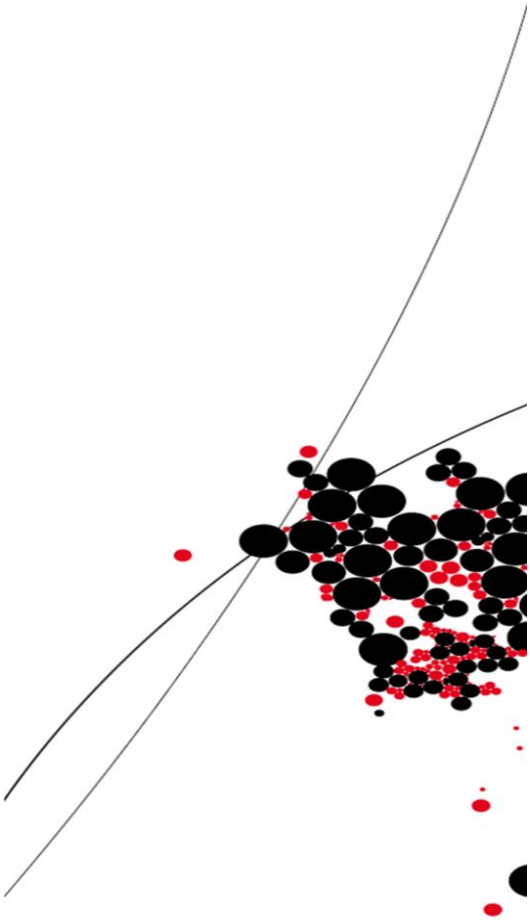
Master Thesis

# BPMN Plus: A Modelling Language for Unstructured Business Processes



Zaharah Allah Bukhsh

August 19, 2015

BiZZdesign

UNIVERSITY OF TWENTE.

# Master Thesis

# BPMN Plus:
# A Modelling Language for
# Unstructured Business Processes

**Zaharah Allah Bukhsh**
S1305131
zaharahbukhsh@gmail.com

Master of Science in Computer Science,
Faculty of Electrical Engineering, Mathematics and Computer Science,
University of Twente,
Enschede, The Netherlands.

19th August, 2015

## Graduation Committee:

Dr. Ir. Marten J. van Sinderen, University of Twente
Dr. N. (Klaas) Sikkel, University of Twente
Dr. Ir. Dick A.C. Quartel, BiZZdesign

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Last but not least, I would like to thank the reader of this thesis for their interest in my research. I hope, my thesis results in an insightful journey for you as it was for me.

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# Executive Summary

In this competitive business era, efficient resource utilization is the priority for a business for their long term survival. This is achieved by an efficient management of business processes using various techniques and methods. The process support paradigm consists of a set of methods and techniques for the management of business processes. On the spectrum of process structuredness, a business process can be broadly categorised as structured and unstructured. Structured business processes are sets of ordered activities that are repetitive and predictable while the activities of unstructured business processes are context dependent, which make them hard to predict.

Management of structured business processes is the topic of research for both academia and industry, where academia focuses on the development of methods and techniques while industry focuses on the development of tools. However, with the shift from routine to knowledge work, the focus on management of unstructured business processes is increasing. Moreover, unstructured processes are goal-oriented and require flexibility during their execution. Therefore, this research is aimed to investigate the techniques to model and manage unstructured processes without limiting their run-time flexibility.

To achieve the goal of the research, process support paradigms, i.e. business process management and case management, are assessed on the basis of their support to manage unstructured business processes. These process support paradigms are analysed with the help of software tools, Bizagi and Cognoscenti, by implementing an unstructured business process and evaluating it using process management aspects such as process modelling, data modelling, user roles, and business rules specifications. Furthermore, the capabilities of Business Process Model and Notation (BPMN) and Case Management Model and Notation (CMMN) is analysed by modelling an unstructured business process. This has enabled us to identify limitations of BPMN and CMMN. For example, BPMN does not provide the run-time flexibility for process execution, while the CMMN is unable to depict the structured process. This analysis led us to define requirements for the modelling of unstructured business processes.

BPMN Plus is an extension of BPMN standard that is proposed in this research on the basis of the requirements set for the modelling of unstructured business processes. BPMN Plus provides a set of concepts and constructs that are aimed to model unstructured processes without limiting their run-time flexibility. The use of BPMN Plus is demonstrated with the help of an example of a knowledge-intensive admission process.

BPMN Plus and the unstructured business process modelling requirements are validated using semi-structured qualitative interviews with the three experienced practitioners of business processes management. They were asked about the usefulness, correctness, ease of understanding, and applicability of BPMN Plus. Interviewees found the BPMN Plus a useful extension to BPMN, which provide many easy to use modelling concepts and constructs. As future research, the evaluation of BPMN Plus with real-world case studies and experiments is recommended.

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# Abbreviations

| | |
|---|---|
| **CM** | **C**ase **M**anagement |
| **BPM** | **B**usiness **P**rocess **M**anagement |
| **DMN** | **D**ecision **M**odel and **N**otations |
| **OMG** | **O**bject **M**anagement **G**roup |
| **GSM** | **G**uard **S**tage **M**ilestone |
| **CMS** | **C**ase **M**anagement **S**uite |
| **CFC** | **C**ontrol **F**low **C**omplexity |
| **MCC** | **M**cCabe's **C**yclomatic **C**omplexity |
| **BPMN** | **B**usiness **P**rocess **M**odel and **N**otation |
| **CMMN** | **C**ase **M**anagement **M**odel and **N**otation |
| **AIIM** | **A**ssosiation fpr **I**nformation and **I**mage **M**anagement |
| **BPMS** | **B**usiness **P**rocess **M**anagement **S**uite |
| **et. al.** | **e**t **a**lii (and others/collaborators) |
| **e.g.** | **e**xampli **g**ratia (for example) |
| **i.e.** | **i**d **e**st (that is) |
| **cf.** | **c**onfer (consult) |

# Chapter 1

# Introduction

Evolution of business and customer requirements are key drivers of business information technology. Business information systems are able to provide the efficiency as well as assist the business in adopting the optimum solutions, draw attention to the delays and bottlenecks, and predict future efforts. A business has a number of business processes, which need to be continuously monitored and optimized. Process support paradigm is an umbrella of techniques and methodologies that facilitates the management of business processes. The examples of such methodologies are business process management, case management, lean management, and six sigma. Many tools provide the support to these methodologies where the business process is planned, modelled and executed.

Traditionally, business processes are classified into external processes, management processes, and support processes. This classification is based on the 'type of task' performed by these processes. However, there is another classification of business processes that is based on 'way' the processes are planned and performed. Such processes include structured and unstructured business processes. Since, business processes are not similar in nature; they require different treatments and one methodology could be better in treating one type of process as compared to other methodology.

Therefore, the focus of this study is to analyse the process support paradigms and process modelling languages to investigate their capability to deal with unstructured business processes.

The structure of this chapter is as follows: the motivation to conduct this research study is provided in Section 1.1. Research goals, research questions and research methodology

are presented in Section 1.2, 1.3, and 1.4 respectively. Finally, Section 1.5 provides the structure of this thesis.

## 1.1 Motivation

Structured business processes have ruled the business process world for centuries. However, according to a recent survey by Association for Information and Image Management (AIIM) [3], 51% of companies indicate that more than half of their process are unpredictable and unstructured in nature. Such processes are dealt in an ad-hoc manner by manually capturing the process related data and stakeholders' communication through e-mails, phone calls, sticky notes, and other informal means. These processes take many unexpected paths based on available data and contextual information. Thus, such processes are difficult to define and model.

In management of business processes, there has been a successful shift from manual processing (paper-based approach) to the automated execution of processes (workflow-based approach). Business Process Management (BPM) is an approach that extends the workflow-based approach in process modelling, process analysis, and process execution [4]. The purpose of BPM is to enhance the overall visibility of processes among IT and business people. In BPM, the processes are well-structured in nature.However, on the other side, there are unstructured business processes where planning of tasks and the order of activities is difficult to predict and model at design-time. Van Der Aalst et.al. proposed the case handling as a new paradigm to deal with such type (unstructured nature) of processes [5]. Data is the main driver of the process flow of unstructured processes.

Case handling, also called case management, is defined as advance BPM where the focus is on processing 'case', which require the collection of data and collaborative activities by many knowledge workers to reach to the conclusions [6]. The notion of case can be understood from medical and legal departments where a case belongs to a specific patient or client. At the processing of cases, data are collected and decisions are made by knowledge workers. But, the required data, course of action, involved parties, and final outcome cannot be predicted in advance. For example, in a process of dispute handling the steps to resolve the dispute, required information, and involved stakeholders cannot

be predicted even after the start of the dispute handing process. A knowledge worker needs to analyse the situation and possible solution steps. Dealing the unstructured business processes in structured way limits the knowledge-worker's freedom into pre-defined activities and flows. In this research, the term 'case' is referred to unstructured business process.

Unstructured business processes is not a new concept. Companies adopt different methodologies to deal with unstructured business processes in a structured way [7]. For instance, insurance claim processing was quoted as an example of structured business process in BPM [8] while now it is used as an example of unstructured business process [9]. Case management as a new concept, with its advertised vendor solutions, pushes the companies to reconsider their approach of dealing with unstructured business processes. For companies, there is a need to analyse the benefits of modelling and managing the unstructured business processes. The initial step includes the focus on process modelling languages to model and communicate the unstructured business processes properly. Therefore, the motivation of this research is to study the unstructured business processes to find suitable ways for their modelling and management. This study provides the insights into the capabilities of existing process management approaches from methodology and modelling perspective. The capabilities of BPMN and CMMN is mainly assessed to model the unstructured business processes.

## 1.2 Research Goals

The goal of this study is to investigate the process support paradigms and process modelling languages to understand their capabilities for the management of the unstructured business processes. We are particularly interested to investigate the possibilities to model the unstructured business processes in a flexible manner.

The objective of this study is

> "To investigate the way through which the unstructured business processes can be modelled and managed without limiting their run-time flexibility."

The research objective is divided into the following sub-objectives:

- To investigate the methodological differences between BPM and CM.
- To investigate whether the current process management paradigms (e.g. BPM) are able to support the unstructured business processes.
- To study the capabilities of BPMN apart from its commonly used notations.
- To study the capabilities of CMMN to model an unstructured business process.
- To investigate the difference between the CMMN and BPMN modelling standards.
- To study the characteristics of unstructured business processes.

## 1.3 Research Questions

The main research question of this research is as follows:

**Main RQ:** *How can unstructured business processes be modelled and managed in a flexible manner?*

To answer the main research question, four subresearch questions are formulated. These subresearch questions allows us to refine our literature search and set the base to answer the main research question.

1. What are the differences between structured and unstructured business processes?

   This question is considered to understand the basic difference between structured and unstructured processes in business. The answer to this question will provide the basic background knowledge to understand the purpose and discussion of this research study.

2. What are the differences between BPM and CM in dealing with unstructured business processes?

   - What is Business Process Management (BPM)?
   - What is Case Management (CM)?
   - What are methodological differences between BPM and CM?

The purpose of these questions is to study the approach of BPM and CM. The answer to these questions will provide the insight about differences between the process management approach of BPM and CM. To compare BPM and CM , an experiment is planned.

3. What are the capabilities of existing modelling notations to deal with unstructured business processes?

   - What are the capabilities of BPMN?
   - What are the capabilities of CMMN?
   - What are differences between BPMN and CMMN?
   - How are the process models of BPMN and CMMN different in their expressibility?

   The purpose of these questions is to investigate the capabilities of process modelling notations to deal with unstructured business processes. The reason to investigate the capabilities stemmed from the fact that the capabilities of a modelling language is not utilised completely and its use is remained confined to a subset of concepts, which are well known. According to Zur Muehlen and Recker [10], less than 20% of BPMN vocabulary is regularly used in academia and industry. The reason to consider BPMN is because it is one of the widely adopted process modelling language. While, CMMN is considered because it is the only available modelling standard that is targeted to model the undefined and not so repeatable set of activities of business processes. Moreover, both modelling notations, BPMN and CMMN, are proposed by OMG, which means the deficiencies of one modelling language is expected to be fulfilled by the other. BPMN and CMMN are compared to gauge their support for modelling unstructured business processes.

4. How to model an unstructured business process while providing run-time flexibility?

   - What are the modelling requirements of an unstructured business process?
   - How to model an unstructured business process flexibly?

   The purpose of this question is to investigate the modelling needs of an unstructured business process. With the identified modelling requirements, it is aimed

to extend a modelling notation that is capable of modelling unstructured process without limiting its run-time flexibility. The practical usefulness of newly proposed modelling notation is investigated by demonstrating it with the help of an example. Moreover, the proposed modelling notation is validated by conducting interviews with experienced practitioners.

## 1.4 Research Methodology

Practical problems and knowledge problems are two main types of research problems [11]. The difference between the current state of artefact and how stakeholders want it to be from the class of practical problems. The other class of research problem is knowledge problem that is the difference between current knowledge of stakeholders and what they want to know. In other words, practical problems, investigate, design, and improve the artefact or certain aspects of it, while knowledge problems analyse the current state of knowledge to analysis its usefulness for stakeholders.

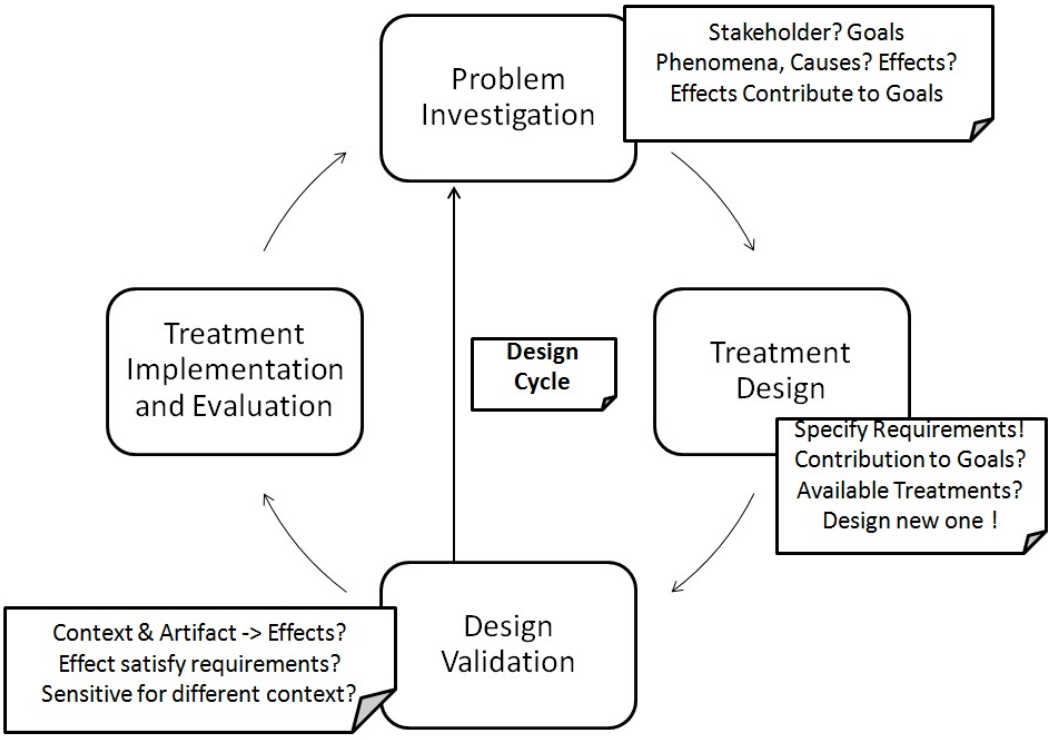



FIGURE 1.1: Engineering and Design Cycle

The research questions of this study belong to the class of practical problems. Wieringa [12] has proposed an engineering cycle as a research methodology to answer the practical problems. The steps of engineering cycle are presented in Figure 1.1. In addition to main steps, a related check-list is defined with each step. The check-list points provide the guidance throughout the research process.

For this research, only a part of engineering cycle, i.e. design cycle is implemented. Design cycle does not include the final implementation phase of the engineering cycle. In the following, the explanation about the adopted design cycle for this research is provided.

**Problem Investigation:** In this first step, the research problem is investigated and reasons for problem consideration is provided. As mentioned in Section 1.1, companies are encountering with increased number of unstructured business processes. These unstructured business processes are dealt in an ad-hoc manner, which results into manual process processing and unstructured process data. In order to have firm understanding of underlying problems, in-depth literature studies will be performed regarding BPM and CM as process support paradigms and BPMN and CMMN as process modelling languages.

**Treatment Design:** In this step, the available design treatment(s) are analysed and the new treatment is designed to solve or mitigate the identified problems. In this research, the available design treatments are BPM and CM, as process support paradigms, and BPMN and CMMN as modelling languages. To assess the process management methodology of BPM and CM, a experiment is planned. A comprehensive business process will be implemented on BPM and CM based software tools. Apart from process management methodology, the process modelling languages, which are BPMN and CMMN will be assessed in order to gauge their support for modelling an unstructured business process flexibly. The capabilities of BPMN and CMMN is planned to be assessed by modelling a sample unstructured business process. Modelling of an unstructured business process with BPMN and CMMN will assist us in tracing their limitations. Based on modelling limitations of both languages, the requirements to model an unstructured business process will be derived. To fulfil the modelling requirements of unstructured business processes, an extension to BPMN modelling standard will be proposed. BPMN is choose to be extended due to number of following reasons.

1. BPMN is one of most popular modelling language that has been widely adopted in business due to its rich and expressive modelling constructs.

2. It is expected that the modelling concepts and constructs of BPMN will be able to fulfils many derived requirements of modelling an unstructured business process in flexible manner, thus requiring only few new constructs as extension.

3. With an extension to BPMN, it will be possible to model the structured and unstructured part of a business process.

The extended BPMN will be named as BPMN Plus. The extension of BPMN will have some new concepts and constructs while some modification in existing concepts of BPMN can also be made. The demonstration of BPMN Plus will be performed by modelling a sample unstructured business process.

**Design Validation:** In this final step, the proposed treatment design can be validated with the help of case studies, client's feedback, experiments, and interviews. The proposed artefact of this research, which is BPMN Plus, is planned to be validated by conducting semi-structured qualitative interviews with three experienced practitioners of BiZZdesign. These interviews will provide us with interesting insights about the BPMN Plus with respect to its practical usefulness.

It is important to notice that the feedback provided by interviewees and practical use of BPMN Plus can initiate another research cycle. However, the scope of this thesis is limited to execution of design cycle only once.

## 1.5 Document Structure

The structure of this thesis is depicted in Figure 1.2. From a formal research perspective, there are four major parts of this thesis. In background part, Chapter 1 provide motivation of this research along with research objectives, research questions, and research methodology. The theoretical background of this study is defined in Chapter 2, which discusses the main terminologies and concepts. The available solutions are described in Chapter 3 and Chapter 4. In Chapter 3, an experiment is described that is conducted

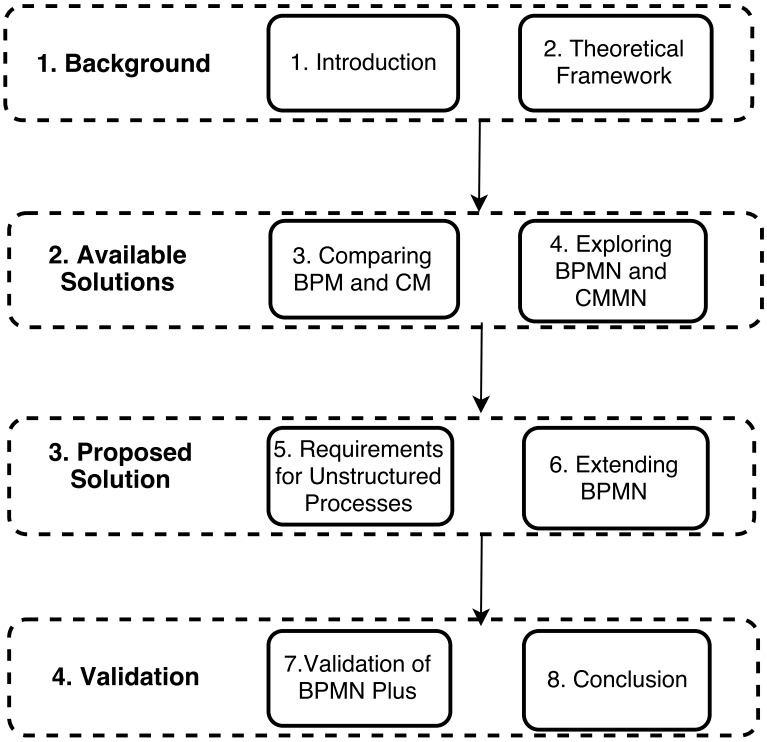



FIGURE 1.2: Thesis Outline

to understand the methodological difference of BPM and CM for dealing an unstructured business process. Chapter 4 provide the analysis of popular modelling notations to investigate their capability to model an unstructured business process.

In third part, an artefact is proposed to deal with unstructured business processes. In Chapter 5, the requirements to model the unstructured business processes are identified. Chapter 6 define the proposed extension to existing modelling standard BPMN. The proposed requirements and extension to BPMN is demonstrated with the help of an example application. In validation part, BPMN Plus is validated by conducting interviews with experienced practitioners. The validation settings and results are provided in Chapter 7. Lastly, Chapter 8 provides the answers to research questions following with recommendations for future research.

# Chapter 2

# Theoretical Framework

In this chapter, the theoretical background of this research is defined. Some parts of this chapter are taken from an internal report conducted for the sake of literature study [13]. Section 2.1 introduce the key concepts of this research. These concepts include the definition and discussion of general terminologies that are used throughout this document. An overview of current literature regarding the management and modelling of unstructured business processes is provided in Section 2.2 and 2.3 respectively. The summary of this chapter is given in Section 2.4.

## 2.1 Key Concepts

### 2.1.1 Business Process

A process is a procedure which consists of a set of activities that produce a certain outcome either in a form of product, service or a decision. The notion of process can be understood from our routine actions. Buying grocery, cooking food, getting ready for work are examples of a process which further consist of a number of small activities. The concept of process in business was first introduced by Adam Smith in 1776 which was mainly focused on division of labour [14]. Even after centuries, a standard definition of business process don't exist. Here, some definitions are quoted to set the base for this research.

Michael Hammer and James Champy define the business process as

> "Collection of activities that take one or more kinds of input and create an output that is of value to the customer" [15]

According to this definition, a process must have input(s) that will produce certain outcome. The aspect of "collection of activities" doesn't define any ordering among activities.

Davenport defines the business process as

> "A structured, measured set of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how work is done within an organization. A process is thus a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action..." [16]

As compared to Hammer and Chumpy definition [15], the Davenport definition [16] implies certain condition on a process to be specified as a business process. According to him, a business process is required to be detailed which answers "how work is done" with structured, ordered and measured set of activities.

In the Open Group's Archimate specification, business process is defined as

> "A behaviour element that groups behaviour based on an ordering of activities. It is intended to produce a defined set of products or business services" [17].

The concept of definition suggested by OpenGroup [17] is similar to the Davenport definition [16] which suggests the ordering of activities as an integral part of the business process.

According to OMG's Business Motivation Model (BMM) specification,

> "Business processes realize courses of action. Courses of action are undertaken to ensure that the enterprise makes progress towards one or more of its goals" [18].

The definition provided in the OMG BMM specification is very generic in nature. Based on this definition, everything that a company do to achieve its goals can be classified

as a business process. Similar to Hammer and Clampy definition [15] the ordering of activities and their structuredness are not a central part of a process.

It is worth noticing that the each of the considered definitions differs in its context and scope while having certain aspects in common. By context, we mean, "business process" term is used in identifying, specifying, modelling, analysing and improving the regular occurring business operations. In any of these contexts, the purpose of process is to provide certain outcome either by following structured and ordered set of activities or by an unstructured collection of activities.

### 2.1.2 Business Process Spectrum

A business perform different business operations on daily basis. These business operations are also defined as business process which help the business to achieve its objective. The nature of business process vary by its associated participants, resources, and its interaction with computer systems [19]. The classification of business process was first provided by Mccready [20] where the process are defined as ad-hoc, administrative and production. Van der Aalst et. al. proposed a slightly different business process classification, which are tightly framed process, loosely framed process, ad-hoc framed process and un-framed process [21]. Here, the business process classification proposed by Kemsley is discussed [22].

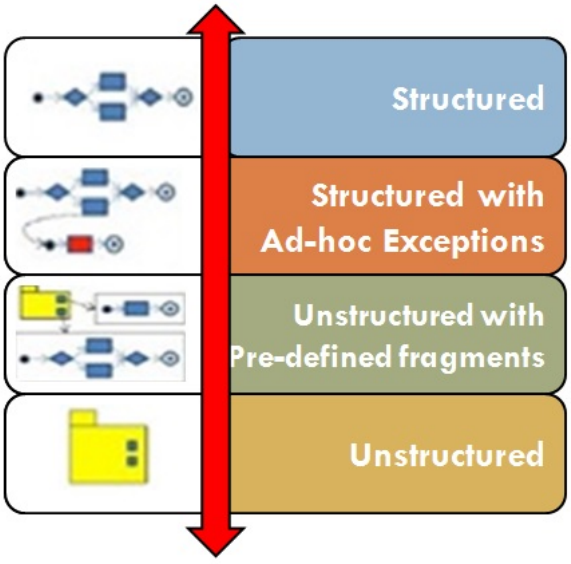



FIGURE 2.1: Business Process Spectrum [22]

Figure 2.1 provides the view of the business process spectrum based on process level of structuredness. On the top of the spectrum in Figure 2.1, there are *structured processes* in which the sequence of activities can be predicted and planned before the real-time execution of process. These processes are application-centric that are easy to automate and are repeatable in nature. Such process can be modelled completely with roles, real-time events, ordered set of activities and their possible flow of data. With process model, a process can be further analysed, optimized, monitored and executed. A fully automated structured process is able to communicate with other systems as well as can take actions based on pre-programmed conditions and events. The regular occurring processes are examples of structured process, e.g. order placement, customer registration, salary payments.

The complex scenarios of business require the structured processes to be able to deal with accidental and unpredictable situations. *Structured processes with ad-hoc exceptions* is an example of such processes where activities are not performed in real-time as it was planned in design-time. The ad-hoc exception of the process include the alternative order of activities execution, adding or removing of activities, varying time, occurring of message or manual events. The common reason of such exception are contextual triggers, changed customer requirements, and process related data. It is difficult to model such processes as real-world situations cannot be predicted in advance. The example of structured process with ad-hoc exceptions are lost of order delivery, financial services transactions, etc.

Moving away from structured processes spectrum, *Unstructured process with pre-define fragments* are those processes which cannot be anticipated and defined in advance however some parts of the process can be predicted. For instance, in customers complain services the process to register customer complain and to provide response are structured, but the required activities to deal with customer complaints can vary for each customer complain.

On the other extreme, there are *Unstructured processes*, as its name implies, are difficult to define and model as the exact course of activities are unknown at design-time. The focus of unstructured process is on available and emerging data, real-time events and knowledge of knowledge workers. Thus, a process is said to be unstructured if its activities can't be anticipated and it requires data, experience, tacit knowledge and decision

making skills from one or more knowledge workers to solve the problem at hand. The example of such process is claim handling, loan approvals, accounts payable, customer service, and travel requests.

In a nutshell, business processes can be broadly categorised into structured and unstructured processes. Structured processes are also said to be activity-centric as the focus is to perform an activity by executing a number of small tasks. On the other hand, unstructured processes are unpredictable, flexible and non-repeatable. Data and human collaboration are integral parts of unstructured process execution.

### 2.1.3 Unstructured Business Processes and Different Terminologies

During literature study, different terminologies for unstructured processes are noticed. These terminologies refer to the similar concept of business process as being unpredictable, context depend and require human collaboration. The possible reason for many terminologies is because of different process support paradigms that are used for process management.

In the following, each of these terminology that provide the concept of unstructured processes is discussed.

**Case** The notion of the case is adapted from legal and medical field where each case tend to be different than the other. OMG defined the case as 'a proceeding that involves actions taken regarding a subject in a particular situation to achieve a particular outcome' [23]. The actions taken vary from collection of data, making decisions and involving other knowledge workers. Unstructured business processes are most commonly referred as case due to case management process support paradigm (see Section 2.2.2).

**Knowledge-Intensive Process** The process highly rely on available data and knowledge of knowledge workers/process manager to take process related actions. Vaculín et. al. define the knowledge intensive process as business process whose conduct and execution is highly dependant on knowledge workers performing different tasks and taking decisions [24]. These processes require a substantial level of flexibility at design-time and run-time.

**Dynamic/Declarative Process** These processes don't follow the design-time defined structure of business process, but tend to change with respect to certain process instance requirement. Such process are declarative in nature which means that process related information is not defined in detail at design-time.

**Person-to-person process** The involved stakeholders play the primary role in the execution of process [19]. Such process requires the human intervention in the form of task execution, making decisions, and regulating process flows.

Each of the discussed terminology refers to same process related concepts, i.e. the process is unpredictable and dynamic in nature, it requires the design-time and run-time flexibility, data and knowledge workers are its primary focus and each process instance tend to be differ than the other. To avoid confusion with different terms, we will be using the term *unstructured business process* to refer to a dynamic, knowledge-intensive, collaborative business process.

## 2.2 Management of Unstructured Business Processes

In this section, two process support paradigms are discussed. These paradigms are referred as process support paradigms because they facilitate the management of business processes by providing the set of methods, techniques and tools.

### 2.2.1 Business Process Management (BPM)

Business Process Management (BPM) is one of the most popular process support paradigm. The purpose of BPM is to innovate, maintain and optimize the business process by defining, modelling and automating it. BPM integrates the business process, information, IT, and human resources, thus aligning the organization's code assets [25]. Initially, BPM was mainly focused on automation of business process, but the advancement of technology enables the BPM with capabilities of process analysis, optimization and management. The most basic activities of BPM are modelling, enactment, analysis and management [4]. In process modelling, the core activities, user roles, and control flow of a process are defined. The process model is further used in the enactment and analysis.

The graphical model of the process, not only defines the process in a concrete manner, but it enables discussion among business stakeholders for the further refinement, optimization and management of the process. While, an automated business process results in increased efficiency and reduced cost. The enactment of process model provides the results which can be further analysed and managed by process managers. These days, many BPM Suites (BPMS) provide the platform for process modelling, process execution and process analysis.

