BPMN, CMMN and DMN modelers and with the ability to integrate them, although without the access to the simulation and process animation[1].

3.1. *Example of the combined use of BPMN + CMMN + DMN*

The example used to demonstrate the combination of the three notations in an integrated model deals with a car insurance application process.

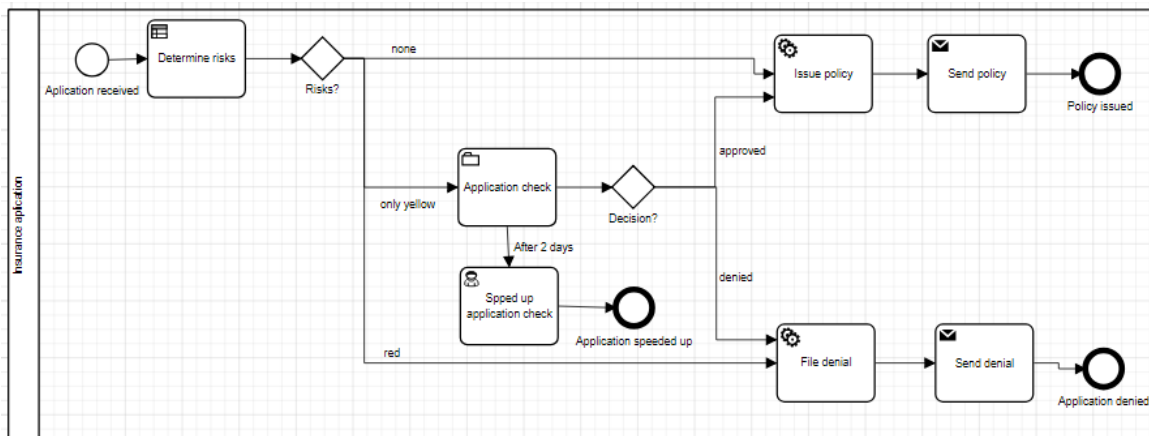The process starts with the BPMN model (Figure 4).

Figure 4 – The BPMN model

An insurance application is received, triggering the process. It then goes through the determination of the risks, performed by a DMN model (Figure 5, explained further on). After that determination the process takes three possible courses. When there are no risks the policy is automatically issued and sent, and the process ends there. When the risk is at "red" the file denial is automatically done, the denial is sent and the process terminates there. When the risk stands at "only yellow" there is the need for a human evaluation and decision, demonstrated by CMMN (Figure 6, further on), and from that comes the determination of the approval or denial of the application.

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[1] This is a problem / because we have no way to test if the created models would complete all the way through. At this very moment the company has been contacted and is working on a solution to grant us access to the simulator and process animator.

Regarding the determination of the risks, performed by DMN (Figure 5).

U	inputs			outputs		Description
	Age	Car manufacturer	Type of car	Determine risks		
				Risks Evaluation	Risk	
	Age (21..30)	Car manufacturer BMW; Porsche	Type of car X3; 911	Determine risks Yellow; Red Risks	Text	
1	<= 21	"none"	"none"	"Yellow"	"Beginner"	
2	<=30	"BMW"	"none"	"Yellow"	"Young" and "fast"	
3	<=30	"Porsche"	911	"Yellow"	"Carelles speeding"	
4	<=30	"BMW"	"X3"	"Yellow"	"Premium car"	
5	<=25	"Porsche"	911	"Red"	"Young" and "too fast"	

Figure 5 – The DMN model

For the determination of the risks there are a series of inputs to define the conditions. In this case there are three inputs that are introduced, being "Age", "Car manufacturer" and "Type of car", from which result five possible outcomes. These outcomes are set by the outputs, that in this case are "Risks Evaluation", used for the BPMN continuation, and a side output that is "Risk", to give additional information in case of being needed later in the process.