Since BPM paradigm has been evolving for years, it possesses many definitions provided by researchers. Johan Nelis et. al. define the business process management as, "the achievement of an organization's objectives through the improvement, management and control of essential business processes" [26]. While, according to Weske, "business process management includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes" [27]. According to John Jeston's definition [26], BPM constitute of those activities that perform process improvement while according to Weske's definition [27] the techniques and methods that are used to perform the process design, administration, analysis and improvement are all part of BPM. The activities of BPM strictly depend on used techniques, methods, and sometimes BPMS, so one can say that definition provided by Weske [27] represent the today's BPM.

Figure 2.2 provides the continuous improvement lifecycle of BPM. On design step, business processes are surveyed based on their technical and organisational environment [27].

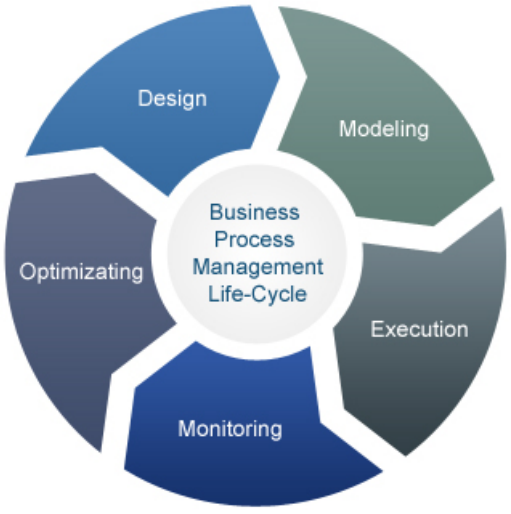



FIGURE 2.2: Business Process Management Lifecycle

The design phase allows the process engineer to analyse and go through the daily occurring processes of business. The business process is designed into collection of activities, real-time events and control logic. Based on process design, process is modelled in graphical form. Process modelling languages provide the notations for representation of activities, events and control logic. Such notations make the process model easier to read and generally understandable for the business stakeholders.

For software engineers, the process model acts as a requirement specification document for the implementation and automation of business process. Once the process is implemented, it can be executed as process instances. The execution of processes requires continued monitoring. The process events and activities require human intervention for triggering process events and for completion of the task. Process execution also provides insights into the resource utilizations, task efficiency and possible bottlenecks. Such analysis report provides the chances for process optimization.

Different process support techniques are used for optimization of process. Lean management and six sigma are examples of such techniques in which waste of resources is eliminated as much as possible, so the assets can be utilized into effective manner.

**Architecture of Business Process Management**

To provide an overview of process modelling and process execution from the perspective of BPMS, Figure 2.3 is adopted from Weber et. al. [1]. Main focused aspect of BPM lifecycle is process modelling. All the subsequent steps of BPM are dependent on the process model. The steps of process monitoring and process optimization are not depicted in Figure 2.3.

Once the process is modelled and ready for execution, the end-user can access the process through the electronic forms. As soon as, end user initiates the process, the process instance is created in the process execution engine. The entire process instance will follow the process model that is defined by the process engineer on design-time. However, end user can only view that part of the process that is assigned to him. The limited view over process is known as context tunnelling. Context tunnelling is explained as the "tunnelling the vision of end-users on the design-time specific tasks and activities without the consideration of real-time contextual information of process" [5]. Moreover, it is worth noticing that process execution and business related data are strictly separated. The focal point of BPM process is ordered execution of activities as defined in the

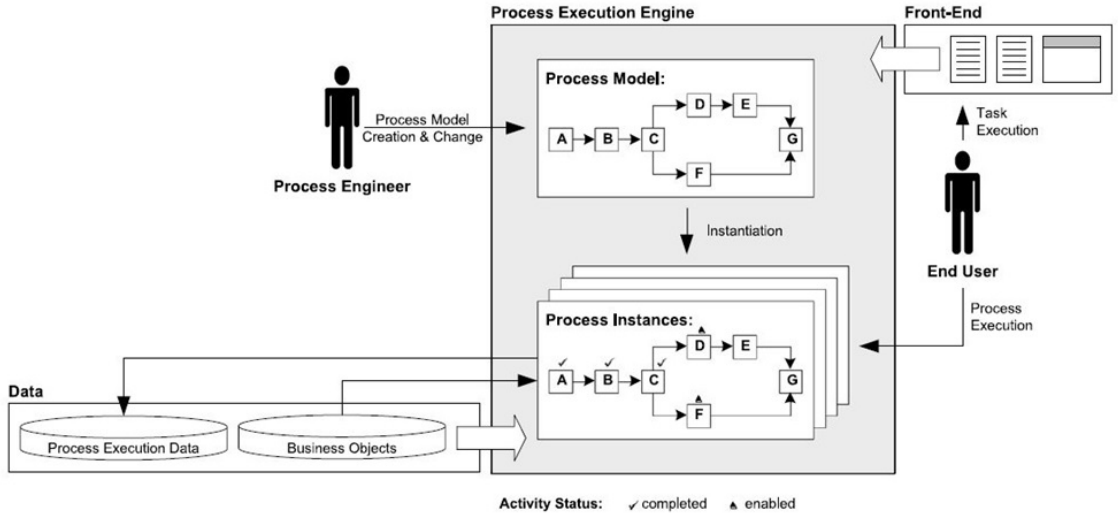



FIGURE 2.3: Architecture of Business Process Management [1]

process model while the data is dealt as the second class citizens. Because of separation of process and data, each process instance has a limited view on in and out flow of business data.

### 2.2.2 Case Management (CM)

Case management is a process support paradigm that facilitates the management of unstructured business processes in a flexible way. It facilitates the government, banking, insurance companies, and legal firms in capturing the complex customer interactions. Case management as a paradigm for business process support was proposed by Van der Aalst et. al. in 2003 [28]. He explained the difference between BPM and case management as BPM focus on what 'should' be done in a business process while the later one is about what 'can' be done [28].

IBM defined case management as, "it is a goal-oriented process where people must make real-time, complex decisions with changing information, often working interactively with others inside or outside of their organizations to obtain the most effective outcome" [6]. Case management as paradigm facilitate the knowledge workers in decision making, data capturing, and employing the tacit knowledge to respond to unique and changing circumstances business environment [29].

In case management, the process instance is referred as a case. The case can be defined as "collection of tasks, actions, processes, and content in support of a specific business process" [30]. Data and actions of knowledge workers are the centre of focus that drive the whole process. Addition or modification of data can change the course of activities and case final outcome.

Case management is broadly categorised into two types: production case management and adaptive case management [31]. In production case management, each process instance can have many variations. Due to the unpredictability and varying nature, it is not possible to define a single fixed process. Yet, the other possible solutions to deal with cases are known and can be taken. The knowledge worker is continuously involved in analysing the case need and providing the appropriate solutions. In adaptive case management, there is need of constant innovation. The knowledge workers are involved in inventing the solution to cases that don't exist before.

In this research, the main concept of case management is studied. Discussion on different types of case management and their characteristics is out of the scope of this study.

Figure 2.4 provide the core principles of case management. A case is goal-oriented in nature as the goal of the case is known in advance, but the course of action to reach the goal is unknown until the case is at-hand. Case management is required to be adaptive as the end users are not process engineers, but the knowledge workers who are required to take complex decisions based on available data and real-time events. The adaptive

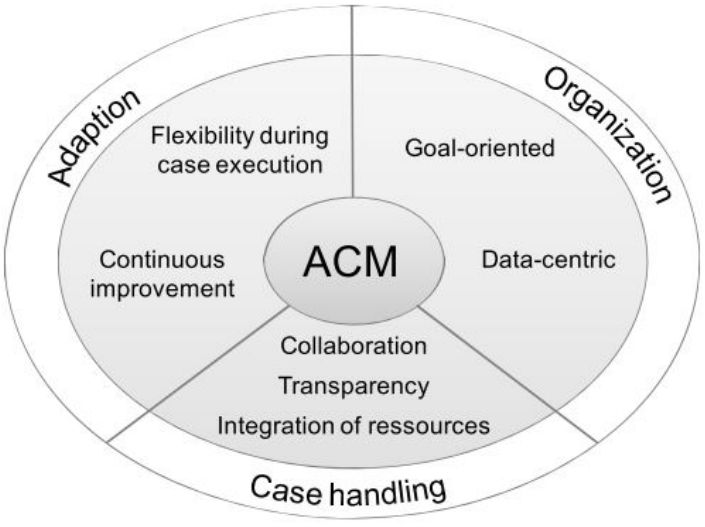



FIGURE 2.4: Core Principles of Case Management [29]

ability of case management paradigm suites the unstructured business process as the structure of the process cannot be predicted at design-time. Moreover, the knowledge-intensive business process requires the collaboration from many knowledge workers. The knowledge workers have to collaborate to reach to the final decision.

### Architecture of Case Management

Figure 2.5 provides the architecture of case management. The architecture of case management is defined based on its execution on Case Management Suite (CMS). In case management, case model is not defined as the ordered set of activities like process model, but all those tasks that can be executed during case processing are modelled.

In case execution, case creator first analyses the nature of the case at hand. If the similar case model already exists in cases directory, then it is adopted as a template. However, it is worth noticing that the adopted case model is used as a guidance tool to solve the case which is not necessarily be followed in case execution. The central focus part in case execution is the case folder. In contrast to BPM architecture (see Figure 2.3), all the relevant data in case is contained in case folder which is easily accessible by case creator and other knowledge workers. Every knowledge worker of the case, based on their permission levels, can add, delete or modify the content of the case. However, the focus

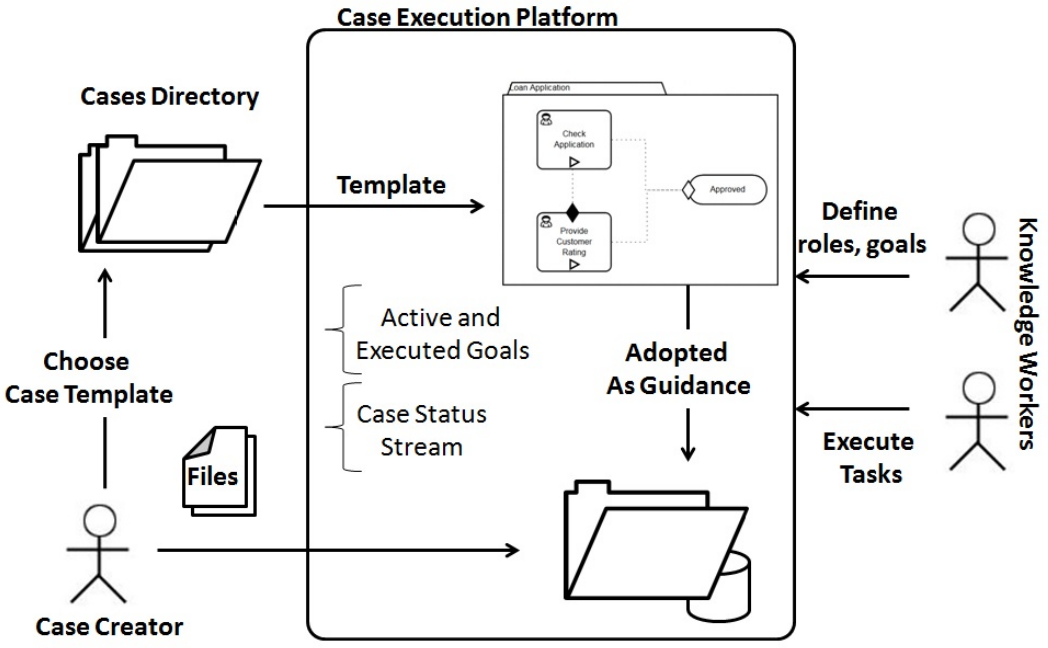



FIGURE 2.5: Architecture of Case Management

on data can also cause the data dependency. The unavailability of particular content can halt the processing of case. Considering the case requirement during execution, knowledge worker can add or edit goals, invite more knowledge workers, extends case due deadlines, request new data and can view the status of the overall case.

## 2.3 Modelling of Unstructured Business Processes

For this research, BPMN and CMMN are selected to assess their capability for modelling unstructured business processes. The reason to consider BPMN is because it is one of the widely adopted process modelling language in academia and in industry. While, CMMN is selected because it is specifically targeted for modelling those business processes which are unpredictable in nature. Moreover, CMMN and BPMN are proposed by OMG, which means the deficiencies of one modelling language is expected to be fulfilled by the other. The brief introduction of BPMN and CMMN is provided in the following Sections.

### 2.3.1 Business Process Model and Notation (BPMN)

BPMN is a graphical modelling notation that promises to model the 'end-to-end' business process. The goal of BPMN is 'to provide a notation that is readily understandable by all business users, from business analysts to technical developers' [32].

BPMN was initially proposed by Business Process Management Initiative (BPMI). Later, as a result of organizational merges, it is adopted by the OMG. BPMN version 2.0, released in 2011, provide very rich set of modelling notations. Three BPMN diagrams were introduced with the name of *process*, *choreography* and *collaboration* [2]. Process diagram describes the sequence of activities flow that perform a business process. Choreography diagram shows the interaction among the business people who are responsible to perform activities. While, the collaboration shows the interaction among inter and intra-organizations' processes.

The focus of this research is to assess the modelling language for unstructured business processes. Hence, the scope is limited to process diagrams of BPMN only. For business process modelling, various concepts with their associated notations are proposed in BPMN standard specification [2]. A process model that is based on BPMN is able to

demonstrate the activities, real-time events, conditions, sequential flows, data objects and many other related concepts. Exploiting these rich notations, BPMN process model is able to depict the extensive real world business process in a graphical model form. The detailed description of BPMN as process modelling language can be found in [2] and [32].

### 2.3.2 Case Management Model and Notation (CMMN)

Case Management Model and Notation (CMMN) is, a very recent modelling standard, proposed in January 2014 by OMG. CMMN, as a graphical modelling notation, promises to model the a case or unstructured business process in a way that can express their essential run-time flexibility [23]. Usually, an unstructured business process is managed and directed by a single or group of knowledge workers. These knowledge workers are responsible to plan the task sequence, take decisions and require ad-hoc collaborations all on the run-time [33].

According to Grudzinka [34], business artefact laid the foundation for CMMN. Referring to Bhattacharya et. al., he defined the business artefact as 'a business entity that is used to store the information to a given process context' [35]. The business artefacts have a complete lifecycle with clear states from start to its completion. Each particular state of business artefact informs the knowledge worker/process manager about how far a business entity is for its completion. Guard-Stage-Milestone (GSM) approach was introduced to capture the information model of business entities as well as their states [36]. It is believed that the proposed CMMN is influenced by GSM [23, 34].

From the modelling perspective, the core elements of CMMN are defined into three types. *Case model element* introduces the notion of the case as a main container which constitute every related element. *Information model element* consist of case files that contains all the case related data. Final and most important element is *plan model elements*. The elements that belong to plan model are particularly visible on case model. It includes events, milestones, plan items, sentry, task, and planning table. The description of each of these elements with their notation can be found in standard specification of CMMN [23]. As discussed in Section 2.1.3, we will refer to case model as an unstructured business process model in this study.

## 2.4 Summary

This chapter provides the introduction to key concepts and terms that will be used throughout this research. In addition to business process definition, the structuredness level of business processes is discussed. On the structuredness spectrum, a business process can be structured, structured with ad-hoc exceptions, unstructured with pre-defined fragments or unstructured. Moreover, various terms that refer to the concept of unstructured process is also discussed. Additionally, BPM and CM along with their software architecture are briefly explained. In the end, a brief background and introduction to BPMN and CMMN is provided.

# Chapter 3

# An Experiment to Compare BPM and CM

In this competitive era, efficient use of business assets is a basic need for an organization for their survival. Effective resource utilization will benefit the business in terms of enhanced profit, reduced response time and low cost. The business employs various methods, techniques and methodologies to optimize their business operations.

Due to various types of process, process support and process improvement paradigms; an organization has to make a decision on which process support paradigm is more useful in dealing with a particular type of business processes. In this chapter, two process support paradigms are compared to better understand their strengths and weaknesses in managing unstructured business processes.

For comparison purpose, an experiment is conducted. The experiment will help us understand about which process support paradigm is more efficient and easy to use for implementing and maintaining an unstructured business process. Moreover, results of experiment will provide us the insights in process management approach of BPM and CM.

Section 3.1 introduces the experiment's purpose and hypothesis. Experiment setup and experiment execution details are provided in Section 3.2 and 3.3 respectively. Results of the experiment are discussed is in Section 3.4. Section 3.5 concludes the chapter with a summary.

## 3.1 Experiment

As discussed in Chapter 2, BPM and CM are process support paradigms with difference in focus. An experiment is planned to assess and compare the capabilities of BPM and CM. The approach of the experiment is adopted from Weber et. al. [1]. The purpose of this experiment is to understand the methodology of BPM and CM by practically executing a comprehensive business process. Moreover, it is also aimed to access, which process support paradigm is more efficient and easy to use for implementing and maintaining an unstructured business process.

BPM is well established paradigm for handling and atomizing the business processes through Business Process Management Suites (BPMS). BPMS is a software platform that facilitates the modelling, enactment and execution of business process [37]. These suites define and model the business process and provide an executable process application. On the other end, CM facilitate the management of unpredictable business processes through Case Management Suite (CMS). CMS is a software tool that provides the features to initiate the unstructured business process, set process related goals, assign task to knowledge workers and define deadlines.

Based on Goal/Question/Metric method template [38], the goal of this experiment is defined as follows:

"Analyse 'unstructured business process' for the purpose of 'comparing process support paradigms' with respect to their ' effort of implementing unstructured business process' from the point of view of 'end-users (process engineer/knowledge workers)"'.

### 3.1.1 Context

Business adopts various process support paradigms to better manage business processes. In the past, for the efficient execution of process, a business process is designed and atomized. However, with unstructured business processes, the atomization is not an option as the process can't be completely defined at design-time. To deal with unstructured processes efficiently, business stakeholders have to make a decision on which process support paradigm is more appropriate. The possible question by business stakeholders is quoted below:

*"Which process support paradigm is suitable for managing unstructured business processes"?*

For some business stakeholders, the unstructured business processes can be handled with BPM as the capabilities of BPM are underutilized. While, for others the BPM is unable to provide the flexibility to business process and there is need of a new paradigm to manage unstructured business processes.

### 3.1.2 Hypothesis

Based on the purpose and context of experiment, the following hypotheses are derived.

**Null Hypothesis:** There is no difference in process support methodology of BPM and CM while dealing with unstructured business process.

**Alternative Hypothesis:** There is a significant difference between process support methodologies of BPM and CM while dealing with unstructured business process.

## 3.2 Experiment Setup

In this section, the setup of the experiment is formally introduced by defining subject, the object of study, factor and factors level, and threats to validity.

The explanation of each aspect is provided as follows:

**1. Subject:** The purpose of this experiment is to understand the BPM and CM methodological differences while dealing with an unstructured business process. Considering the purpose of this experiment, the subject of this experiment is only one researcher who is also responsible for experiment setup as well as for experiment execution.

**2. Object of Study:** The object of study is an unstructured business process of insurance claim. The reason to consider the insurance claim process as the object of this experiment is due to the fact that an insurance claim process is quoted as an example of structured process [4] as well as an unstructured process[39].

In the insurance claim process, each claim request is usually different than the other one. As in case of auto claim, the claim request can vary from the crack in the side

mirrors, to an accident involving police, medical reports, witness reports and may be another insurance company as well. Since, the combinations and permutations of such real-time events are hard to predict, it is difficult to define the process model completely at design-time.

Following is the descriptions of insurance claim process [8].

*Description of Insurance Claim Process:* The insurance claim request starts when the insurance holder submits the claim request to the insurance company. Once the request is received, the *claim handler* checks whether the claimer is a current policy holder of the company or not. If the claimer is not a current policy holder of the company, the claim request is rejected. If, in case, the claimer claims to own a policy type for which he is not paying premiums, the claimer is requested to make necessary changes in provided data. If the claimer is the policy holder of a company the claim request is registered and handed over to *investigation manager*. *Investigation manager* investigate the provided data for its accuracy and completeness. Moreover, he is also responsible to collect further relevant data. Depending on claim request, the data collection activity can require the decisions and data from many stakeholders e.g. police, hospital, traffic controller, auto repair, and witnesses. Once the data is collected, the *investigation manager* needs to make a decision on whether the collected data is enough to make the final claim decision. In case, the collected data is not enough, more data will be requested. Otherwise, the claim process is handed-over to *decision maker*. Further analysis of claim request is performed based on the collected data. Considering the nature of the claim, a single person can make a decision or a panel need to collaborate to reach to the final decision. The claim settlement is made only if the claim is accepted otherwise the claimer is informed about the rejection of claim and the claim process is closed.

**3. Factors and Factor levels:** The factor or independent variable of this experiment is process support paradigm with two factor level which are BPM and CM. Bizagi modeller and Bizagi Studio [40] is selected as BPMS to analyse the BPM capabilities. According to Gartner magic quadrant[41], Bizagi is one of a visionary vendor of BPMS. As a CMS, Cognoscenti software tool is used. Cognoscenti [42] is one of few CMS that is available free of cost for research purpose [39].

**4. Response Variable:** The response or dependant variable of this experiment is 'effort of implementing an unstructured process'. The usage effort will be measured by implementing an insurance claim process on BPM based tool Bizagi and then on CM based tool Cognoscenti.

**5. Analysis:** Analysis procedure provides the design of the analysis process of experiment. Based on the goals and response variable of experiment, the analysis design can be a mathematical model, a statistical measurement or a simple checklist of tasks. In this experiment, it is difficult to quantitatively gauge the effort of implementing unstructured business process as well as to assess the differences between BPM and CM process management methodology. Hence, certain aspect of process management is proposed for analyses purpose. These process management aspects include (a) process/case modelling, (b) data management (c) business rules specification (d) user roles specification (e) process/case progress view (f) process/ case control (g) activities execution and (h) process/case setup effort.

**6. Threats to Validity:** For any experiment, there are some aspects that can influence the final outcome of the experiment. Few threats to validity for this experiment are as follows:

1. In this experiment, it is planned to access the difference in methodology of BPM and CM based on their software suites. However, the features provided by certain software platform can influence the results of this experiment.

2. The experiment has very limited subjects, i.e. only one researcher. The knowledge of researcher about BPM and CM can influence the final results.

3. The object of this study i.e. insurance claim process can have possible biases for one process support paradigm over the other.

To mitigate the effect of these threats, some additional steps are performed. For example, Bizagi provide the functionality of process modelling while Cognoscenti lack this feature. To bring balance of functionality between both platforms, Microsoft Visio stencil was created and used for modelling the case using CMMN. The second threat of validity is mitigated by presenting the results of experiment to two experienced BPM practitioners as well as to three experienced researchers. The third and final threat of validity is

mitigated by carefully selecting a business process, which is mentioned as an example of structured and unstructured business process in [4] and [39] respectively.

## 3.3 Experiment Execution

In this section, the steps of execution of process are defined. Implementation of the insurance claim process can be broadly divided into design-time planning and run-time execution. In design-time planning of the process, the process is defined and modelled. While, in run-time the process instance is created as a result of process initiations. In the following sections, implementation of the insurance claim process is discussed with Bizagi and Cognoscenti software suites.

### 3.3.1 Insurance Claim Process with Bizagi (BPM)

For processing of insurance claim process in Bizagi, process modelling is first and most integral part of the process management lifecycle. Based on process model, data model, business rules, user roles and electronic forms are designed. After the deployment of designed process, the process can be accessed on work portal of Bizagi. On work portal, a process instance can be initiated.

**Process Planning (Design-time):**

*Process Model:* In management of business process, first step is process modelling. Process modelling provides insights and understanding of business process to business stakeholders. The process model specifies the tasks, roles, events and control logic. In Appendix A, Figure A.1 shows the process model of the insurance claim process based on BPMN. This process model also specifies the milestones of the process into claim registration and claim processing. BPMN doesn't provide a concept of milestone, but it is specified by Bizagi modeller.

*Data Model:* After the process modelling, the next step is to model the data. The purpose of data modelling is to specify the process entities, their attributes and relationship between entities. Data modelling also specify the focus of process on data. Figure A.2 in Appendix A shows the data model of the insurance claim process. Insurance claim

request is the central entity of data model which defines the information that is required for a claim request.

*Forms Design:* The attributes of entities are further used in designing the forums for each user task. The user forms are targeted to the roles defined on the lanes of the process model. The forums are used to get data from the user as well as to provide the data to users. Based on the capabilities of the platform used, a file or number of files can be uploaded and downloaded by different process users. Figure A.3 in Appendix A shows the electronic forms for the customer to provide the claim request information.

*Business Rules:* After the forums are designed, the business rules are defined. Business rules specify the control logic of process execution. In the process model, business rules are defined on the outgoing edges of gateways. The rules defined for the insurance claim process are shown in Figure A.4 in Appendix A.

*Performers:* As process model have already defined the roles, these business rules are further assigned for each task in this step. The tasks can be assigned based on the organization's structure, location of a person, and skills of a person. Role definition provides the ownerships of activity to certain person. Figure A.5 in Appendix A demonstrates the roles defined for each lane in the process model. Some roles are based on user id, e.g. customer, while others are based on the position of the person in organization e.g. investigation manager.

**Process Execution (Run-time):**

*Execution:* In run-time, the customer initiates the process by filling the electronic form of insurance claim. Figure A.6 in Appendix A shows the customer form in work portal. The claim handler receives the data provided by customer and analyse it. The request is either approved or rejected. If the request is approved, the investigation manager receive a task of investigation and collect claim data. Once the task is completed, the remaining tasks are assigned to decision makers who will either accept the claim or reject it. Note the script based tasks on the process model, these tasks will be performed by systems or applications automatically and doesn't require human intervention.

Different BPMS provides various features on defining and designing of business process. The tool (Bizagi) used for experiment cover the basic steps in definition of process.

However, these steps can be combined or may be designed into more detailed depending on provided features of a BPMS.

### 3.3.2 Insurance Claim process with Cognoscenti (CM)

The platform used for CM is Cognoscenti which is open source software that is available for research purpose. According to Swenson[43], Cognoscenti is not a complete product, but a testbed to show the capabilities of case management. Due to this reason, Cognoscenti has limited features.

In Cognoscenti, unstructured business process is referred as case. Section 2.1.3 mention the different terminologies that are used to refer an unstructured business process.

**Process Planning (Design-time):**

*Case Model:* Cognoscenti do not provide support for process modelling. To model the business process, MS Visio stencil was created. Figure A.7 in Appendix A shows the case model based on CMMN modelling language. The case model doesn't imply any sequence flow on the execution of tasks. The tasks can be skipped, executed or redone. It shows the limited types of events and tasks.

**Process Execution (Run-time):**

In case management system, most of the case related aspects are executed at run-time. In execution of this experiment, it is assumed that the customer has submitted its claim request through the pre-define workflows.

*Case Folder:* Case folder contains all the relevant documents and information regarding a particular case. Cognoscenti maintain the hierarchy of case folders. On the top level, there are sites which contain similar types of projects. The project of cognoscenti is synonymous to case/process. When a claim request is received, claim handler will create a new project in a site. In this scenario, claim handler will start a project with the name "Insurance claim request by Alex" in site 'claim processing'.

*Case Template:* Many CMS provides the concept of case templates. A case template consists of a set of goals with their description. The case template can be used if a similar nature of the process is received. For each process, the case template can be created where the case execution can be saved.

*User Profiles:* Each claim request is considered as a unique project which might require more experienced users as compared to the other claim request. Once the project is created, the required users to process the claim request are granted permission to access the project. In this case of insurance claim request by Alex, the investigation manager and decision maker are concerned stakeholder. Figure A.8 in Appendix A shows the user profiles defined in that case. More stakeholders can be invited for process management if required. In addition, new roles with unique permission level can be included during the execution of a case.

*Task Assignment:* Once the stakeholder of the particular case is identified, the goals are assigned to them. In Cognoscenti, concept of goals is similar to the tasks as defined in case model (see Figure A.9 in Appendix A). It is worth noticing that the data management and task assignment are dependent on each other. Arrival of new data can initiate the new tasks for the stakeholders. As soon as the goals assigned to each user are accomplished, the case will progress towards the completions. The goals/task of investigation manager will provide the data to decision maker. Decision maker can access the data provided by project documents.

*Document Management:* Cognoscenti doesn't model the data as in Bizagi but availability of the right documents to the right person at the right time is assured. In the processing of case, the central focus is on data. Figure A.10 in Appendix A shows all the documents collected in a particular case. Based on assigned user roles and permission level, each user can upload, delete and modify the case data. Case data define the further processing and execution of case activities.

*Case Overview:* An important aspect of CM is to provide an overall overview of processing of case to all the stakeholders. The overview of the case is helpful in making the contextual decisions. Cognoscenti provide the project stream and status report for this purpose. Figure A.11 in Appendix A shows the status report of the overall case.

## 3.4 Results of Experiment

As mentioned earlier, the procedure of implementing the business process is dependent on the functionalities provided by software suites. Each software suite has different capabilities, which can either make the process management easy, difficult or even complex.

Execution of this experiment is assessed based on process management aspects define in experiment design.

Table 3.1 provide the summary of the experiment execution process.

Considering the result of this experiment, it can be said that BPM and CM are significantly different in managing an unstructured business process.

TABLE 3.1: Difference between BPM and CM

| **Business Process Management (Bizagi)** | **Case Management System (Cognoscenti)** |
|---|---|
| **Process/Case Modelling** | |
| The process model is first and most important activity in process specification as all other process activities (e.g. Data modelling, electronic forms design) is dependent on it. The process model is used as a road map which is followed by each process instance on run-time. | Case modelling is a useful activity in which activities and goals of case are defined. Case model provides guidance for case processing. It is not necessarily followed by case instances at run-time. |
| **Data Management** | |
| In BPM, visibility of data is very limited to users. End-users can provide and obtain data only through the electronic forms. The provided data of end-users define the flow of process activities based on if-else conditions of the process model. | The focus of CM is of data. Case folder maintains all the relevant record of the particular case. Based on available data, the further goals of case are defined and assigned to knowledge workers. |
| **Business Rules Specification** | |
| Business rules can be defined at design-time. These rules specify the flow and execution of activities of the process. | Cognoscenti doesn't provide the functionality to define the business rules. However, in CM, the specification of business rules is an important task. |
| **Users Role Specification** | |
| In the process model, the lanes are used to define the user roles. The activities assigned to users are defined on the process model. User role and assigned activities cannot be modified at run-time. | User roles are assigned as soon as the case is created. New users can be added at run-time as well as existing user can be deleted. Each uploaded document can be assigned with different access level permission. |
| **Process/Case Progress View** | |
| A very limited view of the overall process is provided to each user. The process view is only accessible by electronic forms. | With the milestone concept of CMMN, the process view is visible to process engineers on process/case model. |

| **Process/Case Control** | |
|---|---|
| A BPM system is able to conform to the business level standards. Sequential and conditional flow of process, predefine input of data and inherited business rules provide control to the business. But on the downside, it limits the process on the predefined flow of activities which might not depict real-world situation. | CM system is an open-ended platform where conformance to standards is a difficult task. It doesn't provide the conditional flows or predefine forms for data input. But on the bright side, it can represent the real-world situation by performing the needed activities. |
| **Activities Execution** | |
| The focus is on activities and control. Activities defined in process model are executed with certain sequential flow and control. All the activities that are defined in process model are needed to be performed except omitted by if-else conditions. | The new activities can be initiated during run-time, while, the defined activities can be skipped, executed or deleted. Activities are defined and executed at run-time based on the data. |
| **Setup effort** | |
| Before execution of process, BPM process requires intensive setup steps on design-time. The setup includes process modelling, data modelling, forms design, business rules specification, users' profiles specification and finally deployment of a process. The setup efforts also require some prior knowledge of data modelling and form designing. | A case doesn't require intensive setup steps before the execution. The setup step includes only case modelling and the creation of the particular case project. The case project can be considered as a case folder which contains all the information about the case and its processing. |

However, both paradigms have its strengths and weaknesses. From the unstructured process management perspective, BPM straight jacket the process into predefined activities and flow, but at the same time conforming to business rules and business standards are assured. On the other hand, CM provides the open-ended platform that provides run-time activities specification, task assignment and collaboration among knowledge workers, thus providing the required flexibility to unstructured business processes. However, without the predefined users and activities, the case/process can take longer in its processing than expected. For example, the run-time task assignment to users can cause resource dependency or even deadlocks in certain situations. It can be said that BPM atomize the process management while CM digitalise it.

By analysing the strengths and weaknesses of both paradigms, we can conclude that a software suite that contains the features of BPMS and CMS will facilitate management of an unstructured business process in most effective way. For example, most of the processes of a business are combination of structured and unstructured activities. In this insurance claim process, the activities by the claim handler can be automated with BPM as these are structured in nature while the activities of data collection and decision making can be handled with CM as these activities require data management and stakeholders' collaborations.

## 3.5 Summary

This chapter has discussed the process management methodology of BPM and CM by implementing an unstructured business process. An experiment has planned to compare BPM and CM for their support to manage an unstructured business process. The object of the study is an insurance claim process. BPM and CM are compared based on a number of process management aspects. It is concluded that both process support paradigms are significantly different than each other in managing a business process. Moreover, irrespective of the business process type, both process management paradigm heavily relays on the process model. BPM follow the process model as a road map while in CM the process model is considered as a guidance tool. Considering the focus on process modelling in process management lifecycle, modelling capabilities of BPMN and CMMN is assessed in following chapter.

# Chapter 4

# Exploring BPMN and CMMN for Unstructured Business Processes

This chapter provides an introduction and comparison of two popular modelling languages, i.e. Business Process Model aand Notation (BPMN) and Case Management Model and Notation (CMMN). A sample unstructured business process is modelled using BPMN and CMMN in Section 4.2 and 4.3, respectively. Both notations are investigated based on their capability to model an unstructured business process. The comparison of modelling constructs and concepts of BPMN and CMMN is given in Section 4.4. In the end, Section 4.5 present the summary of this chapter.

## 4.1 Business Process Modelling

Modelling has been a very useful notion as it provides insights into real world scenarios before the actual execution of the plan. For example, a model of the building provides information about the structure of building as well as forecast the required budget for its constructions. Due to the considerable benefits of modelling, this concept is widely adopted in business organizations from the last few decades [44].

A process model maps out the end-to-end business operations of an organization. It provides the business process awareness, filter out the complexities and enable the estimation of resource utilization [45]. A process model represents the business activities,

events, control flows, and view on data. Basically, there are two main purposes of modelling a business process. Considering the modelling purpose, a process model can be very abstract, complex or detailed in nature.

- A process model is used as a communication tool among business stakeholders. Visualizing the end-to-end business process enable the stakeholders to understand the business operations, pin-point congestions, bottlenecks, and underutilized resources. Due to these requirements, a process model needs to be easily understandable by stakeholders.
- A process model is also used for business process simulation or execution. It can be used as requirements specification document or as a base for business process implementation. Considering implementation requirements, a process model should be semantically correct, i.e. it should be able to execute on process engine.

For this study, the focus is to model an unstructured business process which should be easy to communicate and can provide end-to-end visualization of business operation. BPMN and CMMN as process modelling languages are considered for this purpose.

## 4.2 Modelling Unstructured Business Process with BPMN

BPMN is one of the widely adopted process modelling notations due to its ease of use and expressibility. A BPMN process model layout the infrastructure of business process by modelling the set of ordered activities, events, and process flow logic [7].

However, in unstructured business processes modelling, business activities, events and process flow logic cannot be completely defined. Unstructured business processes require flexibility in its modelling and execution. BPMN is often regarded as modelling notation for structured business processes [46]. This notion has become particularly clear due to the OMG initiative of CMMN that is specifically proposed for modelling unstructured business processes.

According to BPMN version 2.0 [2], modelling constructs of BPMN is categorised into basic modelling elements and extended modelling elements. The basic modelling constructs includes event, activity, lanes, pool, gateway and similar concepts. While, the

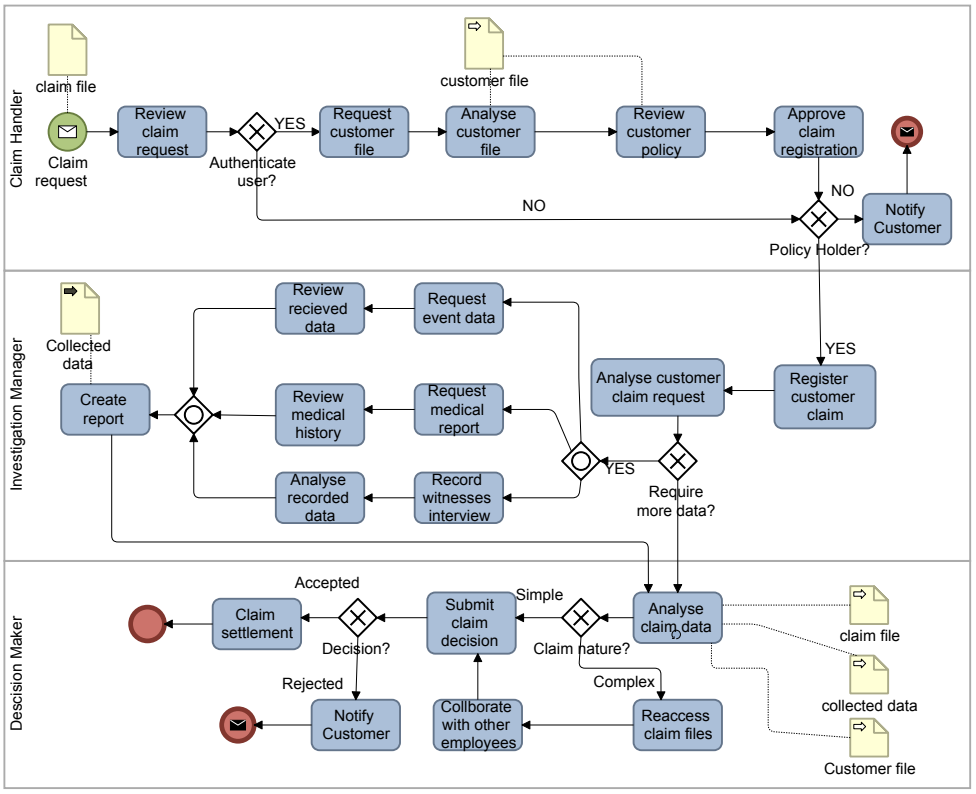
extended BPMN constructs include extended types of events, gateways, sequential flows, and data related concepts. For instance, the extended type of events are message, timer, escalation, and signal.

In the following sections, an unstructured business process is modelled with the basic BPMN constructs following with the modelling using extended BPMN constructs. The reason to introduce such distinction is due to the fact that, usually, only 20 % of BPMN modelling construct are being used in practise [10]. A survey on BPMN element usage also concludes the use of only six main elements in process modelling [47]. All of these six elements belong to the category of basic BPMN elements. The limited use of some of the modelling constructs of BPMN can cause the problems of under-utilization of an available modelling notation.

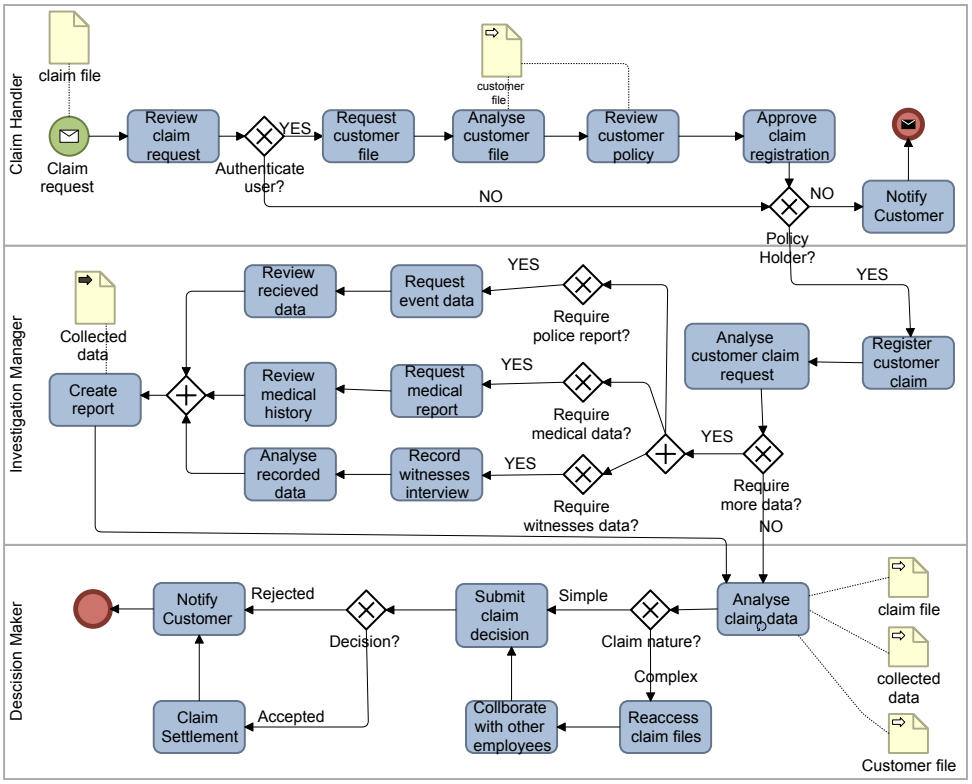
### 4.2.1 Modelling an Unstructured Process Using BPMN Basic

Both of the models defined in Figure 4.1 are procedural in nature, i.e. the tasks and their execution order are defined irrespective of the characteristics of received process instance. Figure 4.1 provides the detailed overview of *insurance claim process* example defined using BPMN basic elements. The detailed description of the insurance claim process is provided in Section 3.2. Each received claim request can vary in its nature. The claim request can be about the damage of bonnet during parking or an accident that involve many other stakeholders. Considering the nature of claim request, there could be the need to obtain data from other stakeholders, to analyse obtained data or to make claim settlements with other insurance companies. For example, in Figure 4.1a, it is depicted that the data can be acquired from witnesses, hospital and police department to make the final claim decisions. Through inclusive getaway, one or all the underlying activities can be performed. Figure 4.1b shows the similar model, but using the exclusive gateway instead of inclusive gateway. Before acquiring the data, the exclusive gateway is used which imply to validate the need of requested data for a particular claim request.

From a visualization perspective, the Figure 4.1a model is fairly simpler than the process model shown in Figure 4.1b. To understand the process model's simulation and execution complexity, the Control Flow Complexity (CFC) of these process models is calculated [48].




(A) Process model using Inclusive Gateway




(B) Process model using Exclusive Gateway

FIGURE 4.1: Process Model of Insurance Claim Process Using BPMN Basic

CFC is process complexity measure metric that borrow some concepts from McCabe's Cyclomatic Complexity (MCC) [49]. Basically, MMC metric measure the complexity of computer program by counting the number of lines and control flows. Cardoso et. al. adopted the concept of MCC and provide the CFC to measure the process model complexity by counting the number of XOR, AND, OR joins and splits [50].

The formula to measure CFC process complexity is

$$\text{CFC(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} + \Sigma\text{CFC}_{\text{OR}}\text{(a)} + \Sigma\text{CFC}_{\text{AND}}\text{(a)}$$

$\Sigma\text{CFC}_{\text{XOR}}$(a) of each activity is calculated by counting the number of outflows from exclusive gateways. The outflow from a gateway/activity is also called fan-out. $\Sigma\text{CFC}_{\text{OR}}$(a) of each activity is computed by the formula, i.e. $2^{\text{Fan-out (a)}}$-1, where the fan-out value is calculated by counting the number of outflows from inclusive gateways. While, for the AND gate (parallel gateway), the complexity is always considered as 1.

CFC of process models presented in Figure 4.1 is calculated as follows:

$$\text{CFC(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} + \Sigma\text{CFC}_{\text{OR}}\text{(a)} + \Sigma\text{CFC}_{\text{AND}}\text{(a)}$$

$$\text{CFC}_{\text{XOR}}\text{(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} = \text{Fan-out(a)} = 10$$

$$\text{CFC}_{\text{OR}}\text{(P)} = \Sigma\text{CFC}_{\text{OR}}\text{(a)} = 2^{\text{Fan-out (a)}}\text{-1} = 2^4\text{-1} = 16\text{-1} = 15$$

$$\text{CFC}_{\text{AND}}\text{(P)} = \Sigma\text{CFC}_{\text{AND}}\text{(a)} = 0$$

$$\text{CFC (P)} = 10+15+0 = 25 \text{ (Figure 4.1a)}$$

$$\text{CFC(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} + \Sigma\text{CFC}_{\text{OR}}\text{(a)} + \Sigma\text{CFC}_{\text{AND}}\text{(a)}$$

$$\text{CFC}_{\text{XOR}}\text{(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} = \text{Fan-out(a)} = 13$$

$$\text{CFC}_{\text{OR}}\text{(P)} = \Sigma\text{CFC}_{\text{OR}}\text{(a)} = 2^{\text{Fan-out (a)}}\text{-1} = 0$$

$$\text{CFC}_{\text{AND}}\text{(P)} = \Sigma\text{CFC}_{\text{AND}}\text{(a)} = 2$$

$$\text{CFC (P)} = 13+0+2 = 15 \text{ (Figure 4.1b)}$$

The higher the value of CFC, the more complex is the process model. By calculating the CFC, it can be noticed that the use of OR/inclusive gateway can increase the process

model complexity tremendously. However, for the unstructured business processes, the OR/inclusive gateway needs to be implied to provide the alternative options for activities executions.

Apart from process CFC, following are some problems of modelling unstructured business process with procedural modelling language like BPMN [51].

- **Task Ordering:** Procedural modelling languages like BPMN introduce the ordering of task executions. With the sequence flow among the tasks, all the task executions are defined at design-time without considering the requirement of the incoming process instance. For example, in Figure 4.1, the task ordering imply that all the data need to be collected even before the analyses of claim request could be initiated. While, in reality, the assessment of available data and gathering of more data can be performed in parallel.

- **Unavailable Optional Tasks:** In BPMN, the execution of tasks can be skipped only by employing exclusive gateway. The defined tasks are (not) executed based on certain conditions that are defined on exclusive gateway. However, tasks that are defined in a sequential flow on process model without any conditions cannot be skipped. Even if the tasks are not required by the particular process instance, the tasks are needed to be executed to continue the process flow. For example, the activity, in Figure 4.1b, 'Create report' can be skipped if the acquired data is not allowed to be copied and stored or in other scenario the acquired data doesn't provide the useful information.

- **Limited Alternatives:** Process model provide the roadmap for the process execution. The tasks and activities depicted on process model can be very limited. For example, in Figure 4.1b, while analysing the claim request it is required to contact with other insurance claim companies. In such case, the process instance will not follow the process model. An e-mail or phone call can be used to request the data, however, the activities performed to acquire data is not recorded on process model which means the process model doesn't depict the real business process.

- **Predefine Human Resources:** In BPMN, lanes are used to define the user roles and to assign the tasks. The user can access and process only those activities that are assigned to him. However, in some process, the expertises of other users are

required while executing the activity. For example, in complex insurance claim request, Figure 4.1, the claim decision and claim settlement task can require the suggestions and discussion from other specialists to reach to a final decision.

- **Limited View on Data:** BPMN provide a very limited view on data. Business processes like insurance claim request, mortgage request, and customer complaints are data-intensive in nature in which the provided data can define the flow of activities. In Figure 4.1 the data input and output flow are depicted, but the state of data is not defined.

- **Tasks Dependency:** The procedural flow in the process model introduces the dependency among the activities. The sequential flows imply that the next activity will only start once the pervious activity has been completed. In Figure 4.1, the analyses of claim data can only start once all the data is collected while actually both of these tasks can be executed in parallel. One can argue about using the parallel gateway for this purpose. However, the parallel gateway doesn't depict the activities interaction during execution.

Some of the problems that are highlighted with BPMN can be mitigated by using the extended BPMN elements. The extended BPMN model provides various types of process and events that are better in depicting real-world business operations.

### 4.2.2 Modelling an Unstructured Process Using BPMN Extended

Figure 4.2, shows the process model of the insurance claim request using extended BPMN elements. 'Authenticate claim request' is an ad-hoc process which means that claim handler can skip the activities while authenticating the claim request. An ad-hoc sub-process do not specify the ordering among activities. The activities in ad-hoc sub-process can be executed number of times without any pre-defined ordering. Based on process instance requirements, the activities of ad-hoc sub-processes can be done, redone or even skipped.

Figure 4.2 provide the process model of insurance claim process using BPMN extended elements. Once the claim request is analysed, the need for further investigation is considered. The exclusive gateway is used to demonstrate such decision. If the investigation is required, then another ad-hoc process of investigate claim case is considered. Expended

'Investigate claim case' shows the event sub-processes. The event sub-process is independent of their parent's start or end event. These processes are started if their start event is triggered. For example, each time a new document is received, independent of its source, the 'Review new document(s)' sub-processes will be executed. When an investigation process is completed, the results are returned to claim assessment task. The claim assessment task decides the future decision making of claim request. If the claim request is of a simple nature than it can be performed by claim handler and decision maker only. However, a complex claim case can involve other users e.g. specialist panel.

As compared to Figure 4.1, the process model depicted in Figure 4.2 provides the flexibility for activities execution.

Concept of ad-hoc sub-processes in extended BPMN elements mitigates the problems of *pre-defined task ordering*, *task dependency* and *unavailable optional tasks* where the

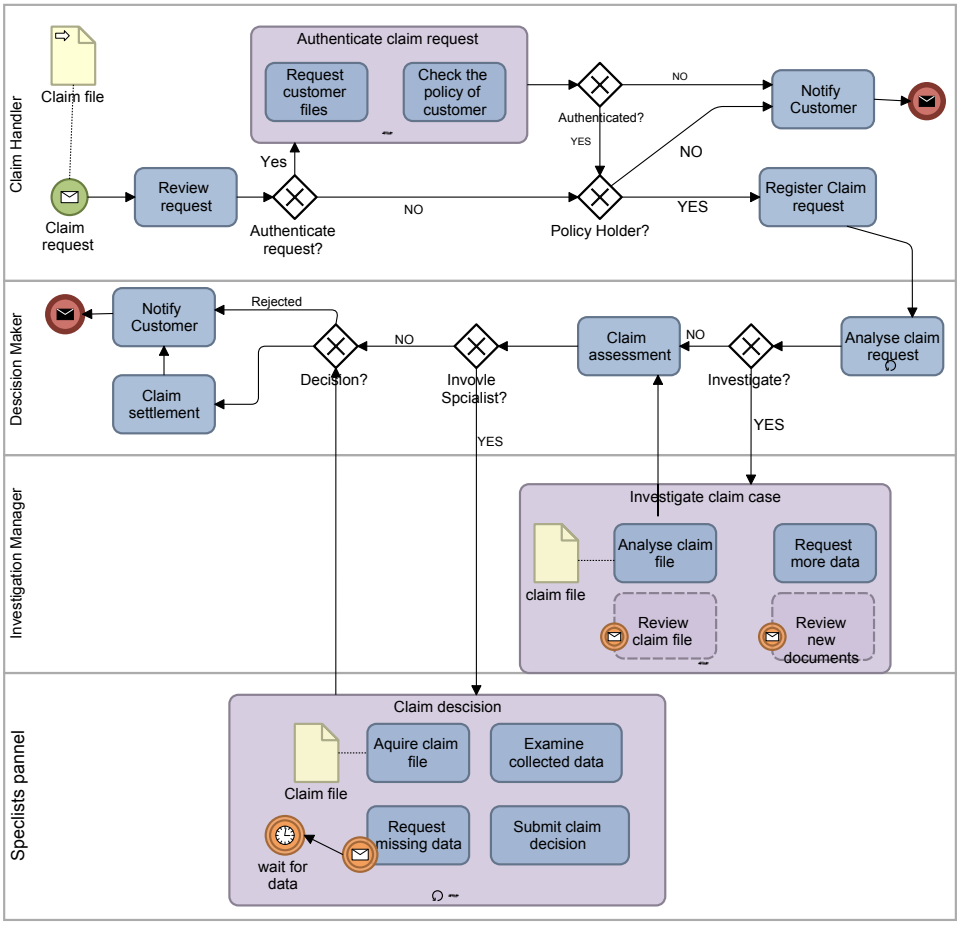



FIGURE 4.2: Process Model of Insurance Claim Process Using BPMN Extended

ordering among the activities and frequency of their execution are not defined at design-time. The problems of *limited alternative* are mitigated by using the event sub-process. Even if the data file is acquired by email or phone call, it will trigger the event sub-process of 'review new document(s)'. However, the problems of predefine user roles and limited view of data persist with extended BPMN elements.

The CFC complexity of the model presented in Figure 4.2 is calculated below.

$$\text{CFC(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} + \Sigma\text{CFC}_{\text{OR}}\text{(a)} + \Sigma\text{CFC}_{\text{AND}}\text{(a)}$$

$$\text{CFC}_{\text{XOR}}\text{(P)} = \Sigma\text{CFC}_{\text{XOR}}\text{(a)} = \text{Fan-out(a)} = 12$$

$$\text{CFC}_{\text{OR}}\text{(P)} = \Sigma\text{CFC}_{\text{OR}}\text{(a)} = 2^{\text{Fan-out (a)}}\text{-1} = 0$$

$$\text{CFC}_{\text{AND}}\text{(P)} = \Sigma\text{CFC}_{\text{AND}}\text{(a)} = 0$$

$$\text{CFC (P)} = 12+0+0 = 12 \text{ (Figure 4.2)}$$

Extended BPMN elements minimize the ordering among activities as well as it combines many activities into sub-processes. The CFC complexity of process model in Figure 4.2 is minimal as compared to process model that use basic BPMN elements. However, according to BPMN version 2.0 standard specification [2], many process engines don't provide the support for the ad-hoc sub-process execution. Moreover, use of extended BPMN elements results into a very complex process model. The use of various events and sub-processes can negatively influence the understandability and readability of the process model. The activities defined inside the ad-hoc sub-process don't depict its run-time characteristics as being optional, required or executable.

Literature on BPMN suggest that the BPMN is for modelling structured business processes while it doesn't support the modelling of unstructured business processes. However, with extended BPMN element, some characteristics of modelling unstructured business processes can be achieved.

## 4.3 Modelling an Unstructured Process with CMMN

OMG proposed a new modelling notation named CMMN for modelling the unstructured business processes [23]. According to CMMN specification, CMMN is for modelling

the case/process where the activities are not so defined and repeated, but dependant on evolving circumstance and decision of knowledge workers [23]. Insurance claims, customer complaints, and mortgage handling are examples of such processes.

Figure 4.3 shows the insurance claim process model using CMMN.

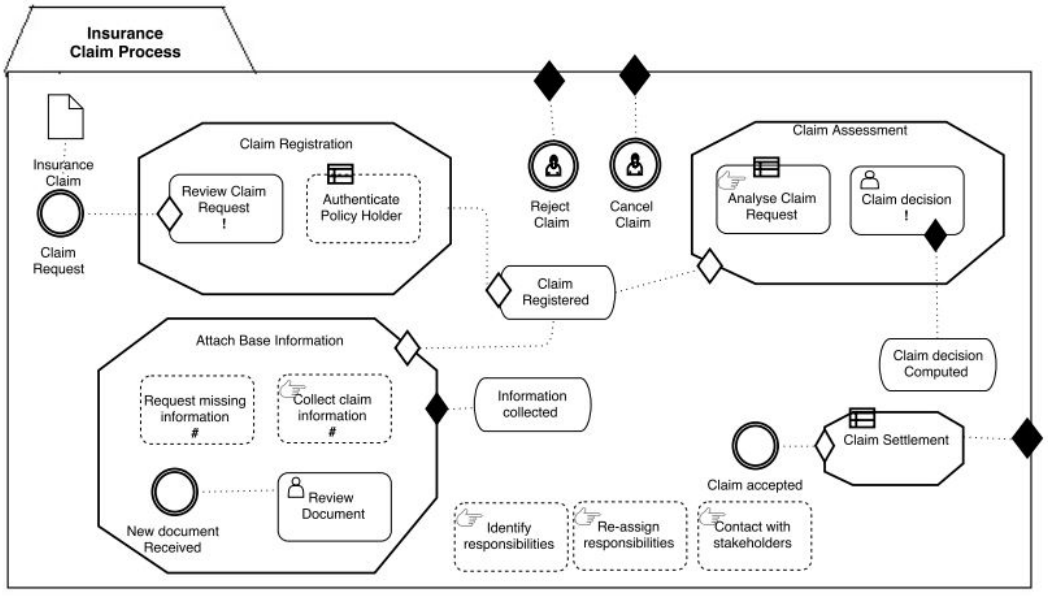



FIGURE 4.3: Case Model of Insurance Claim Process Using CMMN

The folder is a container that consists of all CMMN elements to model the process. The folder is called a case folder and it represent the name of the process which is an insurance claim process. The rectangle shape with angled corners shows the episodes of a process which is called stages. Claim registration, claim assessment, attach claim information and claim settlement are stages of the insurance claim process. The rectangle shapes with half rounded corners are called milestones which represent the goals to be achieved in a process. Claim registered, information collected and claim decision are milestones that are required to be achieved in processing of the claim request. The diamond shapes in the Figure 4.3 are named as sentry which define the entry and exit criteria for any task and stages.

The review claim request will be performed only when a claim request is received. The tasks with dotted boundary represent the concept of discretionary, which means the process can be executed or skipped considering the nature of received claim request. In this process, the task to authenticate policy holder can be skipped considering the

claim handler already knew the person as the existing policy holder. The claim registered milestone will be achieved once the tasks inside the claim registration stage are executed.

Claim registered milestones have connector to two stages. If the claim is registered, then the tasks inside claim assessment and attach base information can be performed. The parallel execution of these stages implies that during the collection of data, the claim assessment tasks can be performed concurrently. The claim assessment stage will be exited only if the claim decision is made. Moreover, it is worth noticing that the claim request can be rejected or cancel at any point during the claim processing which is depicted with user events attached to exit sentry on folder boundary.

Following are problems that were encountered while modelling an unstructured business process with BPMN (see Section 4.2.1. Here, we will again analyse these problems to assess the capabilities of CMMN to deal with them.

- **Task Ordering:** An unstructured business process also has some structured part which require the task ordering. CMMN doesn't define the ordering in tasks execution. It doesn't have the concept of sequential flow like BPMN, connector is used to show the dependency among tasks, stages, events and milestones. The tasks and stages without connectors can be executed in any order and any number of times.

- **Available Optional Tasks:** In CMMN, the execution of tasks or part of the process can be skipped considering the particular process/case instance. Such tasks and stages are represented by dotted boundary. For example, in Figure 4.3, the task 'request missing information' can be skipped if information is not missing or in other words if no information is required from other stakeholders.

- **Limited Alternatives:** Since, the CMMN is declarative in nature, it doesn't model all the steps that need to be taken during process execution. The tasks that are presented are usually abstract in nature, e.g. in a Figure 4.3, 'collect claim information' doesn't specify on how to collect information or to whom to ask for information. Such declarative nature provides flexibility in process execution on run-time. However, a similar argument can be stated for a BPMN model that is very abstract in nature.

- **Predefine Users:** CMMN doesn't have any notation to represent the users. The user roles are defined semantically when the case folder is initiated.
- **Limited View on Data:** The CMMN is meant to model those processes that evolve with time and the execution of process is mainly based on data and knowledge workers' decisions. CMMN has concept of case file along with file versioning. However, the versioning of case file is defined semantically and there is no notation for it. From a visualization perspective, CMMN provide a very limited view over data.
- **Tasks Dependency:** Connectors and sentries represent the concept of task dependency in CMMN. The tasks will be executed only if the entry/exit condition associated with it is fulfilled. For example, in Figure 4.3, the tasks of claim assessment and attach base information will only be executed if the claim is registered.

As compared to procedural languages like BPMN, CMMN is declarative, which specifies on what should be done in the process instead of how it should be done. The purpose of CMMN model is to provide guidance map which instructs the process engineers on what can be done for successful process execution. Instead of design-time defined conditional flows, the evolving data and knowledge of knowledge workers drive the process execution.