Finally, as said before, if the result of the determination of the risks is "only yellow", the process will go through CMMN (Figure 6).
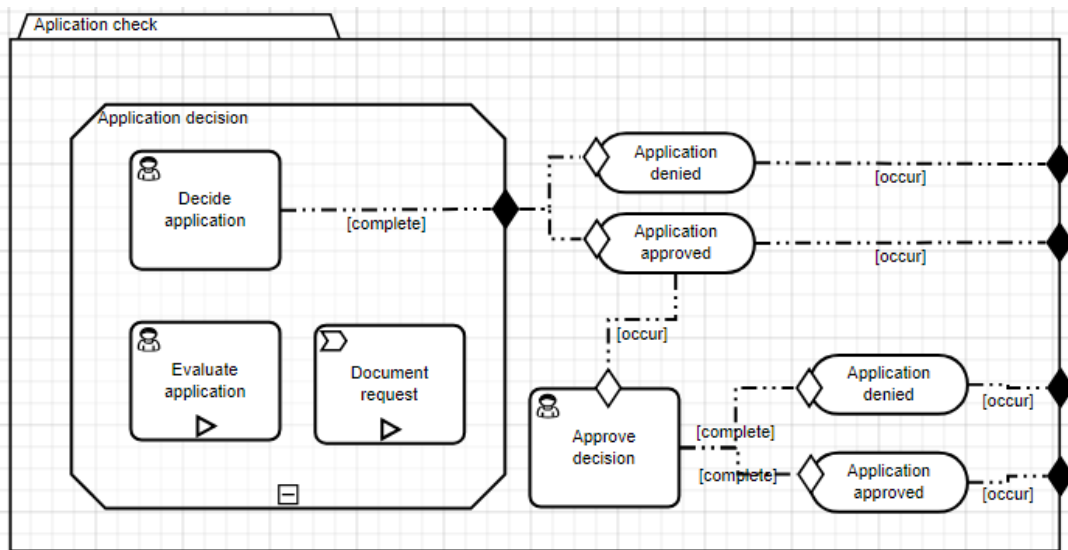

Figure 6 – The CMMN model

So, when the process reaches this stage there is the need for a human evaluation of the insurance application. The application decision is performed by a possible employee that decides if the application is approved or denied, ending the case plan model and proceeding with the process. But this CMMN model also allows for, when the decision is being made, to have a superior also evaluate the application, or to request additional documentation. It also allows for when the employee approves the application, for the superior to approve or denial that decision, finishing there the case plan model.

3.2. *Examples of specific cases*

As said before, in the near future there might be the possibility for us to animate the above business process. Unfortunately, at the present moment there is no way to demonstrate the execution of the process but, obviously, the outcome would be in line with the following scenarios.

For instance, if there was a person with 40-year-old with any car manufacturer and type of car applying for an insurance application the process will receive the application, determine the risks, that will be none, therefore automatically approve it and then proceed to issue and send the policy.

In the case of a 23-year-old with a 911 Porsche applying, the risk will be red and automatically denied, proceeding then to file and send a denial.

In the case, for instance, of a 27-year-old with a X3 BMW applying, the risk will be yellow, leading to a manual decision performed by an employee and, if chosen, to be validated by a superior, and after that to proceed the business process according to that decision.

4. CONCLUSION

This paper describes an experiment in which a process model was defined by integrating three modeling notations: the widely-known BPMN and two other more recent notations (CMMN and DMN). The exploration of the three languages was meant to understand their fundamental roles in improving the modeling and management of business processes in organizations, so they can be able to keep up with the increasingly levels of competition in the market.

Some business process models can get too complex and cumbersome if defined exclusively with the most common process modeling notation (BPMN). This experiment allowed us to conclude that by combining BPMN with the other two notations (CMMN and DMN), business process can become much more simple, comprehensive and easy to maintain. Thus, making the hybrid use of modeling languages the common business processes modeling approach.

It is clear that these modeling notations are perfectly compatible to be used together, as long as one has a BPMS capable of supporting them combined together in the same process model. This will lead to a great change in the way business process are modeled and managed. Nowadays, there is

only a small number of tools with that capacity, but it is predictable that, very soon, this hybrid way of modeling business processes will be the standard approach. We anticipate that, with this hybridization, the modeling of business processes will be reinvented, and the BPM movement will become even more relevant to organizations.

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