However, it is worth noticing that BPMN is more expressive in its process flow as compared to CMMN process model. On the other hand, discretionary task and stages of CMMN provide a better understanding on which tasks can be skipped during process execution as compare to ad-hoc sub-processes of BPMN. In the following section, BPMN and CMMN are compared based on their modelling concepts and constructs.

## 4.4 Comparison of BPMN and CMMN

In this section, the similarities and difference between BPMN and CMMN is discussed. The reason of comparison is due to the fact that both modelling language model business processes. However, the modelled business processes vary in their level of structuredness.

The basic difference in BPMN and CMMN is its modelling paradigm. BPMN is an imperative modelling language that is focused on modelling control flows [52]. A BPMN

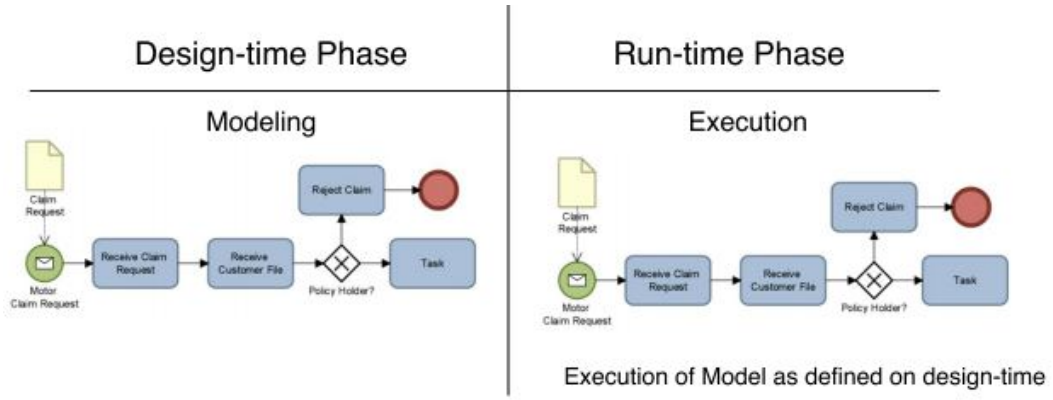



FIGURE 4.4: Definition and Execution of BPMN Model

process model provides detailed information on which and how activities are performed for a certain business operation. On the other hand, CMMN is declarative modeling language that is particularly specified to capture flexible business process [34]. CMMN models don't imply ordering in activities execution, however it model activities and conditional flows that need to be performed on run-time.

Another important difference between BPMN and CMMN lies in their design-time definition and run-time execution. Figure 4.4 shows the design-time definition and run-time execution of process model for BPMN. In BPMN, all events, activities along with their control flows are defined at design-time. At run-time, a process instance will follow the design-time defined process model. Any events or activities that are not defined on process model fall out of the scope of the process execution. In such case, a process instance

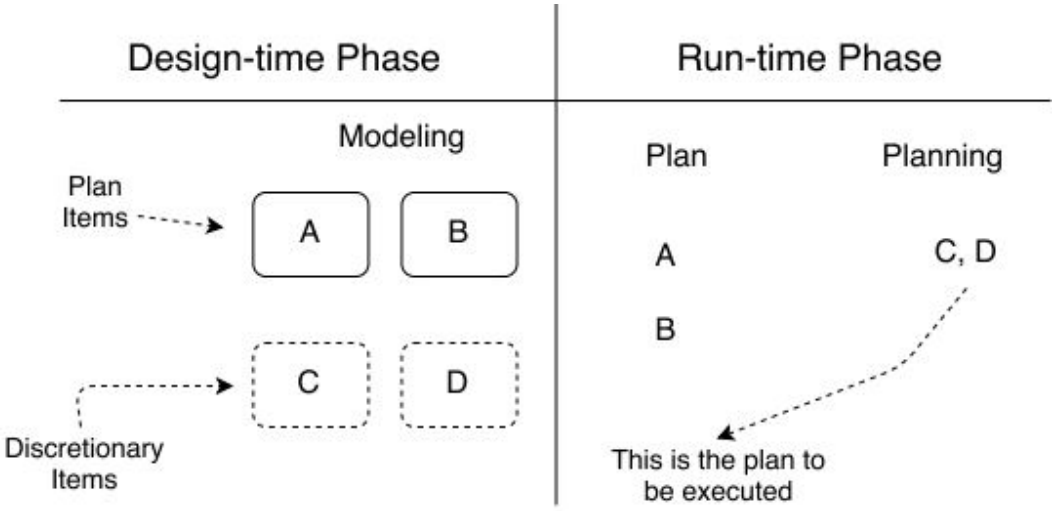



FIGURE 4.5: Definition and Execution of CMMN Model

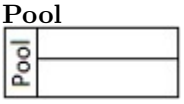
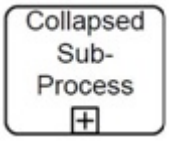
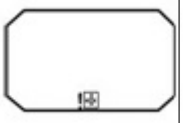
is either not allowed to perform those tasks that is not defined on process model or the executed activities by process instance is not recorded as part of the process.

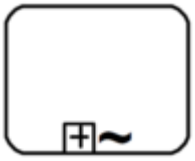
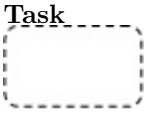
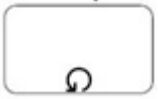
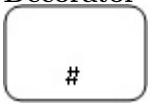
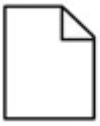
On the other hand, CMMN model differs in its design-time definition and run-time execution. Figure 4.5 provides an overview of CMMN model's definition and execution. On design-time, the activities for case are defined without any defined ordering, and performance requirements. All the activities that can be required during process execution are defined as plan items. While, the activities that might be required or skipped, considering process instance characteristics, are defined as discretionary items. At run-time, the plan items are performed as defined at design-time, while for discretionary items the run-time planning is performed.

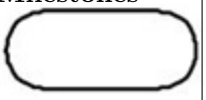
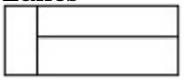
Design-time and run-time distinction between BPMN and CMMN represent that the CMMN provide more flexibility for process modelling and run-time planning as compared to BPMN. However, the extended BPMN elements provide a certain level of flexibility in the process model.

Table 4.1 outlines the similar concepts that are shared by BPMN and CMMN. However, these concepts are defined with different modelling symbols in both languages. Note that, only conceptual similarities between BPMN and CMMN is considered.

TABLE 4.1: Comparison of BPMN and CMMN Modelling Constructs

| **BPMN** | | **CMMN** | |
|---|---|---|---|
| **Pool**   | BPMN pool consists of entire modelling construct that represent the behaviour of a particular process model. | **Case Folder**  | Case folder contains all the modelling constructs of a particular case model. |
| **Sub-Processes**   | Sub-process of BPMN contain the lower level details of process. It is a part of the overall process that hides its containing details. | **Stages**  | Stages of CMMN also contain the tasks or even other stages that present the lower level detail of the particular case. |
| **Task**  | The task is smallest activity in a process which cannot be further divided into sub-processes. | **Task**  | The concept of task in CMMN is similar to the task of BPMN. |

| | | | |
|---|---|---|---|
| **Boundary & Intermediate Event**  | BPMN specifies different concepts for a start, intermediate, boundary and end events. The events, shows in the picture are intermediate event and boundary timer events. | **Events**  | CMMN has just three events which are named as start event, timer event and user event respectively. CMMN doesn't provide the concept of intermediate, boundary and end events separately. |
| **Gateway**  | In BPMN, gateway is used to specify the conditions. The conditions define the flow of process on the base of which an activity is executed or skipped. BPMN has many different kinds of gateways with different meaning. | **Sentry**  | The sentry defines the entry and exit criteria in CMMN by using the connector. In case of entry sentry, the task/stage/milestones will only be reached if the previous task(s) is completed. Similarly, a task/stage with filled sentry will exit only if execution is completed. |
| **Ad-hoc Sub-process**  | Ad-hoc sub-process of BPMN doesn't imply any sequence flow among the tasks. The tasks inside the ad-hoc sub-process can be executed any number of times without predefine ordering. | **Discretionary Task**  | The dotted task boundary represents a discretionary task of the CMMN. The discretionary task can be skipped during the execution of case on run-time. |
| **Loop Marker**  | A loop marker of BPMN represents the task that can be executed number of times. | **Repetitive Decorator**   | Repetitive decorator of CMMN allows a task to be executed in a repetitive manner. |
| **Data Object**  | Flow of data is depicted by the data object. BPMN has concept of collection of data objects, data input, data output, and data store. | **Case File**  | The basic notation to represent data is similar in CMMN and BPMN. However, CMMN has concept of case file items with versioning control. |

| | | | |
|---|---|---|---|
| **Business rules task**  | Business rule task show the tasks that is dependant on some business rule. | **Planning table**  | Planning table that is attached with any task or stage shows their dependency on business rule . |
| **Sequence Flow**  | Sequence flow of BPMN represents the activities ordering and flow of control. Control is transferred through the sequence flow to next activity only if the pervious activity is completely executed. | **Connector** --------- | Connectors of CMMN doesn't imply task ordering. Connectors are mostly used with entry and exit sentry which specify certain conditions for execution or completion of task/stages. |
| **Activities (Task, Subprocess, Call activity)** | All the activities of BPMN are required to be executed by default except for those activities that are inside the adhoc sub-process. | **Required Decorator**  | The required decorator specifies certain condition under which the task has to be executed before the process is terminated. |
| **N/A** | BPMN doesn't have any concept of goals or milestones. | **Milestones**  | The goals of the case are represented in milestones. These milestones provide the overview of case progress. |
| **Lanes**  | Lanes are used to specify the human resources that are assigned to perform certain tasks. However, there is not a specific notation in BPMN for this purpose. | **N/A** | CMMN doesn't have any notation to represent the human resources. |

## 4.5 Summary

The process model of BPMN and CMMN shows that the both modelling languages possess some advantages over the other. In BPMN, the requirement to provide the run-time flexibility to unstructured business process leads to the complex process models. The process model shows that the use of inclusive gateway provides the flexibility in run-time, however it leads to the higher CFC value. Similarly, use of BPMN extended constructs hinders the readability of process model (see Figure 4.2). On the other hand, CMMN

model depicts the run-time flexibility of the process model. However, the unavailability of clear events, gateways and required sequence flows reduces the overall expressibility of the process model. To sum-up the discussion of this chapter, following are the merits and demerits of BPMN and CMMN for modelling an unstructured business process.

**Merits of BPMN**

- Sequential flow of BPMN makes a process model easy to read and communicate for business people.
- The ability to define the business rules task in process model provide the transparent view of process activities and their relatedness to the business rules.
- Lanes of BPMN can be used to assign tasks to users.
- Ad-hoc sub-process provide the flexibility in (un)ordered execution of process activities.

**Demerits of BPMN**

- The notations to represent the activities of ad-hoc process is not expressive on the process model.
- BPMN provides low (no) support for ad-hoc process execution due to the unordered set of activities.
- Sequential flow among activities limit the run-time flexibility of the process during its execution.

**Merits of CMMN**

- CMMN notations are easy to understand as compared to extended BPMN elements. For example, discretionary task represents the task that is optional.
- Milestone concept provides the quick overview of the process.
- The concept of discretionary is supported with case execution semantics in contrast to ad-hoc sub-process of BPMN.

**Demerits of CMMN**

- The process model is hard to follow due to unavailability of sequential flow
- It is unable to model the structured part of the process
- There is no notation to depict the assigned user on the process model
- There is no data input, data output and data store notations to be represented on the process model.

# Chapter 5

# Representational Requirements of Unstructured Business Processes

The way work is performed these days is the result of hundreds of years of thinking about how the work should be performed [53]. The nature of work can be broadly divided into routine work and knowledge work [54]. Routine work includes those activities that are predictable and repeatable in nature. While, knowledge work includes those activities which require decision making, data-capturing and tacit knowledge from one or many knowledge workers [29]. Savage [55] regard the focus on knowledge work as the third wave for human-economic development after agricultural and industrial era. The knowledge work is also referred as unstructured business processes as the data is captured and decisions are taken by knowledge workers. According to Peter Drucker [56], "To make the knowledge work productive would be a great management task of this century as to make manual work productive was the great management task of last century".

The requirement of flexibility in BPM and extensive focus of industry on knowledge work poses the need to model the unstructured business processes flexibly. In the Section 5.1, the unstructured business processes are approached from the perspective of its conceptual difference with structured business processes. Section 5.2 provide the representational requirements of unstructured business process, which are derived from literature. By representational requirements, we mean the requirements to represent the unstructured process which shows the run-time flexibility of process over the process model. Moreover, BPMN modelling notation is assessed to determine their conformance

to proposed requirements in Section 5.3. Section 5.4 provide the summary of this chapter.

## 5.1 Characteristics of Unstructured Business Processes

In this section, the characteristics of unstructured business processes are provided. As discussed earlier, the processes that require the tacit knowledge, data, collaboration and decision making skills from knowledge workers form the class of unstructured business processes. The knowledge work of an organization cannot be straight jacketed into automated process and electronic forms due to its unstructured and evolving nature [5]. Many literature studies has discussed the characteristic of unstructured business processes under the title of case management [30, 57–59].

Following are some of the aspects of unstructured business processes which make them different from structured business processes.

**Goal Oriented:** Unstructured business processes are goal oriented, which means a process is evolved through the series of sub-goals and milestones [57]. The sub-goals could be defined prior to the process execution or it can be revealed as the process progresses. The achievement of each goal depends on a number of factors, e.g. availability of required data, execution of activities, decision of knowledge workers, and response from customers. Every sub-goal of process is well-integrated with one final goal. An achieved sub-goal can be modified or proven wrong as the more data, and knowledge emerges with process progress [59].

**Data Dependent:** The main difference between routine work and knowledge work is its focus on data. In structured processes, conditional flow and events drive the process while data is dealt as second class citizen. In knowledge work, process and data are strictly integrated [60]. The modification, addition or deletion of process data defines the future activities of the process. Process data is managed as the business documents record instead of isolated structured data [30]. The focus on data for process execution limits the problem of context tunnelling as all required data is available to all the process users [61]. The collection of relevant data for a process leads to the complex variety of data, e.g. emails record, the files from third

parties, business policies, sticky notes, and audio files. The proper utilization of process data and invents of final decisions solely depends on knowledge workers' understanding and knowledge of data [58]. However, in unstructured processes the unavailability of particular data may halt the processing of the whole process. Due to such reason, unstructured processes tend to have longer running spans as compared to structured processes.

**Uncertain and Emergent:** Unstructured business processes are unpredictable and uncertain in nature, which makes the design-time definition of process a difficult task. The course of activities and actions are determined by knowledge workers at run-time based on their experience and knowledge of a particular process [59]. As the process executes, new data and knowledge emerges. With the completion of each activity in the process, the knowledge worker needs to make a decision on which path to choose out of available options.

**Coordination and Collaboration:** Executions of unstructured processes highly rely on the coordination and collaboration among the knowledge workers [59]. In contrast to structured processes, the task assignment is not straight forward. Usually, a single process involves many knowledge workers [57]. With the emergence of process, new knowledge workers may get involved or existing knowledge workers may leave their roles.

**Business Rule Driven:** Conformance to business rules and standards is one the most convincing argument to automate the business process. However, due to uncertain and emergent nature of unstructured processes, knowledge workers are required to maintain the business rules and business standards during execution of process. Decision making, availability of data to knowledge workers and resource of time and human are influenced by particular rules and policies of business [57]. For instance, if a business rules state the response time of a customer complaint as five working days then the customer should be informed about the decision with-in a given period of time. Such limitation influence the overall execution of process.

## 5.2 Requirements of Unstructured Business Processes

In this section, representational requirements of unstructured business processes are derived from literature [57, 60, 62]. The definition of requirements will facilitate us into modelling the unstructured business processes in flexible manner. The proposed requirements are based on characterises defined in Section 5.1. The requirements are

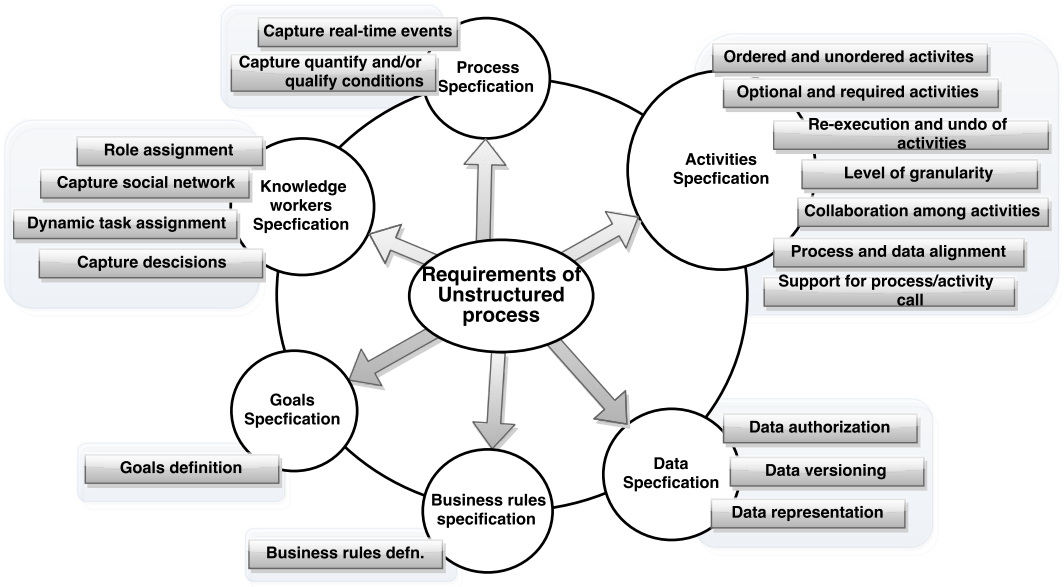



FIGURE 5.1: Requirements (framework) of Unstructured Business Processes

divided into six broad categories. These categories are (a) process specification (b) activities specification, (c) data specification, (d) business rules specification, (e) goals specification and (f) knowledge workers specification. Each of this category has a number of requirements that need to be fulfilled to model an unstructured business process in flexible manner.

Figure 5.1 provides an overview of defined categories along with their requirements. To define requirements concretely, the writing method is adopted from Ming Chiao et. al. [60] where each requirement is explained with the help of an application scenario.

### 5.2.1 Application Scenario

As an example of unstructured business process, the admission process of a national and international student to a university is considered. The admission process is a knowledge intensive process which involves collaboration and communication among

different departments to perform the smooth intake of student. Following is the detailed description of the admission process.

> With the announcement of admission, the students can send their documents to the university through an online form. Students are required to submit their personal information with their academic certificates, motivation letter and language certificate. Based on study background of student, the required documents as well as the admission process can vary. Once the admission application is *submitted* by the student, the **admission office** is *notified*. The ultimate goal of the admission process is to make a final decision on granting the admission to a student. Based on documents received, each admission file might go through the number of reviews before the final decision could be made. Initially, the **admission administrator** *checks* the application for its correctness and completeness. The admission file is then forwarded to the corresponding department of university for *assessment*. **Admission coordinator** will *review* the admission file to check the attached academic certificates. The final *decision* can be made by the admission coordinator only or it can require the *discussion* and *decision* from **admission panel**. During the decision process, the provided details can be *verified* and the new documents can be requested from the student directly or either through the admission office. At the end, a student can be admitted, rejected or conditionally admitted. The involved knowledge workers and decision highly depends on the particular admission file. Finally, the student is *informed* with the decision based on his admission file.

In this scenario, italic letters shows the activities of the admission process while the bold letters represents the involved knowledge workers.

### 5.2.2 Process Specification

Each process has some general requirements that need to be fulfilled to represent the real-world scenario. The general requirements include the ability to capture the real-time events, and to quantify and/or qualify the conditions.

**Support to Capture Real-time Events:** It should be possible for unstructured business processes to capture and respond to real-time events. These real-time events

can be related to process start or end, arrival of data, modification of existing data, or it can be triggered by user activity.

**Capture Real-time Events** When an applicant submits his admission application, the admission office is notified. Submission of application and notifying the admission office are examples of real-world events. The *notify event* can be start event to initiate the admission process for particular application received.

**Support to Quantify and/or Qualify the Conditions:** On certain steps in processing of an unstructured process, the decision to execute next process activities is taken. These decisions are sometimes based on available data, real-time events or knowledge of knowledge workers. It should be possible to represent the conditional flow with-in a process. The conditional flow can be explained as a condition that will decide the execution of next activity in a process.

**Quantify and/or Qualify Conditions** The admission administrator checks the application for its correctness and completeness. The application is then sent to the admission coordinator only if the application is complete.

### 5.2.3 Activities Specification

Irrespective of the type of business process, activities specification is one of the fundamental tasks in business process design and modelling. The activities define the work that is expected to be performed for successful execution of process. These activities can be atomic or non-atomic [2]. In a structured process, the activities define the work that will be performed by every process instance. In other words, design-time defined activities inform the process about its run-time execution. However, in an unstructured process, the tasks, and their ordering is not strictly followed. It is argued that in structured processes, the predefined routing rules drive the process while in unstructured processes the characteristic of particular process instance drive the process [63].

The requirements of activities specification from the perspective of an unstructured business process is discussed below.

**Support for Ordered and Unordered Activities:** A business process consists of structured and unstructured part of the process. It should be possible to define and follow the control flow among the activities to support the structured part of the process. Similarly, it should be possible to skip the order in activities execution. Considering the particular process instance, the activities can be executed in any order.

**Ordered Activities** The steps of admission process that include *submission* of admission file by student and *notifying* it to admission office is ordered set of activities. Irrespective of type of admission application, these parts of the process need to be executed one after another.

**Unordered Activities** Some activities of the admission process are unordered in nature. For example, *assessment* activity by the admission coordinator will require checking of academic certificates, analysis of their authenticity and review of the overall admission file. These sub-activities can be performed in any order. Moreover, the execution of one activity can also lead to a number of other tasks.

**Support for Optional and Required Activities:** Unstructured process is non-deterministic and emergent which means the process flow cannot be completely defined before the execution of process. To maintain the flexibility, it should be possible to define the process activities as optional or mandatory.

**Required Activities** In the admission process, some activities are mandatory to be performed to complete the process. For example, irrespective of type of admission file, it is required to inform the students about the status of its application. Initially, the status could be (in) complete and later in process it can be either changed to accepted or rejected.

**Optional Activities** During the *assessment* activity, it might be required to perform additional verification of the admission file. In case, the student's certificates are not from well recognised institute, which might lead to the verification of documents provided. However, such additional verification is not needed for every admission application. So, it should be possible to perform the additional verification for some admission files and skip it for others.

**Support for Re-execution and Undo Activities:** Due to evolving data and emergent process context, an unstructured process rely on decisions made by knowledge workers. Decisions based on data and process context may lead to undo the previously performed activities or in other cases re-execute some process activities. The management of unstructured processes should be flexible enough to support the undo and re-execution of activities.

**Re-execution of Activities** Considering the particular admission file, review activity can be performed a number of times. For instance, an admission application from the recognised national university might require single review while the international admission application might go through a number of reviews.

**Undo Activities** The data and process context can lead to undo the performed activities in the admission process. For example, the admitted student request to defer the admission till next year. Such change in context will require the admission administrator to undo certain activities that had marked the student as an upcoming admitted student.

**Support for Collaboration among Activities:** Processing of unstructured business processes requires communication and collaboration among knowledge workers and their activities. In addition to parallel execution of activities, it should be possible to define and depict the collaboration among the individual process activities. The collaboration among activities can be depicted either as message passing, association links or with certain markers. BPMN depicts the collaboration between the external and internal process through message passing.

**Collaboration among Activities** The activities of *discussion* and *decision* require communication in admissions panel. Normally, the discussions between the admissions panel will yield a final decision of acceptance or rejection of the admission application. However, in some cases, the *discussion* among admissions panel can trigger the *verification* and assessment of the admission application. In such scenario, it is required to show the collaboration among activity of *discussion* and activity of *verification*. Both activities are dependent on each other.

**Support for Varying Levels of Granularity:** From the modelling perspective, it should be possible to specify an unstructured process with varying levels of granularity. The lower level of granularity provides the flexibility for knowledge workers in process execution while the high level of granularity limits the knowledge workers' freedom.

**Activities Granularity** *Assessment* activity can be defined with varying level of granularity. At a higher level, the assessment activity can be defined into a number of sub-activities to check the provided documents, analyse the motivation letter, and research the academic record. While, on lower level of granularity, the definition of *assessment* as activity is sufficient.

**Support for Process and Data alignment:** Data is the central entity in unstructured business processes. Such knowledge intensive processes require alignment of process and data. With alignment, it should be possible to trace back data through a process and vice versa. Unlike traditional business process, where data are limited to defining control flows, unstructured processes have an abundance of data with changing states.

**Process and Data Alignment** Admission process have a variety of associated data. With each activity in the admission process, the data should be associated. Documents of the admission application, remarks of involved users and final decision need to be represented with related activities. Such representation of data will provide the view on emergence and changing states of data as the process progresses.

**Support for Process/Activity Call:** Irrespective of process type, it should be possible to call the already available process or activity during the process execution. The callable aspect will reduce the burden of re-doing the same activity.

**Process/Activity Call** In case, the applicant, who had applied for admission, also submitted his application for a scholarship. Instead of re-evaluating provided data, the results of the authentication and verification activities can be called from admission process to be used in scholarship process.

### 5.2.4 Data Specification

Unstructured business processes are fundamentally data-centric, which means the process and data are strictly bounded [35]. Both, process and data, are dealt as first-class citizen [5]. The execution of process highly relies on available and evolving process data. However, due to its knowledge intensive nature, the incorrect and unavailable data can influence the process.

**Support for Data Representation:** Unstructured processes produce and consume data during execution. Considering the unique nature of unstructured processes, it should be possible to represent the data. The data can be an atomic information or chunk of documents. It should be possible to clearly define the inflow and outflow of data files for a particular activity of process.

> **Data Representation** Admission process solely based on data provided through admission application. For example, in *assessment* activity, it should be possible to represent the admission application as an input data file while remarks as output data file.

**Support for Data Authorization:** In the processing of a particular process instance, many knowledge workers can be involved. However, considering the sensitivity of process data, it is should be possible to define the access level of data. Data authorization concept can be employed either by defining the knowledge workers' roles or through managing the authorization of each process document.

> **Data Authorization** Admission process can involve many knowledge workers with varying roles. For example, admission application should not be accessible to admission coordinator and admissions panel before it is verified by admission admission administrator.

**Support for Version Control of Data:** In unstructured processes, data is evolved throughout its lifespan. It should be possible to provide the version control for process data. The concept of versioning for unstructured processes is introduced by OMG in CMMN version 1.0 standard specification [23]. Some tools (e.g. Alfresco) provide the support of document versioning for unstructured processes. Data versioning can be modelled as data states on process model.

**Data Versioning** The admission file of a student evolves with time. The remarks and decision on admission file can be revised, added or deleted. In such evolving scenario, it should be possible to maintain the version control of documents.

### 5.2.5 Business Rules Specification

To conform to standards and business policies, business rules need to be employed during process execution. Business rules of an organization set the business standards as well as impose conditions on business operations. These rules provide information on how certain business processes should be performed and how the resources can be used [64].

**Support for Business Rules Definition:** It should be possible to define the business rules in an unstructured process. The definition of business rules will provide the transparency for process execution. Moreover, in case of change in business policy, the explicit business rules will enable the long running process to follow the changed business rules [65]. The alignment of process with business rules will answer the questions about 'how and why certain activities were performed and specific decisions were made'.

**Business Rules Definition** The policies and regulation influence the decisions taken by admissions panel. For example, if the language certificate sent by official body is received in university later than the defined deadline, then specific institute rules need to be considered to deal with the situation. As in such case, the applicant is not responsible for the delay.

### 5.2.6 Goal Specification

Goal-orientedness is one of the most distinguishing characteristic of unstructured business processes. Based on the main goal, a process evolves into a number of sub-goals and milestones as process progress. Due to variability of unstructured processes, the final goal of the process is known, but the path to reach the goal remain unclear till very late in process execution.

**Support for Goals Definitions:** It should be possible to define main goal and evolving other goals for an unstructured process. The definition of goals will provide an

overall overview of the process progress to knowledge workers. Moreover, due to long running time-span, the definition of goals will be helpful to keep the execution of process on track.

**Goals Definition** The admission process has one main goal and number of other associated goals. The main goal is about final verdict of acceptance or rejection of admission application while the other goals can be 'application received', 'application reviewed', 'application investigated' and 'application verified'.

### 5.2.7 Knowledge Workers' Specification

Knowledge worker' plays a critical role in managing and solving unstructured business processes. Knowledge workers primary job is to create, distribute and apply their tacit and explicit knowledge to access process, analyse information and make decisions [34]. Knowledge workers include managers, researchers, doctors, lawyers, and emergency responder. Each incoming task of knowledge workers tend to differ than the other which require specialise knowledge and solution based on context details.

It is important to notice that all the requirement define for knowledge workers, except role assignments and capture decisions, are specifically targeted for system implementation rather for an unstructured process modelling.

**Support for Knowledge Workers' Roles Assignment:** In the processing of unstructured business process, many knowledge workers can be involved. It should be possible to define the roles of each knowledge workers and their assigned task.

**Roles Assignment** Admission administrator, admission coordinator, and admission decision panel are knowledge workers of the admission process. With the involvement of many knowledge workers, there is need to clearly define the roles of each knowledge worker along with their assigned tasks.

**Support to Capture Professional Networking:** Unstructured processes heavily rely on tacit knowledge of knowledge workers. Such characteristic of unstructured processes require the knowledge workers to communicate and collaborate for the efficient process execution. It should be possible to enable and capture the collaboration among

knowledge workers. The suggestions, concerns and decision points of each knowledge worker should be recorded in the system. Moreover, the social network among knowledge workers makes the task dependencies explicit.

**Capture Professional Networking** During processing of the admission application, knowledge workers need to communicate and collaborate with each other. After initial assessment of admission file, admission administrator sends the files to admission coordinator. Admission coordinator collaborates with admissions panel to perform further verification or final decision. To understand the role of each knowledge worker, there is a need to capture the activities and communication among knowledge workers.

**Support for Dynamic Task Assignment:** Due to the evolving process context, it should be possible to involve other knowledge workers during the process execution. Moreover, the existing knowledge workers can leave their tasks during process execution or can be assigned to other tasks. In other words, there should be flexibility in task assignments and role assignments during the processing of certain process instance.

**Dynamic Task Assignment** During the admission process, it can be required to involve other knowledge workers or re-assign the tasks to existing knowledge workers. For example, for a particular process instance, the investigator role can be required to verify the academic certificate of student through some official body. Such scenario will introduce new knowledge workers and new activity in the admission process during run-time.

**Support to Capture Knowledge Workers' Decisions:** One of the most important characteristic of knowledge workers is to utilize their tacit knowledge, available data and process context to make the certain decisions. The decisions made by knowledge workers affect the process running time, its control flow, final outcome and many other process related aspects. It should be possible to capture every decision of knowledge workers.

**Capture Decision** Admission administrator needs to make a decision on completeness of admission application before forwarding it to admission coordinator. These decisions define the rest of activities of the admission process.

## 5.3 BPMN and Conformance to Requirements

In this section, we will take a closer look at BPMN v2.0 specification [2] to determine the conformance of BPMN constructs with respect to the requirements defined in Section 5.2.

**Process Specification based on BPMN** Process specification of unstructured business processes include the requirements to capture the real-time events and to depict the quantifying and qualifying conditions. BPMN provides the complete support to represent the events and conditions on the process model.

To *capture real-time events*, BPMN have events construct. These events can be triggered by changes in data state, start of an activity, end of an activity, or cancel of an activity/process. With start, end and intermediate events, the related events of a process can be captured. BPMN has very wide range of different events. Moreover, for the *support to capture conditions*, BPMN provides the gateway construct. The gateway implies the validation of conditions to determine the next executable activity. However, in an unstructured process, the focus is not on process controlled flow, but on why and how a particular activity is performed considering certain conditions. These conditions can be completion of previous activities, arrival of new data, and change in the state of data.

**Activities Specification based on BPMN** BPMN has different kinds of activities, e.g. tasks, sub-process and call activity. Some of the requirements proposed in Section 5.2.3 can be fulfilled by the concepts and constructs provided by BPMN. With call activity, an available activity/process can be used in process execution, thus, providing the *support for process / activity call*. Similarly, with the BPMN sub-process concept, a number of detailed activities can be defined with *varying levels of granularity*. Moreover, loop characteristic of activities defined in BPMN can provide the *support for re-execution* of process activities. BPMN also specifies the concept of standard re-execution and multi-instance re-execution. The concept of data object, data input and data output to and from the activity provide the *support for process and data alignment*.

It can be noticed that BPMN fulfils many requirements to model an unstructured business process. However, there are some requirements that are not supported by BPMN e.g. *support for ordered, unordered, required, optional and undo activities*.

**Data Specification based on BPMN** Many data modelling languages (e.g. DFD, ERD) provide rich constructs to represent the data and its states. In such modelling languages, the focus is to represent data, related data attributes and interaction of data to the system. However, with unstructured process, it required to represent the data related to process activities. Data is created and manipulated throughout the lifecycle of a process. BPMN provides many data related concepts, e.g. data object, data input, data output and data store. Data store indicates the permanent storage of data irrespective of process execution life. Data object capture process related data. The data object has a well-defined lifecycle and states. To represent the data along with process execution, the data object is one of the most important construct for representation. Along with data object, data input and data output are also defined which are related to an activity. An activity can require zero to more data inputs and data outputs for its successful execution. Based on data need, the data input and related data output are represented for an activity. Considering the data representation requirement of unstructured process, it can be said that BPMN provide the *support for the data representation* along with process activities. However, BPMN doesn't support the concept of *data versioning* and *data authorization.*

**Business Rules Specification based on BPMN** BPMN provides the concept of business rules task. These business rules task shows a task which is based on business rules. For the unstructured processes, it is intended to represent the actual business rules on the process model. With the business rules modelling on process model, the activities related to business rules and affect of business rules on process control flow can be visualized. BPMN doesn't provide any concept for the representation of business rules on the process model.

**Goal specification based on BPMN** In process modelling languages, the process are defined into a set of activities with related events and conditions. While, the overall goal is to execute the process as modelled at design-time. However, due to its long running time-span, unstructured process is decomposed into number of goals. These goals represent the state of process execution. BPMN doesn't provide any construct to represent the goals on the process model.

**Knowledge Workers' Specification based on BPMN** In process execution, knowledge workers' are assigned to different activities of the process. Lanes of BPMN

are used to represent the association of a person, department or organization to the process. However, there is no notation to represent the role assignment if a process is modelled without using the lanes. According to BPMN version 2.0 standard specification [2], lanes are defined to model the sub-partitions of a business process. Moreover, BPMN does not have any concept to *capture the decisions* taken by knowledge workers.

It is not aimed to *capture the professional networking* and *dynamic task assignment* on the process model. These requirements are directed for the systems implementation. A software suite that is designed to manage unstructured processes should be capable to assign dynamic tasks during process execution.

## 5.4 Summary

In this chapter, the characteristics of unstructured business processes are discussed in detail. An unstructured business process is goal oriented, data dependent, uncertain, emergent, require coordination and collaboration and driven by business rules. Based on these requirements, number of modelling requirements are derived for unstructured business process. With these requirements, an unstructured business process can be modelled without limiting its run-time flexibility. At the end, BPMN modelling concepts are analysed to assess its conformance to the proposed requirements.

Table 5.1 provide the overview of the discussion on BPMN capabilities to conform to the requirements of unstructured business process.

It is noticed that BPMN already provide many concepts and constructs which fulfil the requirements to represent the unstructured business process. Considering the existing capabilities of BPMN, an extension to BPMN standard is proposed in following chapter.

Table 5.1: BPMN and Conformance to Requirements

| **Requirements of Unstructured Process** | **BPMN Capabilities** |
|---|---|
| **Process Specification** | |
| Capture real-time events | BPMN events |
| Support to quantify and qualify the conditions | BPMN Gateways |
| **Activities Specification** | |
| Support for activities re-execution | BPMN (Activities loop characteristics) |
| Support for activities undo | No concept, No notations |
| Support for ordered activities | Sequential Flow among activities |
| Support for unordered activities | Modified BPMN (Modification in sequential flow characteristics) |
| Support for required activities | By default, all modelled activities are required |
| Support for optional activities | The concept is available, but no notation |
| Support for varying level of granularity | Concept of sub-processes and activities |
| Support for process/activity call | BPMN (Call activity and callable element) |
| Process and data alignment | Concept of data modelling |
| Collaboration among activities | No concept, no notation |
| **Data Specification** | |
| Support for data representation | Concept of Data Modelling |
| Data versioning | Concept of data state, but no notation |
| Data authorization | No concept, no notation |
| **Business Rule Specification** | |
| Business rules | No concept, no notations |
| **Goal Specification** | |
| Goals | No concept, no notation |
| **Knowledge Workers' Specification** | |
| Role assignment | No concept, no notation |
| Capture social network | Not needed for modelling |
| Dynamic task assignment | Not needed for modelling |
| Capture decision | No concept, no notation |

# Chapter 6

# Extending BPMN for Unstructured Business Processes

BPMN Plus is an extension to the standard BPMN. BPMN Plus is proposed to fulfil the requirements of unstructured business process modelling. This chapter introduces the concepts and constructs of BPMN Plus. Section 6.1 provide the concepts of BPMN Plus along with its class diagrams. Notations of extended concepts are presented in Section 6.2. BPMN Plus is demonstrated and compared with BPMN and CMMN in Section 6.3. In the end, Section 6.4 provide the summary of this chapter.

## 6.1 BPMN Plus

BPMN Plus is the modelling notation that is based on market de-facto modelling standard BPMN. It proposes new modelling concepts and constructs for the representation of unstructured business processes. As discussed in Section 5.1, unstructured business processes have unique characteristics which require run-time flexibility. Available BPMN constructs limit the flexibility of unstructured business processes by defining every activity on design-time. However, extended modelling constructs of BPMN provide a certain level of flexibility in process modelling, but it yields very complex process model that is difficult to read and communicate. BPMN Plus is aimed to specify and model the unstructured process requirements, proposed in Section 5.2. It is aimed to utilise the available BPMN constructs as much as possible. However, some new concepts are also

introduced. Moreover, the relationship among BPMN core classes is also modified to fit the needs of modelling an unstructured business process.

The purpose of BPMN Plus is to introduce an optimum set of modelling concepts that is able to model the unstructured and structured part of process flexibly. For this reason, not only an extension to BPMN is proposed, but some complex and detailed concepts of BPMN are also omitted.

### 6.1.1 BPMN Core

BPMN core is the technical structuring of BPMN main concepts. It consist of layers which define the basic BPMN concepts and also allow the extensibility. Figure 6.1 shows the layering structure of different classes. Each internal layer extends the upper layer. The classes defined in the central BPMN core provide the standardization of extended concepts, e.g. process, collaboration, choreography.

Each layer with thick black boundary in Figure 6.1 shows the concepts that belong to BPMN Plus. The core of BPMN consists of three sub-packages. The *foundation* package defines the constructs needed for BPMN modelling. The *service* package consist of constructs that are needed for modelling services and interfaces. *Common* package contains

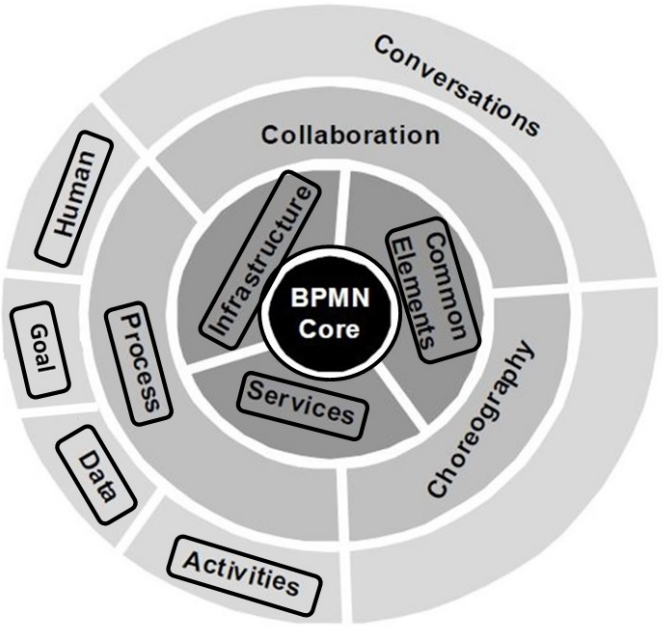



FIGURE 6.1: BPMN Core Diagram

those classes which are used for modelling of process, choreographies and collaboration. Each of these sub-package consist of a number of classes.

According to BPMN version 2.0 standard specification [2], three different types of models, i.e. process, choreographies, collaboration can be modelled with BPMN constructs. Extension of BPMN, i.e. BPMN Plus, is focused only on modelling of the process. The outer most layers show the concepts of human, data, and activities, which belong to process modelling. In BPMN plus, a new class, with the name of the, goal is introduced. Explanation of each related aspect of the process is given in the following sections.

### 6.1.2 Process

A process is set of related activities which are responsible to carry out the business work. A process model represents the end-to-end business operations which facilitates the communication among stakeholders. A process model is composed of a number of

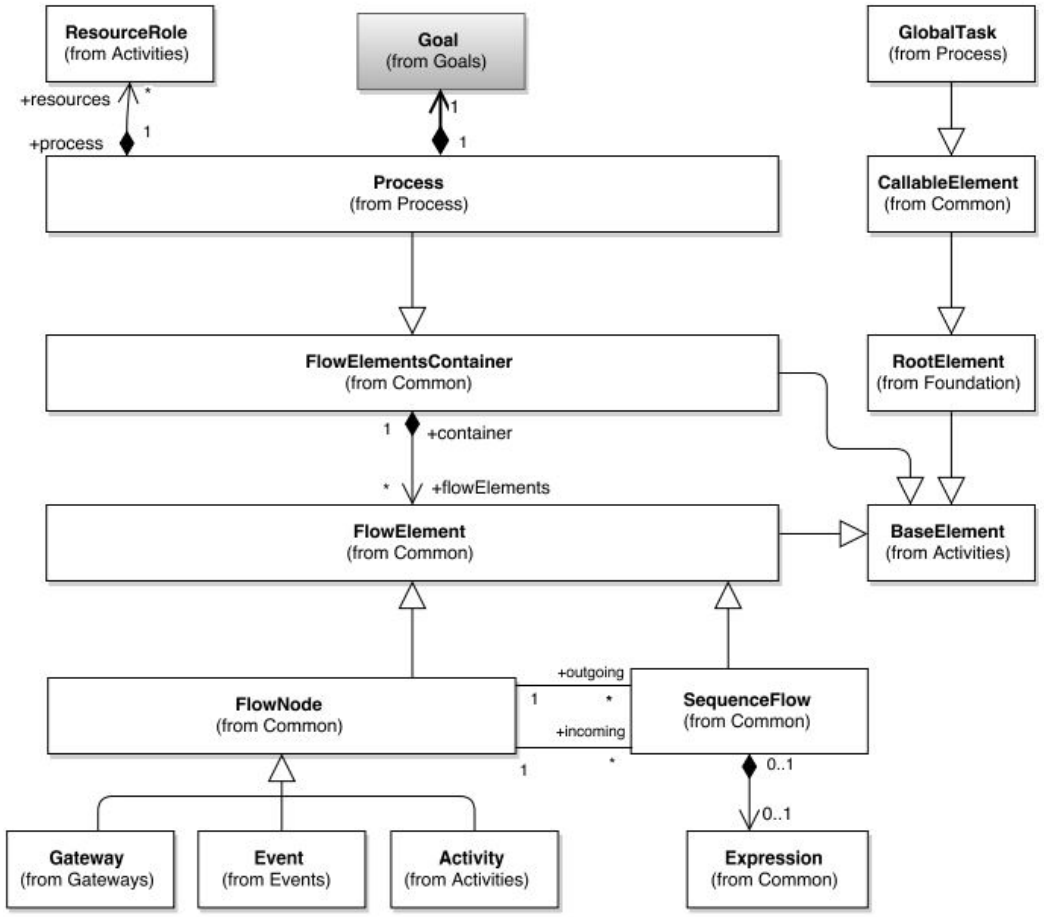



FIGURE 6.2: Process Class Diagram

constructs which are able to represent the real-world business process.

Figure 6.2 provides the overview of all the BPMN classes that are related to the modelling of a business process. Moreover, the classes represented in grey colours are those which are modified or added considering the requirement of unstructured business processes.

*Process* class is inherited from the FlowElementContainer class which belong to the core common sub-package of BPMN. FlowElementContainer is an abstract class which acts as container in which all the process related concepts are defined. The fundamental *process* related concepts are activity, event and gateway. Each *process* of BPMN Plus also has one associated goal. The Goal defines the purpose of *process*. Moreover, the ResourceRole define the human performer who is responsible to perform the tasks of *process*. Each *process* can have one to many human performers.

### 6.1.3 Activity

*Activity* defines the work that is required to be performed in a process. A process has different kinds of activities which must be representable on the process model.

Figure 6.3 provides the class diagram of *activity* adopted from the BPMN specification. *Activity* is the super class which is further inherited by other specialized classes. The variants of *activity* are call activity, task and sub-process. Call-activity represent the

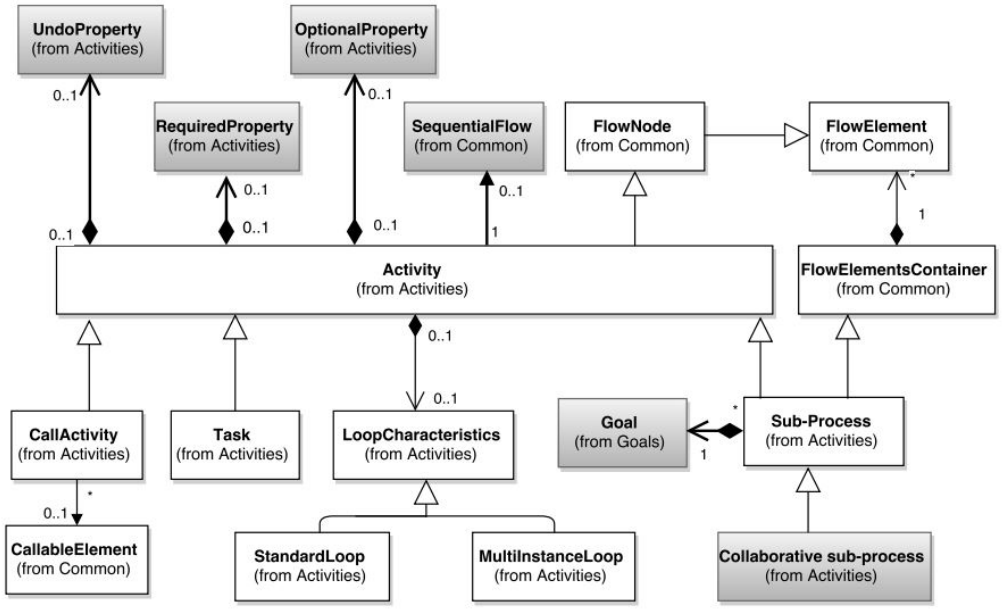



FIGURE 6.3: Activity Class Diagram

call and use of global task or global process. A task is defined as a unit of work which cannot be further divided into detailed tasks. While, a sub-process consists of a number of tasks, or sub-processes. The sub-process contains, the finer level details of an activity.

The classes defined in grey colour are added concepts of BPMN Plus. Undo property, required property and optional property are characteristics of an activity. An activity marked as an undo represents that an activity can be undone if required in process context. Similarly, an activity with the required property must be performed irrespective of process context. Optional activity represents that an activity can be skipped or performed during process execution based on particular process characteristics.

The relationship between activity and sequential flow shows that a activity can have zero or one incoming/outgoing flows. With such characteristics, an activity can be defined without any design-time defined order. The need of the sequential flow depends on the requirement to represent the (un) ordered activity.

Activities can be combined into sub-process. The relationship between *activity* class and sub-process class shows that an activity can belong to one sub-process while the sub-process can belong to number of activities at a time. The concept of the collaborative sub-process is proposed in order to represent those activities that collaborate closely and depend on each other for their performance.

The goal is the new concept introduced by BPMN Plus. A goal must belong to a process or sub-process. The relationship between sub-processes and goal define that a goal can be associated with a number of sub-processes while a sub-process can belong to only one goal. With the execution of activities in sub-process, the associated goal is defined to be achieved.

**Task**

A task can be defined as a unit of work that cannot be defined into further details. Task class is inherited from activity class which means it possesses all the properties of activity (parent) class. A number of different types of tasks are proposed in the BPMN standard specification. However, for BPMN Plus, only two basic types of tasks are considered. Figure 6.4 provide the class diagram of BPMN Plus tasks. The user task defines the tasks that are performed by human performers. Such tasks are difficult to automate and require human intervention for their execution.

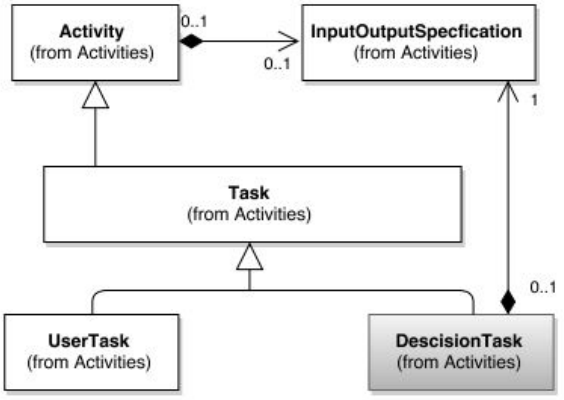



FIGURE 6.4: Activity Class Diagram

To capture the decisions taken during process execution, the decision task is introduced in BPMN Plus. The decision task requires the related data definitions in order to demonstrate the dependency of decision on a particular data object.

### 6.1.4 Data

*Data* is the most intrinsic unit of unstructured business processes. It is required to represent the incoming, outgoing, storage and manipulation of data in the process model. Figure 6.5 provides the class diagram of data class. The root data class is inherited into specialized types of data. *Data store* provide the concept of data storage where the process related data can be stored. *Data object* is a primary concept to represent the data. The data is further defined as *data input* and *data output*. The inputed data is processed by an activity which yields the data output.

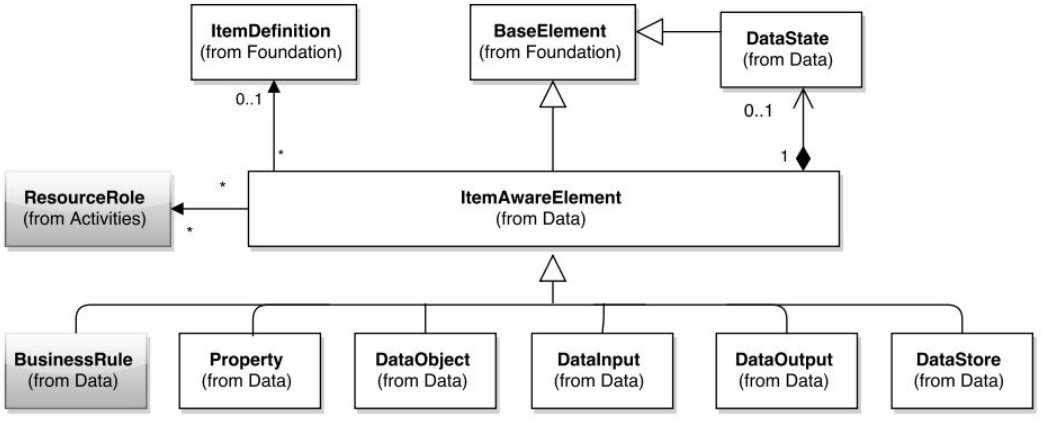



FIGURE 6.5: Data Class Diagram

To provide the data authorization concept, the ResourceRole is associated with ItemAwareElements. Each data element has associated resource role who has the right to access, modify and store the data. If the data is associated with an activity, then the resource role of activity and data will be the similar. Moreover, to define the changing status of data on the process model, the *data state* class is adopted from BPMN.

Business rule as a data item is an addition provided by BPMN Plus. Modelling of business rule with respect to an activity shows the relationship and dependency of business rule on work performed by an activity. Usually, the business rule is depicted by data object or data input on the process model. However, it causes the confusion for the reader as if the data input is process related data or business related rule. Definition of business rule as a separate type of data item provides a clear distinction between process data and business rule.

**Data and Process**

In a business process, the data and process are tightly integrated with each other. During the process modelling, it is required to model the data along with process activities. With process and data alignment, the data inflow, data processing and data outcome become clear to understand and communicate.

Figure 6.6 represent the class diagram of data and process which is adopted from BPMN. InputOutputSpecification is the main class which enables the process and data alignment. This class contains the definition of required data input and data output for a particular activity. The requirement of data is captured with DataInput and InputSet while the processed data is produced and provided with DataOutput and OutputSet. These data input and data output also define the particular data format needs. However, the data formats are not related to visualisation of process model.

### 6.1.5 Performer

*Performer* class contains the information about knowledge workers for a particular process. The performer class inherits the characteristics of ResourceRole as depicted in Figure 6.7.

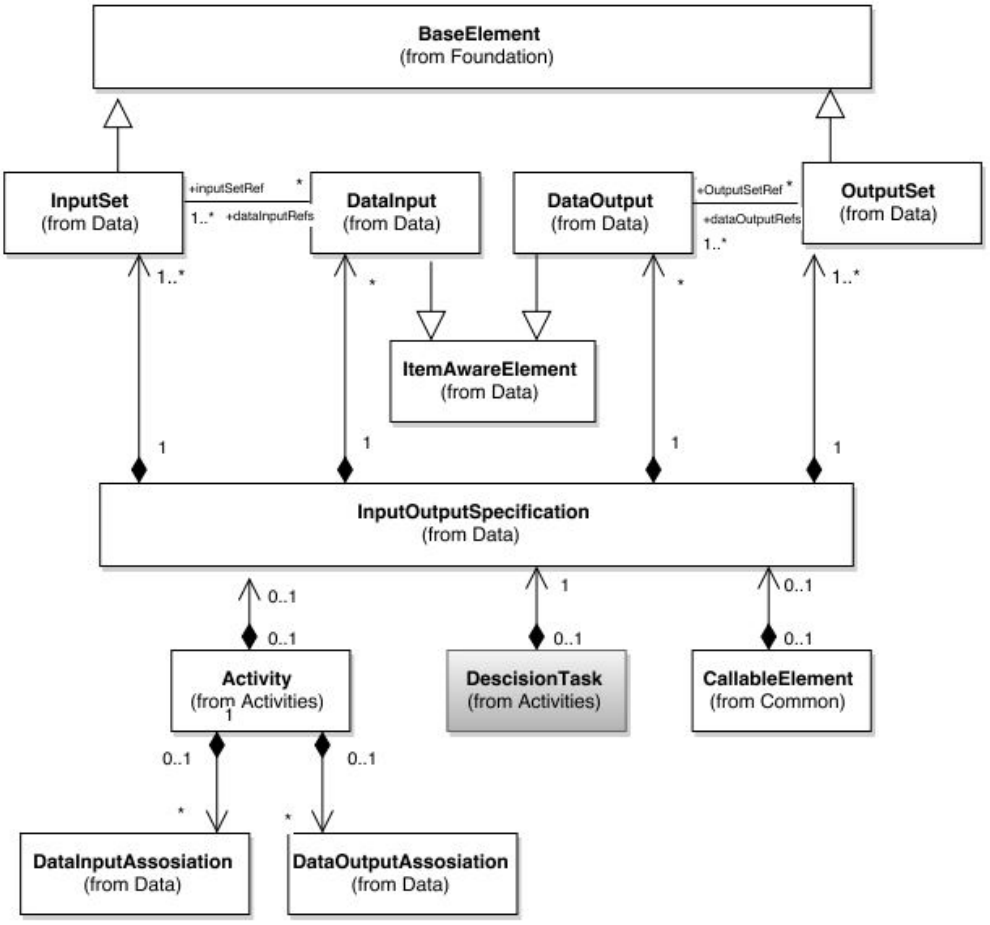



FIGURE 6.6: Process and Data Class Diagram

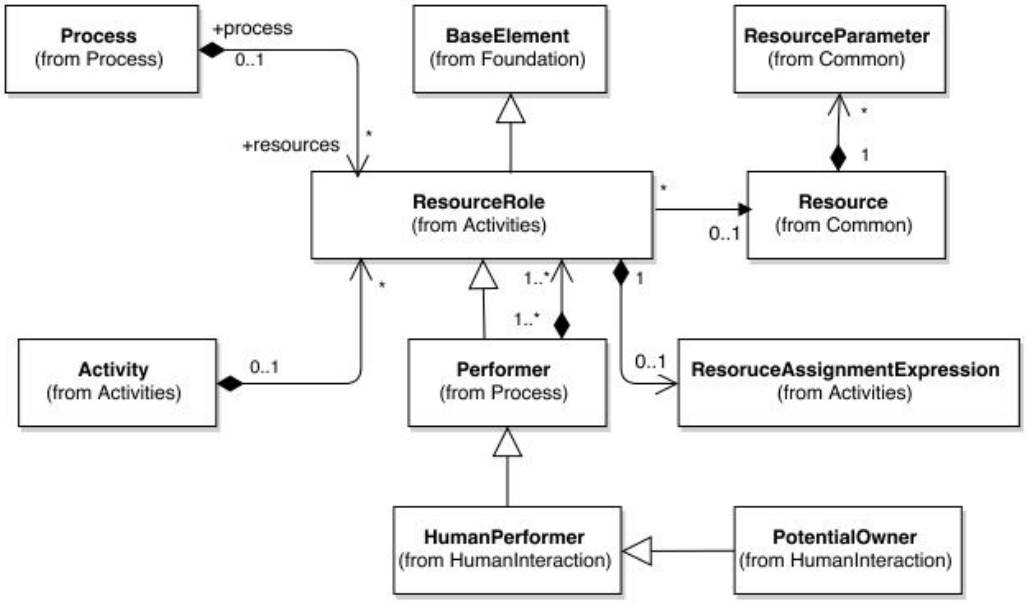



FIGURE 6.7: Performer Class Diagram

The purpose to define the performer and associated resource role is to represent the roles who are responsible to perform the particular activities of the process. ResourceAssignmentExpression assign the roles to the process activities. Each process can have multiple resource roles. Similarly, an activity can also be associated with multiple resource roles who are responsible to perform the activity.

### 6.1.6 Event

Events capture the real-world happening related to process. It directs, re-directs and influence the execution of process. Arrival of new data, change in data, a particular point in time, start of an activity, end of an activity and user actions can trigger the events.

The class of *events* for BPMN Plus is similar to events class of BPMN, however, to avoid complexity, only a few types of events are considered such as standard event, timer event and user events.

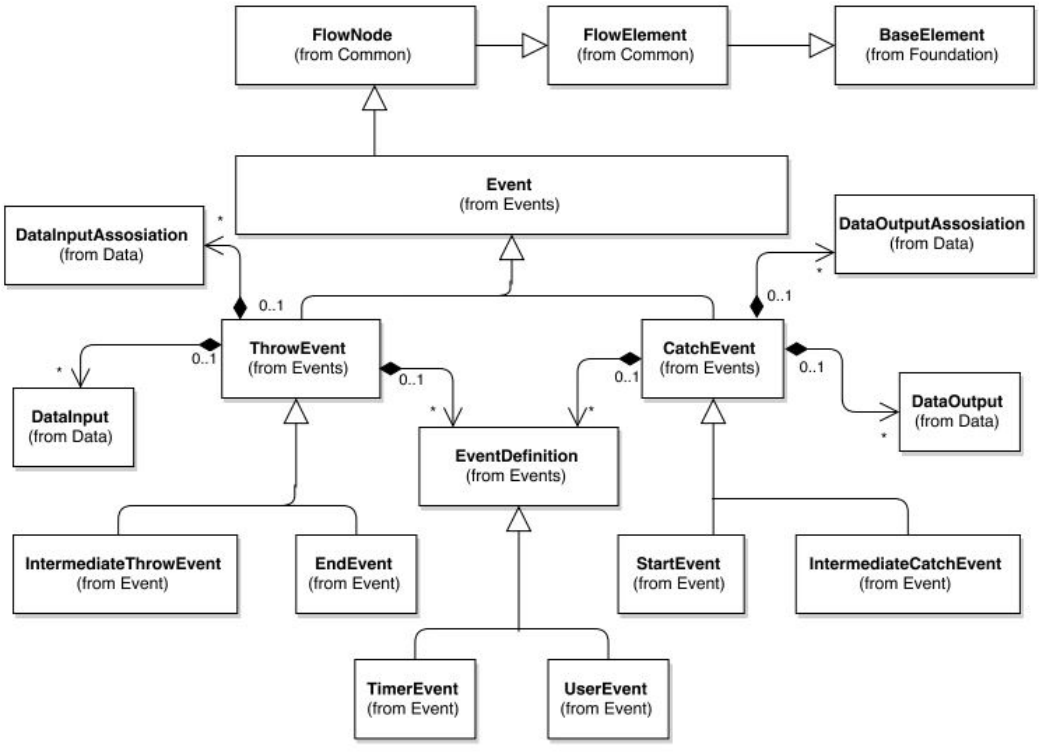



FIGURE 6.8: Event Class Diagram

Figure 6.8 shows the class diagram of *events*. There are three basic types of events. The start event indicates the start of the process while the end events represent the end of the process. The intermediate event indicates that something has occurred during the execution of process. Within these basic types, events can have two different nature. The catch event catches the trigger initiated by some activity, data or the user. All the start and intermediate events are catch event. For BPMN Plus, the concept of boundary catch event is excluded as it introduces unnecessary complexity to represent process control flows. The other type of event is throw events. These events throw the result that might be captured by other events. All the intermediate and end events are throw events.

### 6.1.7 Gateway

Gateways are used to define the process control flow based on certain process conditions. With a gateway, the process control converge and diverge within a process [2].

The process conditions are explicitly defined on gateways. As soon as the process control reached on the gateway, the defined conditions are evaluated. Based on the type of gateway, process flow is transferred to one activity or number of activities.

Figure 6.9 shows the *gateway* class diagram. The gateway class is inherited by exclusive gateway, inclusive gateway and parallel gateway. The concept of complex gateway is

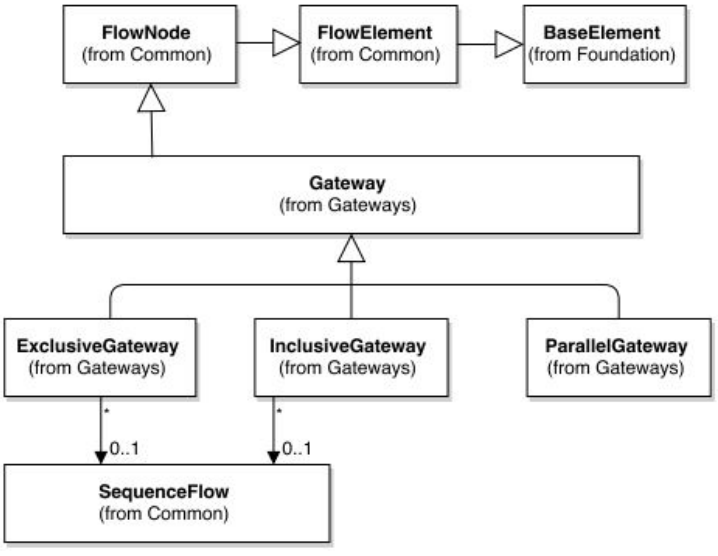



FIGURE 6.9: Gateway Class Diagram

omitted as the decisions are required to be made by human performers instead of by automated expressions.

### 6.1.8 Goal

In unstructured business processes, *goal* state the purpose of the process. Each process has only one main goal. The activities of process are performed to achieve this particular goal. A process contains number of other goals associated with a sub-process. A sub-process can have a only one associated goal while a goal can be related to many other sub-processes at a time. All the goals defined on process model provide the overview of the complete process.

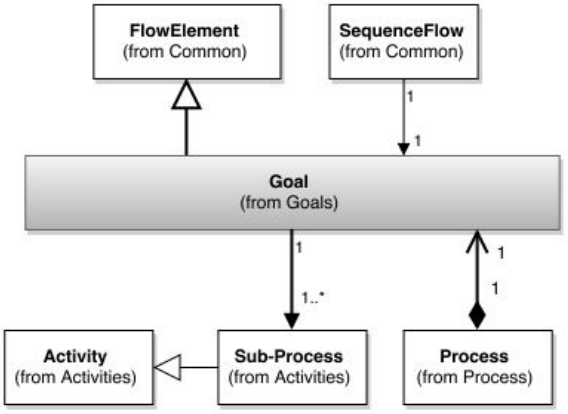



FIGURE 6.10: Goal Class Diagram

## 6.2 BPMN Plus Notations

In this section, the notations for the BPMN Plus concepts are proposed. Notations that are most relevant for modelling unstructured business processes are provided here.

### 6.2.1 Lane

Lane is the container for all the modelling constructs that define the process behaviour on the process model. It represents every detail relevant to a process. The lane is represented as a rectangle shape with process name at the corner.


FIGURE 6.11: Lane Shape

### 6.2.2 Activity

Activity defines the tasks of a process. A process consists of different types of activities. To enhance the understandability of the process model, each type of activity is assigned with a unique symbol. The standard activity or task is represented in Figure 6.12. Standard activity is defined on process model if the exact property of an activity as an optional or required is not clear on design-time. In the following, different types of activities with their description and notations are defined.

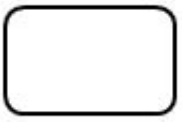


FIGURE 6.12: Activity Shape

**Sub-Process**

The sub-process is the type of activity which consist of a number of other activities. The collection of activities belongs to certain process, hence referred as sub-process. The sub-process is represented with the plus/minus sign at its centre. The plus sign indicates that the sub-process is hiding its details while the minus sign shows all the containing activities of sub-process. Sub-process has its specialized concept which is referred to collaborative sub-process.

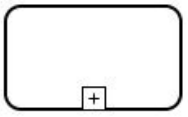


FIGURE 6.13: Sub-Process Shape

**Collaborative Sub-process** Collaborative sub-process represent the collaboration among different activities of the process. It is type of sub-process which consist of those activities which interact, collaborate and share data for their successful execution. Collaborative sub-process is represented by the two arrow heads at the corner.

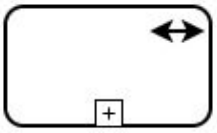


FIGURE 6.14: Collaborative Activity Shape

**Call Activity**

An unstructured process consists of many structured and unstructured parts. During the

execution of process, it is, sometimes, required to call the external process and activities. In the process model, call activity represent that an external process is required for the execution of the current process. Moreover, it is type of sub-process which consist of further details of callable process/activity. The call activity is represented by a thick boundary line.

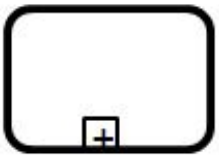


FIGURE 6.15: Call Activity Shape

**Decision Activity**

During an unstructured process execution, a number of decisions are required to be taken by performers. These decisions are based on available data, performed activities and also on knowledge of the performers. The decisions taken during the process flow are demonstrated by an activity with a tick mark at the corner.

FIGURE 6.16: Decision Activity Shape

**User Activity**

User activity, also called human activity, represent those activities that are performed by human. For example, the task to analyse the application, assignment of tasks, are those activities that can't be automated. These activities are required to be performed by humans. The user activity is represented by user sign at the corner of activity shape.

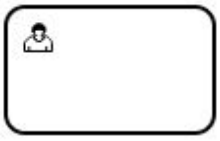


FIGURE 6.17: Human Activity Shape

**Optional Activity**

The purpose of optional activity is to provide flexibility in process execution. As its name implies, the optional activity can be skipped during the process execution considering

the process context. The optional activity is represented by a standard activity with a scrambled paper sign at the bottom centre.

FIGURE 6.18: Optional Activity Shape

**Required Activity**

Required activity defines those activities of process that are must to be executed. These activities shouldn't be skipped with any condition and control flow of the process. The required activity is represented by standard activity with an exclamation mark inside the circle at the bottom centre.

FIGURE 6.19: Required Activity Shape

**Re-execute Activity**

These activities define the need of re-execution of activities. In normal process flow, a single activity is executed only once. However, sometimes, there is need to re-execute the activity number of times. Process model represents such activities with the loop sign in the centre bottom of the activity.

FIGURE 6.20: Re-execute Activity Shape

**Undo Activity**

The undo activity represent those activities of the process that needed to be undone considering the particular process context. As the process and data evolve with time, process may encounter with such activities need to be undone in order to correct the process execution. The undo activity is represented by a scissor sign at the bottom centre of activity.

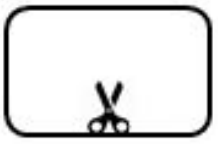


FIGURE 6.21: Undo Activity Shape

### 6.2.3 Event

Event represent the occurrence of real-world happening that is related to process. There are three types of events. All of these events can be regarded as standard event which can capture the arrival of the new document, change in data, message from external actor, etc. The standard catch event is represented by a circle with a hollow centre. *User event* shows the initiation of action taken by the performer of the process. The user event is represented by a circle with a user marker in the centre.

(A) (B)

FIGURE 6.22: Standard and User Event Shape

*Timer event* catches the occurrence of particular time that is crucial to the process. These events trigger some actions or in some other cases marks the end of certain activity. The timer catch event is represented by a circle with the clock marker in the centre, while the timer throw event is represented with thick boundary circle having clock marker. Timer event is the only event of BPMN Plus that has the distinction of catch and throw.

(A) (B)

FIGURE 6.23: Timer Event Shape

### 6.2.4 Goal

Goal represents the purpose of the process. It is a milestone that is required to be achieved by the process. Each process has one main goal and the number of associated

goals. A goal is represented by the boundary of rectangle shape with half-rounded ends.

FIGURE 6.24: Goal Shape

### 6.2.5 Business Rule

A process needs to consider the business rules for the execution of its activities. Business rule represents the related business rules on the process model. The business rule is represented as a data item with table sign at the corner.

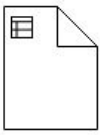


FIGURE 6.25: Business Rule Shape

### 6.2.6 Gateway

The gateway is used only with the ordered set of activities. The purpose to use gateway is to represent the conditional flow in a more transparent way.

*Exclusive Gateway* provide the alternative process flow points based on certain decision. The condition is evaluated on exclusive gateway and flow is transferred to only one path among the number of available alternative paths. By default, a gateway is exclusive and it is represented by a diamond shape with the cross marker in the centre (see Figure 6.26a).

*Parallel Gateway* enable the process control, flow on a number of alternative paths. The parallel gateway demonstrates the execution of a number of related activities in parallel. It is represented by a diamond shape with the plus sign in the centre (see Figure 6.26b).

*Inclusive Gateway* is combination of exclusive gateway and parallel gateway. Unlike exclusive gateway, the process flow can be transferred to one or number of paths if the defined condition results to be true. The inclusive gateway is represented by a diamond shape with a circle in the centre (see Figure 6.26c).

(A) Exclusive (B) Parallel (C) Inclusive

FIGURE 6.26: Gateways Shape

### 6.2.7 Sequential Flow

Sequential flow defines the transitions of process control flow from one activity to another. It specifies the order among activities. The outflow from one activity is the in-flow for the another. Sequential flow is represented by an arrow. Sequential flow can also have a defined conditional flow. In case of conditional flow, the flow is transferred from one activity to another only if the conditions are fulfilled.

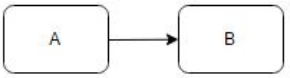



FIGURE 6.27: Sequence Flow

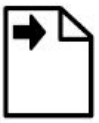
### 6.2.8 Data

One of the requirements of unstructured process is to provide the process and data alignment. The notations of data are adopted from BPMN.

The data input represents the data that is assigned to some activity for some processing. Similarly, the processed data provided by an activity is called data output. These data input and output are assigned to activities, events and other constructs by the data association. The data association is dotted line with an arrow head. The data input can only have an outgoing data association while the data output can have only incoming data association.

Apart from input and output, data object is the generic unit of data that demonstrate the process related data. The activities of process can be dependant on the data object. Moreover, datastore concept enables the process to store, update and retrieve the process related data into datastore. The datastore can be referenced in process number of times.

(A) Data Input



(B) Data Output

(C) Data Object


(D) Data Store

FIGURE 6.28: Data Shape

### 6.2.9 Performer

The performer is the class of people that are assigned to process execution. Each performer can have one or number of roles. Each roles is associated to one sub-process. Such association demonstrates the responsible role to execute the activities contained inside the sub-process. The notations to represent the performer and role is adopted from ArchiMate modelling language.

(A) Performer

(B) Role

FIGURE 6.29: Performer and Role Shape

## 6.3 BPMN Plus Demonstration

In this section, new concepts of BPMN Plus are demonstrated with the help of an application example. The application scenario is about the admission process of a national and international student in the university. The detailed description of the application scenario is provided in Section 5.2.1.

### 6.3.1 BPMN Plus Application Example

Figure 6.30 provides the admission process model based on BPMN Plus modelling notation. The whole process is binded together in a *lane* container. Lane has a name of the process and one associated goal. In this example scenario, the name of the process is 'admission process' with the associated goal of 'application decision'. Each process has a number of other goals that are achieved during process execution. Admission process consist of three main sub-process, which are application intake, application assessment and application decision.

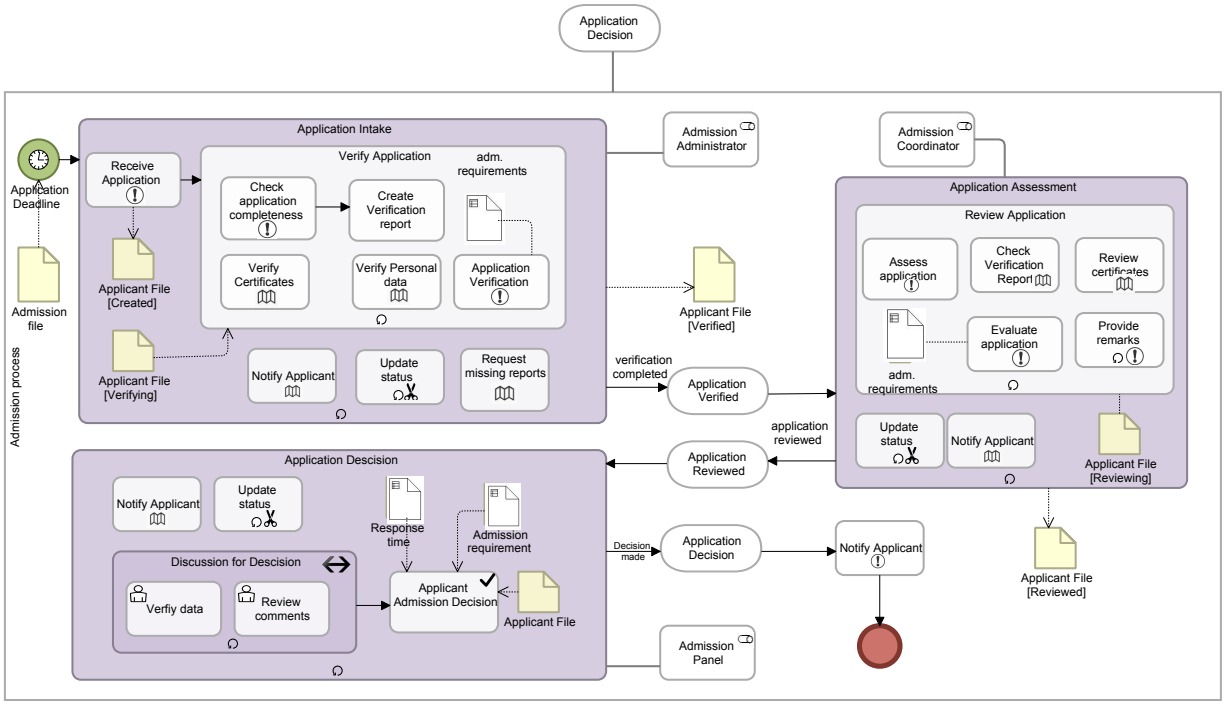



FIGURE 6.30: Process Model of Admission Process using BPMN Plus

The admission application process begins with the timer catch event. 'Receive application' is the process activity which is represented as *required activity*. The activity is must to be executed irrespective of process context as it will create an admission applicant specific file. The data object file represents the name of the file as well as the state of data in file. Once the applicant file is created, the next step is to 'Verify Application'. The application verification step is demonstrated with *sub-process* which can be repeated number of times as marked with *re-executable* marker.

In the verification process, all the activities without incoming and outgoing sequential flow are unordered. These activities can be executed, re-executed or skipped. For example, 'verify certificates' and 'verify personal data' are marked as optional activities which can be executed or skipped considering the provided data from applicant file. While, the activities like 'Check application completeness' and 'Create Verification report' has sequential flow that define ordering of these activities. Moreover, an activity with the incoming sequential flow is always required.

The 'Application Intake' sub-process has one associated goal which is 'Application Verified'. The *conditional flow* on the boundary of sub-process represents that the goal 'Application Verified' will only be reached once the verification of the application is completed. The 'Application Assessment' will start only if the goal 'application verified' is achieved. In the review application step, the applicant file is reviewed considering the admission requirement. The admission requirement that is set by the institute is represented as *business rule* data item. Moreover, the status of an application can be updated number of times in order to keep the applicant informed. 'Update status' is marked as undo and re-doable activity as the review process might lead to number of updates to the status of the application.

Once the application is reviewed, the activities that belong to 'Application Decision' is performed. 'Discussion for Decision' is *collaborative sub-process* which shows the interaction among user activities. All the activities inside the collaborative sub-process are dependent on each other. The final *decision activity* take the input from applicant file, collaborative sub-process, business rules and finally provide the final decision. Once the decision is made, the application decision goal and main goal of process is achieved and the applicant is notified.

The process model also defines the roles who are responsible to perform the process activities. The roles are associated to the each sub-process of a process. Moreover, data objects with its changing states is also represented on process model. The location of data object on process model shows the data access levels for the involved performers. For example, the data object applicant file with verifying state is only accessible by admission administrator while the applicant file with verified state can be accessed by all the involved performers.

### 6.3.2 Comparison of BPMN Plus with BPMN

In this section, the modelling capabilities of BPMN Plus are compared with BPMN basic and extended modelling concepts. This comparison is aimed to provide a clear view on how the BPMN Plus process model yields the run-time flexibility as compared to BPMN process model. The general problems of modelling unstructured process with BPMN have discussed in Chapter 4.

For comparison purpose, the admission process is modelled using the BPMN basic and extended modelling constructs.

Figure 6.31 shows admission process model based on the basic constructs of BPMN. The process model implies the sequential flow where all the activities need to be performed expcept those that are left out based on conditions defined on gateways. The process model doesn't consider the characteristics of a particular process instance and require to execute the every process instance in the same manner.

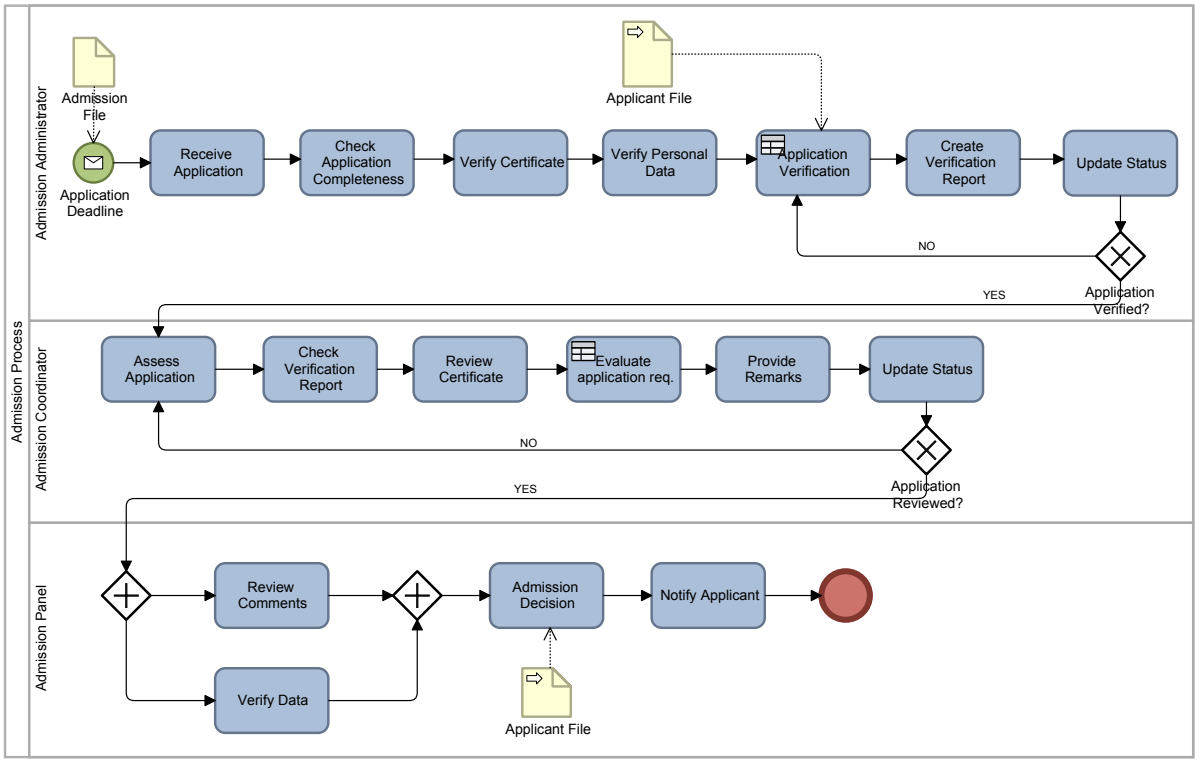



FIGURE 6.31: Process Model of Admission Process Using BPMN Basic

In the following, the limitations of BPMN basic elements for modelling the admission process as an unstructured business process are briefly discussed [51].

- **Strict Task Ordering:** The sequential flow imply the task ordering among the activities. While, an unstructured process like the admission process demand the flexibility and minimal task ordering. For example, according to process model of BPMN basic, the *update status* activity will be executed once all the activities assigned to admission administrator has been performed. While, it is required to update the application status after each activity. Such requirements can lead to modelling of the same activity on process model number of times.

- **Inability to Define Optional Tasks:** During modelling of an unstructured process, certain scenarios can be encountered which require some activities to be marked as optional. For example, during the admission process if the certificate of applicant belongs to well-known national university the task of certificate verification can be skipped. However, it is argued that optional tasks can be modelled using gateways, but a process with many optional tasks will demand modelling of several gateways. Such process model will not only be difficult to read, but from the point of implementation, the CFC is expected to be very high (see Section 4.2.1).

- **Inability to define Activities Collaboration :** With BPMN modelling constructs, it is not possible to model the collaboration among the activities. For example the activities of *review comment* and *verify data* is required to collaborate and take action based on each other's result. However, the process model in Figure 6.31 depicts both activities as parallel, but independent of each other using the parallel gateway.

- **Limited view on Process:** BPMN define the user roles and activities in the process model. Each user is assigned with certain activities to perform. However, with individual activity of process, it is difficult to understand the overall progress view of the process. For example, the activity 'review certificate' doesn't indicate the about the overall process state.

Due to BPMN modelling limitations, a process model is unable to depict the real-world management and execution of process. Use of extended elements of BPMN introduces some level of flexibility, however, it incurs some other problems.

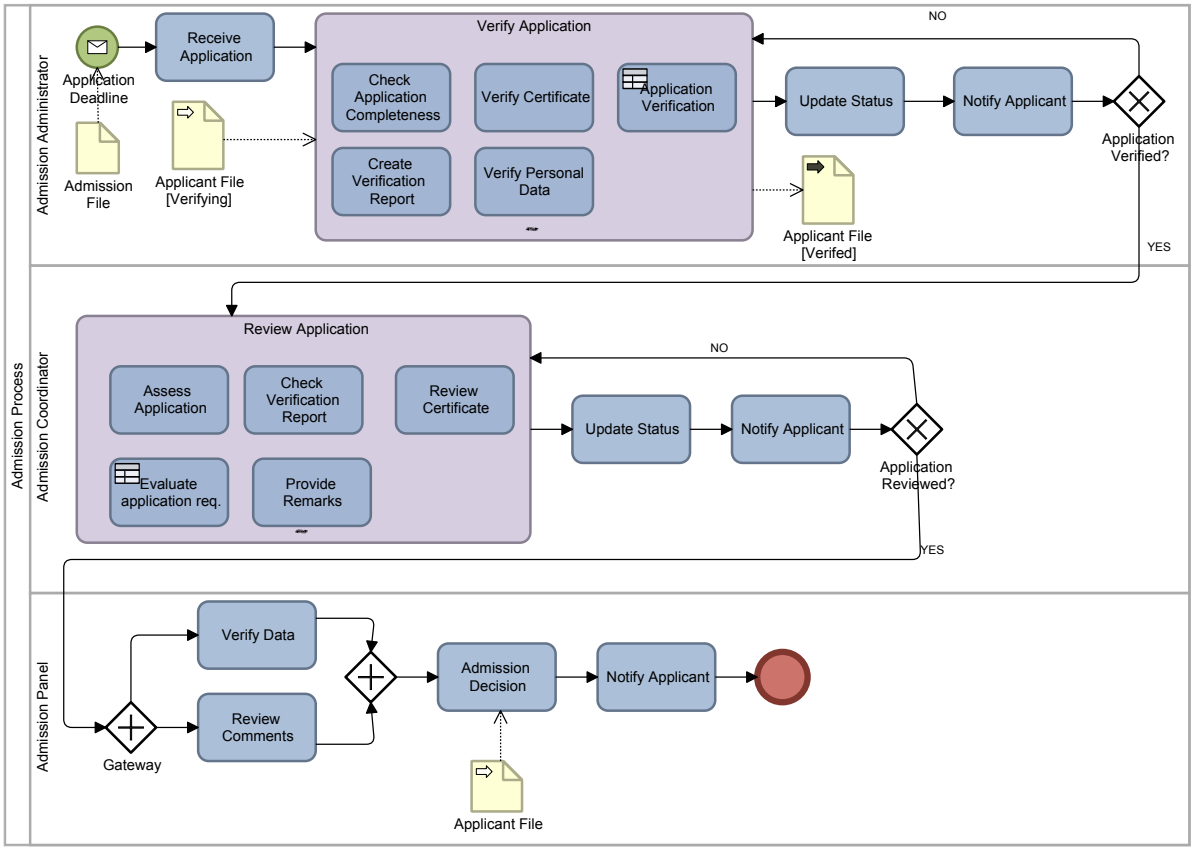



FIGURE 6.32: Process Model of Admission Process Using BPMN Extended

Figure 6.32 shows the admission process model based on extended BPMN elements. Ad-hoc sub-process and various types of events are able to depict the run-time flexibility on process model. The ad-hoc sub-process doesn't imply any task ordering among its activities. Moreover, an activity in ad-hoc sub-process can be considered optional as the decision to execute or skip an activity depend on the process manager. As compared to basic BPMN modelling constructs, extended BPMN elements provide some level of flexibility in modelling unstructured process. However, some limitations of modelling unstructured process with extended elements are noticed, which are provided as follows.

- **Low Expressibility of Ad-hoc Sub-process:** Ad-hoc sub-process define the activities without any ordering. Moreover, an activity can be executed or skipped with-in ad-hoc sub-process. However, there are no specific notations to express these behaviours. For example, by looking at the *verify application* ad-hoc sub-process, one can't say if the *verify certificate* will be performed or skipped.

- **Low (no) Execution Support:** Execution of a process model on process engine is an important requirement for the process simulation and automation. However, ad-hoc sub-process have low or no execution support from the process engine as discussed in p. 183 BPMN version 2.0 standard specification [2].

- **Inability to define Structure in Ad-hoc Sub-process:** As discussed in earlier chapters, a process is neither completely structured nor unstructured. It is a combination of structured and unstructured process activities. In the ad-hoc sub-process, it is not possible to define the sequence flow or task ordering among the activities. Such limitation leads to a process model which has many ad-hoc sub-processes.

The modelling constructs that are proposed as part of BPMN Plus tries to mitigate all of these problems that are discussed. The use of sub-process instead of ad-hoc sub-process allow the tasks (un)ordering on the process model. Moreover, the definition of required, optional, decision, and collaborative sub-process enhances the readability of the process model.

### 6.3.3 Comparison of BPMN Plus with CMMN

In this section, BPMN Plus modelling constructs are compared with CMMN. The similar admission process is modeled using CMMN in Figure 6.33. CMMN provide various new concepts that allow an unstructured process model to represent the run-time flexibility. The concept of required task, optional task and no ordering among activities are useful construct for modelling unstructured business process. However, there are some modelling limitations of CMMN which make it difficult to adopt by many process managers.

Following are some of the limitations of the CMMN.

- **Inability to Model Structured process:** Due to unavailability of sequential flow, it is complicated to define the task ordering using CMMN. The connector (dotted line) and a sentry (diamond shape) is used to represent the ordering of tasks which introduce the unnecessary complexity over process model. For example, after the receive application activity, the verify application activity needs to be performed which is depicted through connector and the sentry.

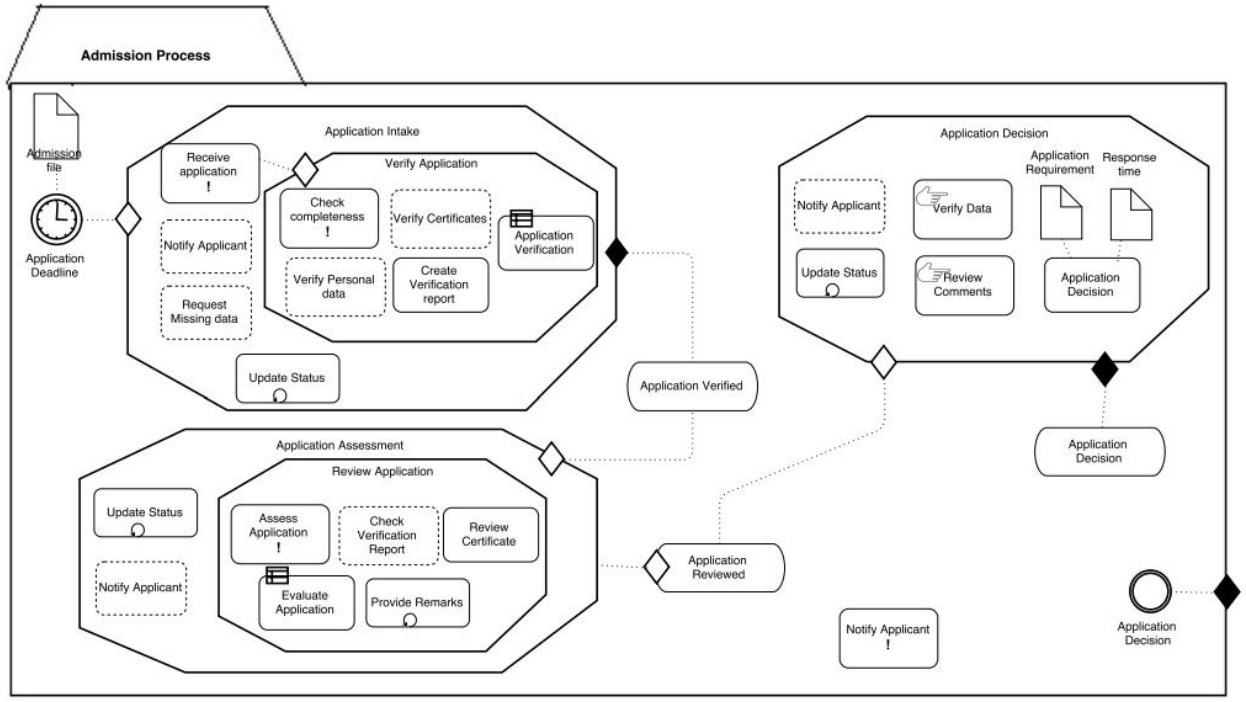



FIGURE 6.33: Process Model of Admission Process Using CMMN

- **Unclear Process End:** In CMMN, the process end is not as explicit to trace and read as in BPMN. The end of the process is represented using an event and exit sentry (filled diamond) attached to folder boundary.

- **Inability to Model User Roles:** CMMN doesn't have any notation to show the resource role on process model. Figure 6.33 doesn't depict any involved user on th process model. Such limitation hinders the task assignment need during the process management.

- **Hidden Process Control Conditions:** As shown in Figure 6.33, the process model doesn't define the conditions explicitly. Process control conditions are depicted through the combination of task/stage and sentry. For example, the process control will be transferred from application intake to application verified by evaluating the exit sentry (filled diamond).

The modelling constructs of CMMN (e.g. sentry, discretionary) are difficult to understand and communicate. Moreover, the unavailability of sequence flow reduces the modelling scope of CMMN to unstructured process parts only.

### 6.3.4 Modelling Benefits of BPMN Plus

As compare to BPMN and CMMN, BPMN Plus provide many useful modelling concepts that facilitate the modelling of a business process in flexible manner. Some of the modelling benefits of BPMN Plus are discussed below.

- **Expressive Process Model:** As compared to CMMN and ad-hoc sub-process of BPMN, the BPMN Plus process model is easy to read. It has a well-defined process start and end event. Moreover, the modelling constructs to show the required, optional, decision and collaborative tasks makes the process model easy to read and communicate.

- **Ability to Model (un) Structured Process:** BPMN Plus has the capability to represent the structured and unstructured business process. The sequential flow of BPMN Plus defines the task ordering and task dependency between tasks which is a must requirement to model structured process. CMMN don't have the concept of sequential flow while in BPMN the use of the sequential flow inside the ad-hoc sub-process provides a process model which is semantically incorrect.

- **Ability to Model User Roles:** With user role notation, a person or group or departments can be set as responsible to perform certain activities. CMMN and BPMN don't have any notation to define the user roles on the process model. However, in BPMN lanes are used for this purpose.

- **Ability to Model Data Access Level:** In BPMN Plus, the concept of data access level is proposed. The data access level is defined based on data object position on the process model. A data object that is defined inside the sub-process belong to the assigned user only. While, the data object outside any sub-process is accessible by all the involved users of a process.

- **Ability to Model related Business Rules:** With BPMN Plus, it is possible to model the business rules on the process model. With BPMN and CMMN, it is feasible to represent the business rule related activity either by business rule task or planning table. However, in order to show the effect of business rules on process control flow, it is required to represent the most relevant business rules only.

- **Ability to Model Collaborative Activities:** With BPMN Plus, it is possible to model the collaboration among the activities. The collaboration among activities shows that the activities are dependant on each other for their execution.

## 6.4 Summary

In this chapter, a modelling notation named BPMN Plus is proposed. It is an extension to the BPMN standard in which some new modelling concepts are defined while few existing concepts of BPMN is modified. All the proposed modelling concepts are aligned to existing BPMN standard in order to provide conflict-free extension to BPMN standard. For the demonstration purpose, an admission example is modelled using modelling constructs provided by BPMN Plus. Moreover, the modelling capabilities of BPMN Plus are compared with BPMN and CMMN. It is concluded that BPMN Plus provide many useful concepts for modelling an unstructured business process in flexible manner.

# Chapter 7

# Validation of BPMN Plus

The third and final part of the design cycle is to validate the proposed artefact [11]. After demonstrating the BPMN Plus with the help of an application example, BPMN Plus is validated. In this chapter, the validation settings along with validation results are presented. Section 7.1 present the assessment criteria and validation method. The validation outcome is provided in Section 7.2. Based on the validation outcome, the recommendation to improve the BPMN Plus is provided in Section 7.3. Personal reflection and summary of interview session is discussed in Section 7.4.

## 7.1 Assessment Criteria and Validation Method

The validation phase observe and measure on how well the proposed artefact solves the particular problem or, in other words, fulfils the research goals [66]. The validation phase requires the clear understanding of certain analysis metrics or techniques on which the proposed artefact will be validated. To validate the representational requirement of unstructured process and BPMN Plus, the analysis metrics as assessment criteria is proposed.

- Usefulness
- Ease of Understanding
- Correctness
- Applicability

These analysis metrics are defined by considering the characteristics of proposed artefact, thus these metrics are solely opinion based. With usefulness metric, the usability of the proposed requirements and BPMN Plus will be validated. Ease of understanding will validate the BPMN Plus' constructs for their expressibility on process model. While, correctness and applicability metrics will validate the BPMN Plus perceived level of correctness as compared to BPMN and its applicability to provide practical support.

According to Peffers et. al., different forms of validation could be performed depending on the artefact characteristics [66]. The validations include the comparison of artefact's features with existing methods, surveys, client feedback, expert's interviews and/or measurement of performance metrics.

For this study, qualitative semi-structured interviews with experienced practitioners of BiZZdesign are conducted. Qualitative interview is one of most common and useful way of gathering information and validating the artefacts. Rubin and Rubin highlighted the importance of qualitative interviews by stating: "qualitative interviews permit us to see which is not ordinarily on view and examine that which is looked at but seldom seen" [67]. While, semi-structured interviews are defined as an interview with incomplete script [68]. Qualitative semi-structured interviews allow the researchers to ask the planned questions, but also leave the space for open discussion.

The interviews for this research are conducted with three business consultants from BiZZdesign. Each of these consultants has considerable working experience with BPMN process modelling language. Separate interview sessions were arranged with each of the participants that lasted from 60 to 90 minutes.

In the first half of the interview session, the research motivation, limitation of existing modelling languages and proposed extension of BPMN was introduced. Later, the validation questions provided in Table 7.1 was asked to interviewees. These questions are defined to collect the valuable feedback from interviewees to assess the proposed artefact with respect to its assessment criteria. The first two validation questions were asked to get the basic understanding about unstructured business process and perceived limitations of BPMN from the point of view of interviewee. While, the remaining validation questions were asked to assess the proposed BPMN Plus based on its defined assessment criteria. All the interview sessions were audio recorded with the consent of interviewees.

TABLE 7.1: Assessment Criteria and Validation Questions

| No. | Criterion | Questions |
|---|---|---|
| 1 | Market Trend | What is your understanding of an unstructured business process? Do you think companies are more focused on modelling and management of unstructured process now than ever before? |
| 2 | Limitations of BPMN | Based on your experience, do you find it difficult to model the unstructured process (parts) with BPMN? |
| 3 | Usefulness | From practical perspective, do you think the representational requirements of unstructured process are significant? Do you suggest any modification? |
| 4 | Usefulness | Do you think the BPMN Plus provide useful constructs to model the unstructured process? What could have been included/ omitted? |
| 5 | Ease of understanding | Do you think the BPMN Plus model is easy to understand and communicate? Compared to CMMN model? |
| 6 | Correctness | Does the extended concepts of BPMN Plus fits well with the existing BPMN concept? Do you see any similarities and/or conflicting concepts? |
| 7 | Applicability | Do you think it is feasible to provide the modeller support for BPMN Plus? Can you foresee any problems? Conflicts with BPMN semantics? |

## 7.2 Validation Outcomes

In this section, the result of interview sessions is discussed with respect to its assessment criteria. All the recorded interviews were transcribed. The detailed description of transcribed interviews is provided in Appendix B.

### 7.2.1 Market Trend

Structured business processes have received considerable attention for last few decades. The survey conducted by AIIM highlighted the increasing focus of companies from structured to unstructured business processes [3]. To understand the market trend, interviewees were asked to provide their insights on companies' focus on management and modelling of unstructured business processes. According to two interviewees, the

interest and need to manage unstructured business processes is increasing due to shift of work from automated business processes to knowledge-intensive business processes. However, based on their experience, companies prefer to model unstructured processes in a structured way. Such structured way of modelling provide a layout of an unstructured process that is used only for communication purpose. One of the interviewees proposes that there is need to let the companies understand the usefulness of modelling unstructured process in an unstructured way. Such unstructured process models can also be used for process execution instead for communication only. According to one of the respondents, the unstructured process will be future in next 5 to 8 years specifically in banking and government. Based on his experiences, 80% of business processes of a company are structured while rest of 20% are handled in an ad-hoc manner.

Considering the responses of interviewees, the focus on unstructured business processes can be foreseen in coming future which will require different resources for modelling and management than conventional structured processes.

### 7.2.2 Limitations of BPMN

In the Chapter 4, the limitations of BPMN for modelling the unstructured business processes are highlighted. The sample insurance claim process was used to gauge the capabilities of BPMN for modelling unstructured business processes. Based on interviewees vast practical experience, interviewees were questioned to provide their insights on the BPMN capability to model an unstructured business process. Most of the respondents agree that it is difficult to model the unstructured business processes with BPMN. Interviewees mentioned that they adopt various modelling styles to avoid limitations of BPMN. For example, modelling an unstructured business process in a very abstract way by including only main activities. However, one need to be very careful while omitting process related details from process model.

Moreover, the unstructured business process can be modelled completely with extended BPMN modelling elements as suggested in Chapter 4. But, such process models are too complex to communicate to the business people. Ad-hoc sub-process is one the most important modelling concept of BPMN that is used for modelling unstructured business process. However, it is noticed that the ad-hoc sub-process of BPMN is not very expressive, thus results into the complex process model.

### 7.2.3 Usefulness

For modelling the unstructured business processes, two artefacts were proposed. The requirements to model the unstructured business processes flexibly are provided in Chapter 5. While, the extension to BPMN i.e. BPMN Plus is proposed to fulfil the modelling requirements of unstructured business process in Chapter 6. The extension of BPMN is based on the proposed representational requirements. Before, validating the usefulness of BPMN Plus, the requirements to model the unstructured processes were validated by interviewees.

**Requirements for Unstructured Processes Modeling**

Interviewees share the same opinion regarding the usefulness of proposed representational requirement. All the respondents find the requirements to be sufficient and didn't suggest any modification. However, according to one interviewee, the stated requirements are too much to start for a process manager. He proposed to classify the requirements into different level of maturity. The more a process model can fulfil the requirements, the higher will be its maturity level.

Further suggestions are made regarding the practical implementation of these requirements on process model with real case studies. For readability, it is important for a process model to not be over-crowded with number of modelling constructs. It is also noted that many proposed modelling requirements are not solely for unstructured business processes, but also belongs to structured business processes e.g. decision task, and ordered activities

**BPMN Plus Concepts and Constructs**

BPMN Plus is validated based on its concept and modelling notations. Interviewees are presented with a set of proposed notations and asked to provide their insights. Different perceptions were given regarding each extended concept and notation.

The ability of BPMN Plus to explicitly mark the process activities as required and optional is regarded as most needed extensions of BPMN. However, many relevant concerns were raised. For example, according to one interviewee, the optional task concept can be achieved by BPMN gateways. But he also acknowledges the fact that the concept of optional activity is far less complex as compare to defining it with the relevant conditions and number of gateways.

Furthermore, another interviewee suggested to keep the only one concept between required and optional activities. According to him, any activity that is not optional is required. On the other hand, some interviewees find marking the activities as required and/or optional is very useful construct for enhanced process model readability. All the respondents have recommended to change the symbol of optional activity to something more intuitive and readable.

Two of the respondents find the concept of collaborative sub-process very interesting. With existing BPMN constructs, it is very hard to model the activities that are dependent on each other. The parallel gateway, that is used for this purpose, shows the simultaneous activities execution but not their dependability. Any symbol to model the interaction among activities is missing in BPMN. BPMN Plus fulfil this gap with the collaborative sub-process.

The idea to represent business rule(s) in process model gave raise to many different concerns. Each of the respondents provides very diverse views related to business rule. The business rule is shown as data object with table sign at the corner. Two of the interviewees disregarded the need of business rules due to a number of reasons. First, a business process consider number of business rules throughout its lifecyle. Modelling the business rules, even most relevant one, might result into a overcrowded process model. Second, business rules are defined usually with long statements. It is not possible to name the business rules on the process model. If the business rule is named after its numeric value (say a.34) then it doesn't yield any benefit for readability. Third, business rule can also be considered as data input instead of providing with a different data object notation. However, the interviewee agrees that the different notations for data object and business rule data object provide a clear distinction between process related data and business rules. It was advised to reconsider the need to model the business rules on the process model. In contrary, one interviewee really likes the idea to model the most relevant business rule on the process model. Talking about BiZZdesign Architect, he mentioned that the business rules are already modelled but with some associated reference. Such referencing system doesn't help in process model visualization.

Concept of decision task has been welcomed just as another type of task. Decision task can be combined with existing BPMN tasks. For example, an activity can be marked as user task as well as decision task.

The notations to represent task assignment is proposed in BPMN Plus as role and performer. According to all the interviewees, the lanes of BPMN have been already available for this purpose. However, in BPMN v2.0 standard specification, lanes are defined as a construct to show sub-partitions of the process. BPMN has a concept of resource role, but there is no associated notation for it. Currently, it is not possible to show the role on process model without the use of lanes. With the BPMN Plus, it is possible to represent the resource role without the lanes. Considering the fact that an individual can own number of roles, the concept of the performer was introduced. It is suggested by all the interviewees to keep one of the concepts between role and performer in BPMN Plus.

Two of interviewees find the concept of undo activity as similar to a compensation event of BPMN. However, respondents also mentioned that the compensation event is very complex to understand by business people. Moreover, interviewees point out that the use and need of undo activity in process modelling is unclear. According to them, any activity that is needed to be undone is yet another activity. There is a need to clarify the applications of undo activity for process model.

To provide a quick overview of the process, the concept of goal is introduced in BPMN Plus. All of the respondents find the concept of goal very similar to the undefined intermediate events. According to one respondent, the goal concept can be add-on to the undefined intermediate events as it is very interesting to see the goal associated with the process.

### 7.2.4 Ease of Understanding

Compared to CMMN, all the respondents notice the BPMN Plus very easy to understand. According to one of the interviewees, the CMMN require some background knowledge to understand its process model. While, the BPMN Plus exploits simple constructs that can be understood easily. BPMN Plus provides the view on process flow using sequential flow, which is missing in CMMN. Moreover, the interviewees also indicate their expertises with BPMN and very limited or no use of the CMMN. Thus, indicating the BPMN Plus as more easier to understand could be because of their experience with BPMN like notations.

In comparison to BPMN, the notations proposed for BPMN Plus are regarded as complex to understand. For some respondents, the concept of optional, required and undo are either similar, conflicting or not needed at all. For example, the application of undo activity on process model is objected by all respondents. For one respondent, undo activity is similar to the compensation boundary event. For other respondent, the undo activity is not needed at all as any activity that need to be undone is in itself a new activity.

### 7.2.5 Correctness

The correctness of BPMN Plus with respect to standard BPMN is also assessed. Proposed concepts and constructs are validated by tracing similar and/or conflicting concepts of BPMN with BPMN Plus.

Interviewees marked the optional, required, collaborative, decision, role concepts and notations as correct. With respect to these notations, no conflict or similar notations were found in BPMN. However, there are few notations that are discussed based on their similarities with BPMN.Two of the interviewees found the goal of BPMN Plus exactly similar to the undefined intermediate event of BPMN. According to them, both concepts shows a certain state during the process flow. Only one interviewee acknowledges the difference between a goal and undefined intermediate event as one provide the quick overview of the process and also regulate the process flow while the other shows the process particular state with optional text annotations.

Moreover, undo activity of BPMN Plus and compensation event of BPMN is also found similar by some respondents. The compensation event is boundary event attached to an activity. In case of undoing the activity, the compensation event is fired. The concept of undo activity is similar but with less visual complexity as compared to the compensation boundary event of BPMN.

Apart from similar concepts of BPMN and BPMN Plus, the respondents found the visualization of data authorization concept very powerful. According to one respondent, the visualization of the data access of BPMN Plus is very intuitive as compare to technical specification provided in the BPMN standard specification.

### 7.2.6 Applicability

Regarding the practical applicability of BPMN Plus, all the respondents share the same opinion. They don't foresee any problems in providing the modeler support for BPMN Plus.

However, one of the respondents highlighted the exchange format compatibility issues. The exchange formats provide the machine readable process files that can be read and interchanged to other users. These process files are written in standard formats (i.e. XSD, XMI, and XSLT) which can be executed on any process engines. The extension of BPMN proposes new classes and an extension to existing classes. Such extended classes are not recognizable by process engines and can introduce the compatibility issues.

## 7.3 Recommendations for Improvement of BPMN Plus

BPMN Plus provide number of concepts and constructs for modelling an unstructured business process. Interviewees have provided their reviews on each of proposed concepts as well as on the overall usefulness and correctness of BPMN Plus. Considering the insights and suggestions from interviewees, the recommendations to improve the BPMN Plus is provided in this Section. These recommendations is provided to be used as future work in order to improve the BPMN Plus.

**Recommended Modifications for BPMN Plus** Considering the feedback from interviewees, few modifications in BPMN Plus is proposed to make the modelling notation more consistent.

1. The concept of activity, required activity and optional activity is found to be confusing by some interviewees. It is difficult to interpret an activity that is not marked as optional and required. To make the BPMN Plus more consistent, only one concept from required and optional is recommended to be kept in BPMN Plus while the activity can be set with default property.
2. To assist in use of proposed modelling constructs, there is need of process modelling rules for BPMN Plus. Number of rules can be settled to assist the process manager in modelling an unstructured business process. Some

modelling rules could be (a) An undo activity will always be an optional activity (b) An activity with incoming sequential flow is always required or (c) At one point in time, an activity can be either required or optional.

3. Some suggestion to modify the notations of BPMN Plus were provided by interviewees. It is recommended by all the interviewees to change the notation of optional activity to something more readable and intuitive. Moreover, to enhance the readability of process model, instead of symbols the colour views and different shapes for modelling notations can be used. One of the interviewee also mentioned that color views and different shapes are more interesting for business people as compared to small symbols.

**Assist on use of Concepts:** BPMN and BPMN Plus introduce various concepts and constructs for modelling the structured and unstructured business processes. It is also suggested by one of the interviewees to provide a method or set of guidelines on how to use and misuse the particular notations and concepts while modelling the business processes.

**Introduce BPMN Plus as Modelling Level :** For BPMN Plus, it is intended to provide the optimum set of modelling notations that can model the unstructured business process. For this purpose, some new concepts are introduced while some existing complex constructs are disregarded. An interviewee has suggested to just provide an extension to BPMN while avoiding the over-looking of existing concepts. Considering the different process modelling levels [69] as descriptive, analytical and executional, it is recommended to introduce the BPMN Plus as new level of process modelling for unstructured business processes.

## 7.4 Personal Reflection and Summary

The validation of BPMN Plus yields number of interesting points. Some concepts of BPMN Plus are considered as welcoming extension to BPMN while few are regarded as complex, similar to BPMN and/or not needed at all. In this section, we will provide our personal reflection on views provided by interviewees and the summary of validation results is given.

From the experience of interviewees, it is noticed that there is need to let the process manager and process engineer to understand the need to define and model the unstructured business processes.

With respect to BPMN Plus, the concept of goal, undo activity and business rules is discussed the most. As mentioned earlier, the goal and undefined intermediate business event is considered as similar. However, we believe that the both concepts are quite different in its meaning and its use on process model. Goal defines the purpose of process as well as the executing activities. Moreover, goal represent the process control as most of the goals are sequential in nature. The achievement of one goal will lead to another set of activities which will ultimately achieve the subsequent goals. On the other hand, the intermediate event represents the occurring of some real-time event during the process lifecycle while the undefined markers indicate the state of change. Hence, one can say that goal is superset of undefined intermediate event which can show the process state as well as represent the purpose of process explicitly.

Undo activity and compensation boundary event are also found to be similar by interviewees. From the conceptual point of view, the undo activity and compensation boundary event are similar as both indicate the undoing of the certain task. However, with respect to notation, the undo activity is easy to represent and communicate on process model as compared to compensation boundary event.

Another concept that is discussed intensively during interview sessions is business rules. We intend to model the most important business rules on process model for the purpose of clear process flow definition. Representing the business rules will allow the business people and process engineers to understand on which business rules can influence the process activities execution.

We believe BPMN Plus mitigates the limitation of BPMN by introducing an optimal set of modelling constructs. These modelling constructs are able to model the unstructured business process without representing the unnecessary details and complexity as with BPMN. Required, undo, optional, and repetitive activities show the process run-time flexibility on process model. With business rule data object, the business rules and process related data can be visually differentiated. The overall process view is provided by goal concept. While, roles and performer shows the process related users.

Table 7.2 provides the summary of interview session with respect to assessment criteria.

TABLE 7.2: Summary of Interview Session

| **Criterion** | **Answers of Interviews Session** |
|---|---|
| Limitations of BPMN | It is difficult to model the unstructured business processes with basic BPMN elements. But such limitations can be avoided by modelling the process on a higher level of detail. Moreover, the extended BPMN elements can model the unstructured business process, but the resulting process model is very complex to communicate. |
| Usefulness | Required, optional, collaborative sub-process and decision activities are regarded a very welcoming extension to BPMN. While, the applications of few modelling constructs, i.e. performer and business rule was indicated as unwanted for process modelling. |
| Ease of Understanding | As compared to CMMN, the process model of BPMN Plus is considered as very easy to understand. While, as compared to BPMN, the process model of BPMN Plus is indicated to be difficult to read. |
| Correctness | All the proposed modelling notations were found correct by interviewees except the two. Goal and undo activity of BPMN Plus is indicated to be similar to the undefined intermediate event and boundary compensation events of BPMN respectively. |
| Applicability | From the notations perspective, providing the modeler support for BPMN Plus is not a problem. However, one the interviewee highlighted the compatibility issue of exchange formats due to the introduction of new (sub) classes in BPMN Plus. |

# Chapter 8

# Conclusions and Recommendations

This chapter provides conclusions and recommendations based on the work presented in the previous chapters. Section 8.1 provides the answers to the research questions proposed in Chapter 1. The practical and theoretical contributions of this research are provided in Section 8.2. Additionally, research limitations and the recommendations for future work are provided in Section 8.3 and 8.4, respectively.

## 8.1 Answers to Research Questions

The research goal of this study is to model and manage the unstructured business processes without limiting their run-time flexibility. To fulfil this research goal, the main research question of this study is:

**Main RQ:** *How can unstructured business processes be modelled and managed in a flexible manner?*

The main research question is further divided into a number of subresearch questions. The answer to each of the subresearch question is provided below.

**RQ1:** *What are the differences between structured and unstructured business processes?* The answer of this research question is provided in Section 2.1. Structured and unstructured business processes are mapped on the business process structuredness spectrum. Structured business processes are defined as: "the ordered sequence of activities that

can be predicted and planned, completely, even before the execution of process." These processes are application-centric, which are automated and are usually repeatable in nature. While, the unstructured business processes are "hard to predict, plan and defined at design-time". These processes are context dependent that means the available process data, tacit knowledge of knowledge workers, and other context variables such as real life events define the activities and their execution order during process run-time.

Thus, it is concluded that the main difference between structured and unstructured processes lies in their definition of a process model at design-time and their execution of process at run-time. Structured process defines the process in procedural detail while unstructured process is defined declaratively to provide the run-time flexibility. Detailed discussion on characteristics of structured and unstructured processes is provided in Section 5.1.

**RQ2:** *What are the differences between BPM and CM in dealing with unstructured business processes?*

In Chapter 2, BPM and CM are discussed on theoretical bases. To understand the paradigm difference in managing an unstructured business process, a comparative experiment is conducted. For the experiment, Bizagi and Cognoscenti, as a software tool, are used for BPM and CM respectively. Both paradigms are compared based on a number of different process management aspects such as process modelling, data management, business rules specification, role specification, process view, process control, setup effort, and activities execution.

It is concluded that both BPM and CM have their own strengths and weaknesses in managing the unstructured business processes. BPM automates the business process and ensure the conformance to business rules and standards. However, it limits the run-time flexibility of a process. On the other end, CM provides the open-ended process collaboration platform for knowledge workers. However, such flexibility leads to delayed process execution or even cause deadlocks sometimes. The detailed description of the experiment setup and results are provided in Chapter 3.

**RQ3:** *What are the capabilities of existing modelling notations to deal with unstructured business processes?*

The unstructured process requires an optimum level of granularity on its process model. Two popular process modelling languages, BPMN and CMMN, are assessed to gauge

their capability for modelling an unstructured business process. A sample unstructured process is modelled with both notations. The sample process models and comparison of modelling constructs shows that both modelling notations are not fully capable of representing an unstructured business process. BPMN process model defines the complete process at design-time thus limiting the process run-time flexibility while the CMMN process model is difficult to read due to its complex modelling constructs.

**RQ4:** *How to model an unstructured business process while providing run-time flexibility?*

To model the unstructured process flexibily, the representational requirements of unstructured processes are proposed in Chapter 5. A process model that fulfils these representational requirements of unstructured process able to present a model that provide the process details on design-time without limiting its run-time execution flexibility. BPMN Plus is proposed in Chapter 6, which is an extension of BPMN. BPMN Plus provides the new modelling concepts along with their corresponding constructs. The modelling constructs of BPMN Plus are demonstrated with the help of an example scenario.

The extension of BPMN is validated by conducting interviews with experienced practitioners of BiZZdesign. The interviews provided interesting insights about the BPMN Plus. BPMN Plus modelling construct is found to be easy to use and communicate, as compared to the CMMN. Interviewees find some proposed modelling constructs as a much needed extension to BPMN. Detail description of interview session is provided in Chapter 7.

## 8.2 Contributions

This section describes the theoretical and practical contribution of this research to the field of business process management.

### 8.2.1 Theoretical Contributions

This research study provides a number of contributions to the process management literature.

1. *Comparative Experiment:* The first contribution lies in discussing the BPM and CM theoretical background. The theoretical discussion provides the understanding of BPM and CM software architectures. Chapter 2 of this document is dedicated to introduce the BPM and CM. The understanding of software architectures of BPM and CM leads to conduct a comparative experiment. The experiment yields a number of interesting results, which includes the BPM ability to define and conform to business standards as well as the CM capability to provide the open-platform for collaboration among knowledge workers. The experiment setup and results are presented in Chapter 3.

2. *Assessment of BPMN and CMMN:* Second theoretical contribution lies in our investigation of BPMN and CMMN for modelling of unstructured business processes. A number of limitations of BPMN and CMMN are identified for modelling an unstructured business process in a flexible manner (cf. Chapter 4).

3. *Proposed Artefacts:* Most important theoretical contribution of this research lies in its proposed artefacts. Modelling limitations of BPMN and CMMN led to propose the list of requirements to represent the unstructured business processes. To model an unstructured business process flexibly, an extension of BPMN, named BPMN Plus is proposed. The demonstration of BPMN Plus with the help of examples shows that BPMN Plus represents run-time flexibility on process model as well as it is able to depict the structured part of the business process. Chapter 5 and 6 provide the detailed explanation of the proposed requirements for unstructured business processes and an extension to BPMN Plus.

### 8.2.2 Practical Contributions

The practical contributions of this research are enlisted below.

1. *Comparison of Modelling Constructs:* This research provides a comparison of BPMN and CMMN based on their modelling constructs. The comparison provides a table of similar concepts with relatively different notations provided by BPMN and CMMN standard. Such comparison provides useful insights in the development of software tool that is intended to conform to the standards of both modelling languages.

2. *Base for Software Tool Support:* The list of requirements as well as an extension to BPMN standard is proposed to model the unstructured business processes flexibly. The requirements list and class diagrams of BPMN Plus along with its associated modelling constructs can be used to develop the modeller for BPMN Plus. Moreover, the list of requirements can be used to propose the new modelling language and to develop a complete software suite for modelling and managing the unstructured business processes.

## 8.3 Limitations

The limitations of this research are enlisted below.

1. The scope of this thesis is limited to two process support paradigms. The reason of such limitation is time constraint. BPM and CM, as process support paradigms, are selected for assessing unstructured business processes. BPM is chosen since it is one of widely adopted process support paradigm [27]. While, CM is considered due to the fact that it is one of emerging process support paradigms for unstructured business processes [5].

2. The literature on business process modelling languages is very rich. However, the scope of this study is only limited to BPMN and CMMN. The selection of these two modelling notation is made considering the research focus of the BiZZdesign, where this research study is conducted. Apart from it, BPMN is market de-facto standard for modelling business process while the CMMN is new modelling notation, which promises the modelling of unstructured process without limiting its run-time flexibility. Moreover, both modelling notations are proposed and managed by OMG and targeted to model the business processes that are easy to read and communicate for business people.

3. For the demonstration purpose, the proposed artefacts are implemented with the help of application example of an unstructured business process. Two different examples of unstructured business processes (i.e. Insurance claim process and Admission process) is used to demonstrate the capabilities of modelling notation as well as to show the characteristics of proposed artefact. Such demonstration fulfils

the criteria of internal validity, however, the external validity and generalisability of proposed artefact is still questionable.

## 8.4 Recommendations for Future Research

The limitations discussed in Section 8.3 leads us to indicate a number of interesting future research directions, which are given below.

1. Considering the feedback provided by interviewees, number of recommendations are provided in Section 7.3 to improve the BPMN Plus. These recommendation include the modification in BPMN Plus provided concepts and notations, propose set of guidelines to assist about BPMN Plus usage and introducing the BPMN Plus as a modelling level.

2. We recommend considering other modelling approaches such as ActivityFlow, YAWL to broaden the scope of this research [70]. This extended comparison could provide more insights and could enable us to improve the artefact proposed in this research.

3. The CMMN is relatively new modelling notation, proposed in January 2014. It is believed that the new versions of CMMN specification will either provide new concepts or modify the exiting concepts. Such updated version of CMMN will also lead to re-evaluation of the proposed artefact.

4. The proposed artefact can be evaluated by conducting an experiment with a considerable number of subjects. Such experiment will first require the development of software modeller that is capable of modelling BPMN Plus notations. The use of BPMN Plus with number of subjects will provide the insights into its usefulness and expressibility.

5. The interaction and communication among knowledge workers is one of the most fundamental aspect of unstructured business processes. The choreography of BPMN shows the interactions among process and roles. However, it is rarely used in practise due to its perceived complexity. A literature overview of business related modelling shows the need to propose a modelling pattern(s) that is able to capture the interactions among knowledge workers sufficiently.

# Appendix A

# Business Process Implementation

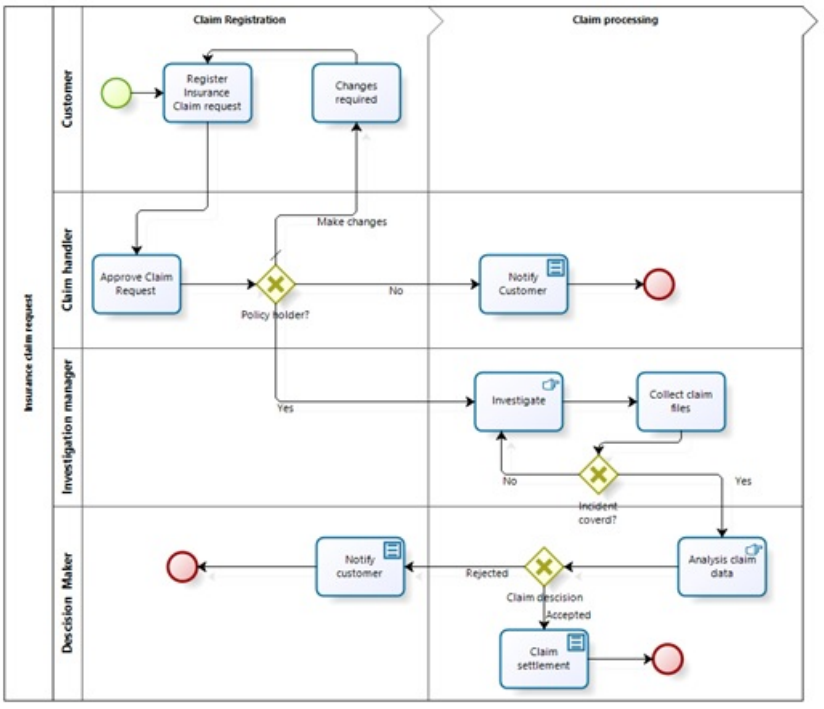



FIGURE A.1: Process Model

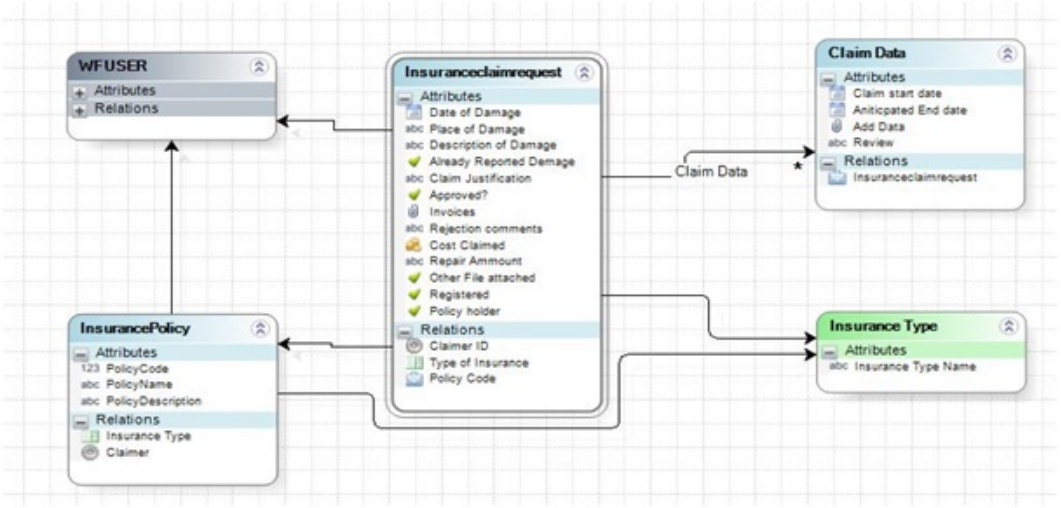



FIGURE A.2: Data Modelling

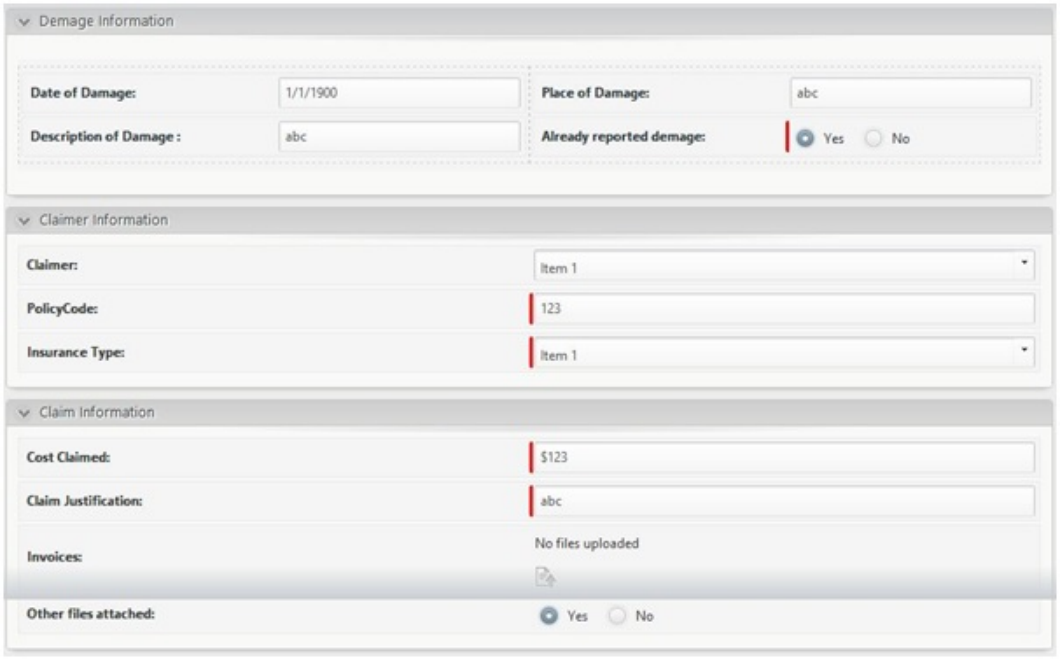



FIGURE A.3: Register insurance claim request form

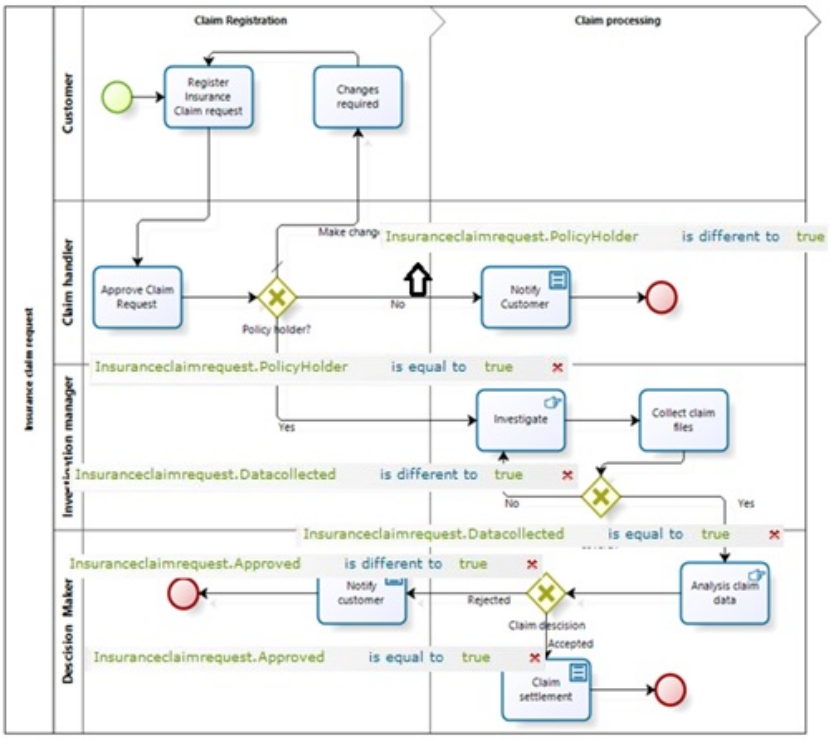



FIGURE A.4: Business Rules

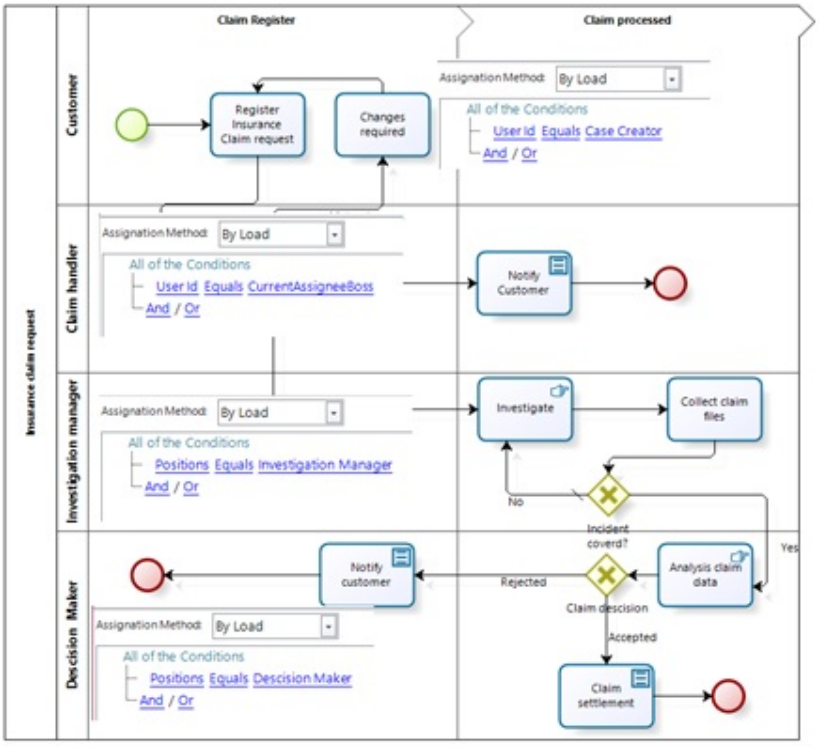



FIGURE A.5: User Roles

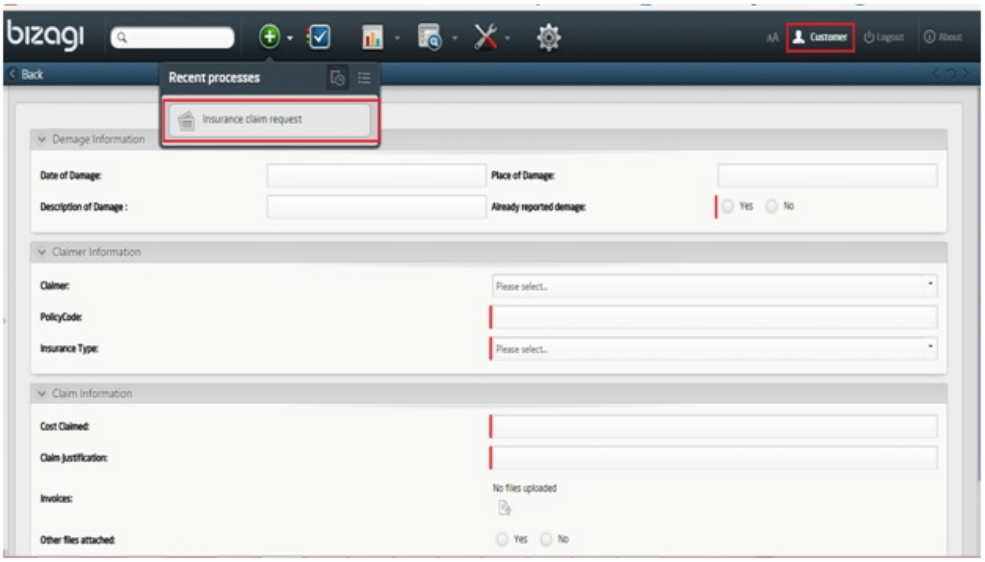



FIGURE A.6: Work Portal view from Customer profile

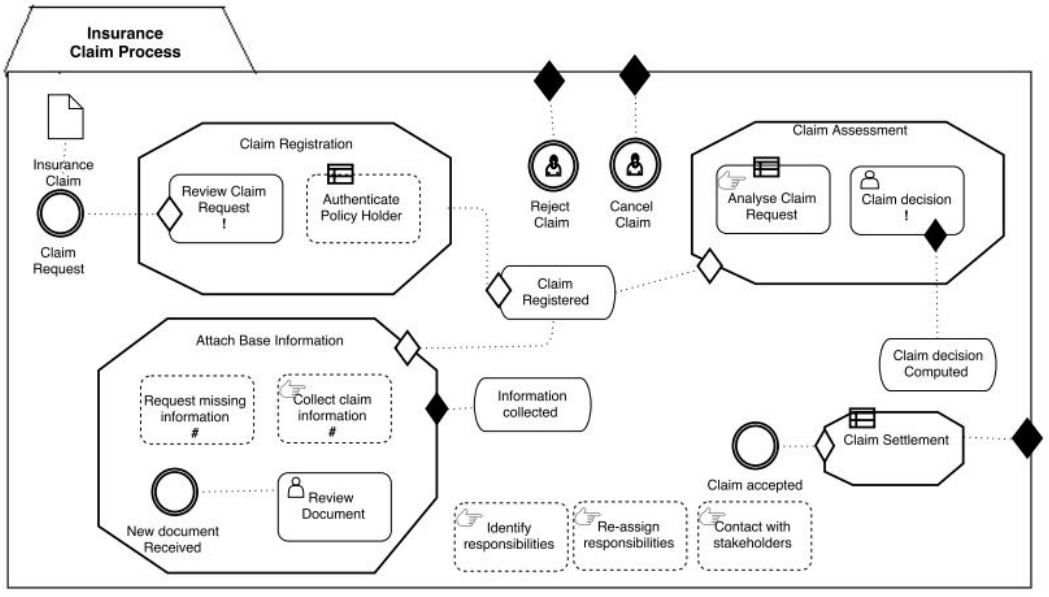



FIGURE A.7: Case model

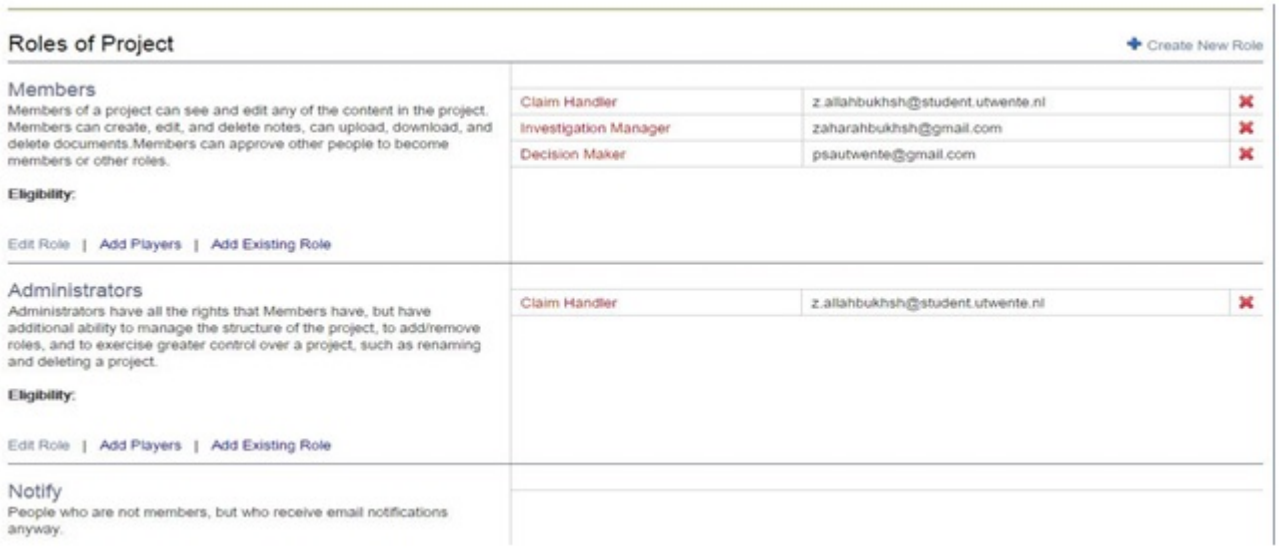



FIGURE A.8: User profiles

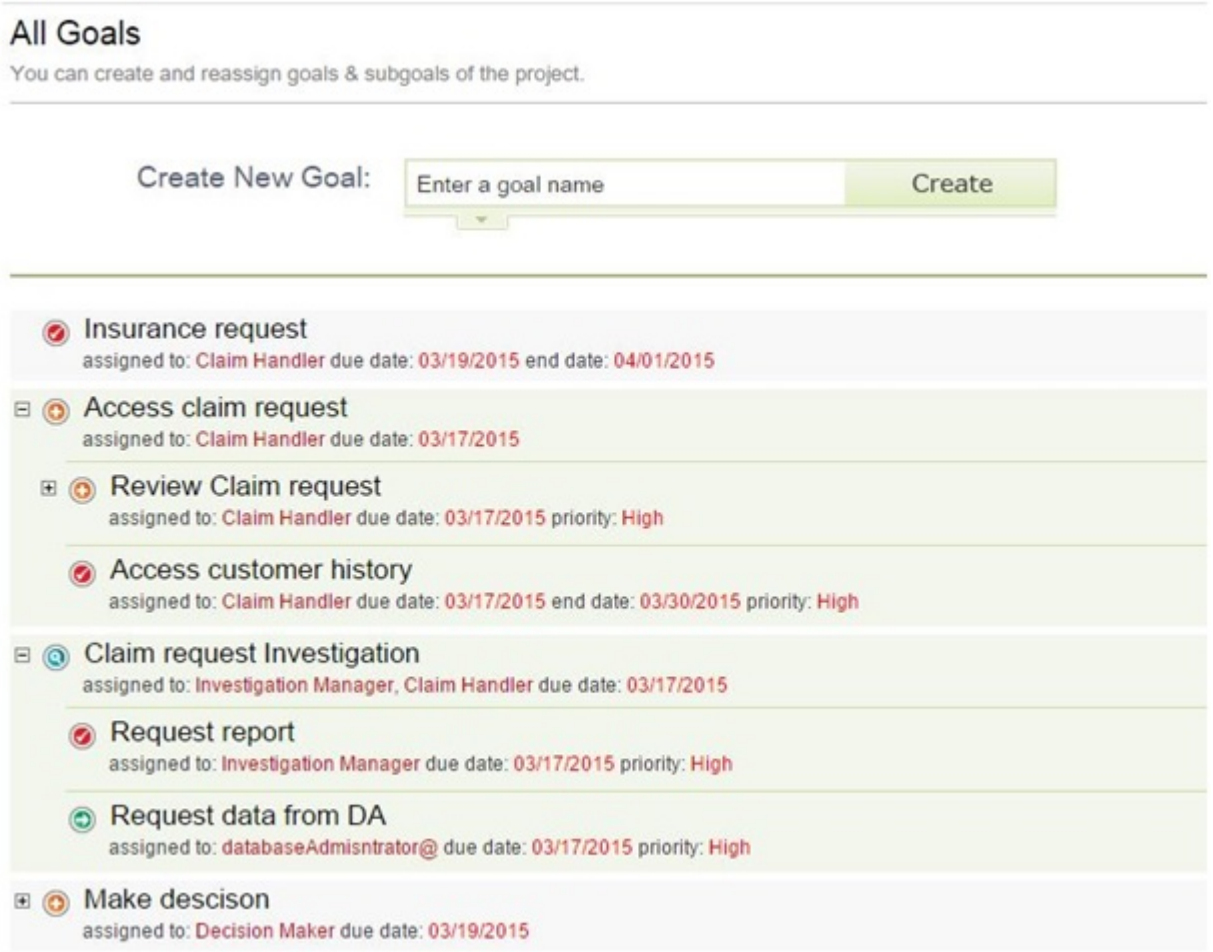



FIGURE A.9: Task Assignment


FIGURE A.10: Document Management

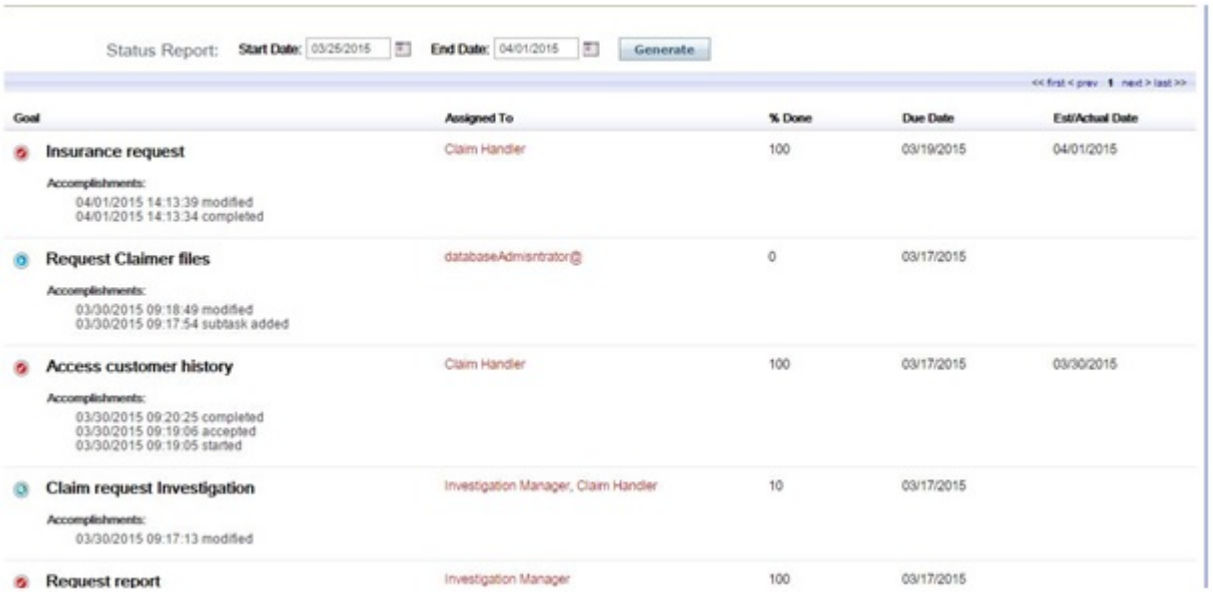



FIGURE A.11: Case Overview

# Appendix B

# Interviews Transcripts

The following tables are transcribes of recorded interview sessions conducted with three experienced practitioners. The interviews session were conducted as part of validation phase of research cycle. Chapter 7 provide the comprehensive view of interview setting and validation results.

| **Interview 1** | |
|---|---|
| **Interviewee Role** | Business Consultant on BPM and Lean Management |
| **Interview Date** | 6th July 14:00-15:00 at Amersfoort |
| **What is your understanding of unstructured process? Do you think companies are more focused on modelling and management of unstructured process now than ever before?** | |
| I think the unstructured processes are not that important at the time because there are many laws and rules which make the process structured and I think many companies do want their process modelled. They start with zero and the first thing they do are structured process modeling, the easy processes, and lot of companies don't reach unstructured. They leave the last 20% ad-hoc. Its too difficult to model it, so I think that's the future. They only model 80% that is structured and leave the other 20 %. I think in the future when companies mature on first 80% they do the next level but they are not mature right now.<br>In about 5 to 8 years the unstructured process in government and banking will be the future but not right now. It is too difficult to start with unstructured process. There is first need of maturity for structured processes that could be achieved through business process management lifecycle and then there could be unstructured process. | |
| **Based on your experience, do you find it difficult to model the unstructured process (parts) with BPMN?** | |

| |
|---|
| It wasn't difficult. The details were on paper not on the model. So, I can easily model unstructured process but on the higher level and the differences and all the possibilities were on paper. But, yes it is difficult to model the complete unstructured process. It gets too complex, too big, unreadable. So, when you really want a complete unstructured process, it is very difficult. Moreover, the extended constructs of BPMN are understandable by me. But sometimes the employees who need to understand the process model, they don't get these symbols. So, I have to do, first of all, two days language course of process thinking and BPMN and then it was possible but then it become really expensive process. |
| **From practical perspective, do you think the representational requirements of unstructured process are significant? Do you suggest any modification?** |
| The representational requirements are too much to start. May be theoretically, it is an ideal scenario but when you want to sell it to company. You first have to let them understand that it is necessary to structure your unstructured process and then if the companies need to consider these entire requirements they will run away. These are good but like in three phases. You can propose level of maturity. |
| **Do you think the BPMN Plus provide useful concept and constructs to model the unstructured process? What could have been included/ omitted?** |
| I would love to see the *business rules* officially on it. We already use it but not with some official symbol. The *collaborative sub-process*, I never used it I never missed it but when it is there may be I am gonna use it. *Decision task* is interesting but we have got decision modelor when it is about decision I need other tool, other language. Do I need decision task it in BPMN , NO. but is it interesting YES. We have talked about *performer* and *role*. I think every role should be performer so I think you can skip role. Role isn't lane and you can add-on a performer. Sometimes, two different performers do one task and in which lane do you put it. It is difficult, then you can put it in lane who is responsible and then add another performer in another lane. I think that is interesting. *Re-execute activity* is interesting. We talked about *optional activity*. It would be great to model but I think but with the right gateways you don't need it. I would also prefer another symbol but I don't know which symbol. That symbol isn't optional activity for me. The *undo activity* is not very interesting to me. Because when you undo an activity it should be a new task. It is always just a normal task it doesn't matter if it is undo activity. |

| |
|---|
| May be undo activity is an optional activity and in one case you add a new information and then you are further in the process and then you have to undo the information then that is the optional new task. I would use the optional activity instead of undo activity. A suggestion, for required activity and optional activity I will not use different task or symbols. I would use colors. Colors on the normal task. For instance, in BiZZdesign Architect the normal task is blue the optional activity is always yellow and required activity is always purple. I think colors views are always interesting for performers and for the customers who read it. I think we should work more on colors and less symbols. I think *goal* is interesting but I don't see the difference between goal and intermediate event. I would use a intermediate event and goal ad-on. But it is very interesting to see the goals in a process. Final remarks about colors and symbols as combination to one construct or only color. Suggestion to standardize the colors for process model. BiZZdesign just made up these colors but it will be interesting if in every modelor we have defined the standard colors to show start and end events. |
| **Do you think the BPMN Plus model is easy to understand and communicate? Compare to CMMN model?** |
| Compare the CMMN, for me it is easy to read. But that's because I am used to BPMN symbol. So it is not fair to say that CMMN is not readable. I never saw the symbols of CMMN. That is not a fair question for me to answer. BPMN Plus model is better than the other. It is not expressible for the people for whom the process is made . I think both are too difficult for average employee. |
| **Does the extended concepts of BPMN Plus fits well with the existing BPMN concept? Do you see any similar and/or conflicting concepts?** |
| Yes. For the decision, execute, optional, undo and required you used square with round angles. May be that's too much, you got the so many types of tasks. May be, some other thing. For example, re-execute activity make the whole symbol as round and the undo activity why it is not triangle. Symbols are most expressive of their own. There is not conflicting concept only about the intermediate event and goal and also about the role and performer. There is conflict with undo and optional, I think every undo activity is optional activity. There is conflict with in BPMN Plus. |
| **Do you think it is feasible to provide the modeller support for BPMN Plus? Can you foresee any problems? Conflicts with BPMN semantics?** |
| Once the OMG thinks these are rich notations then technology can implement everything. |

| **Interview 2** | |
|---|---|
| **Interviewee Role** | Business Consultant on BPM |
| **Interview Date** | 7th July 14:00-15:00 at Enschede |
| **What is your understanding of unstructured process? Do you think companies are more focused on modelling and management of unstructured process now than ever before?** | |
| Yes, especially for knowledge work. Because of digital transformation of last years/decades. It worked like can the structured be automated and the hard part is how to look and analyse the knowledge work. When you have to make decisions depending on the context. I think in that unstructured process is having a lot of attention these days. | |
| **Based on your experience, do you find it difficult to model the unstructured process (parts) with BPMN?** | |
| Yes, Although we mainly use BPMN for structured process and our clients have usually structured process. Although, I think BPMN is very strong in its exceptional handling I see exception handling as kind of unstructured event to happen, depending on which flow to follow. But overall, it is hard to model unstructured process with BPMN. Sometimes I don't model the unstructured process at all or I remark or leave out the details of information instead of using the blocks of BPMN. The more detail you add to the process then it every single activity can be unstructured. So, I think there are ways to look at the level of detail where you can communicate the essence of your process while not leaving the relevant details away. At the same time, that is also interesting would you want to model unstructured business process. From execution perspective, it is really good to model unstructured processes but I think the disadvantage of BPMN is where you can make things very complex. Specially, for exception handling, a lot of our customer and their customers i.e. business people don't understand BPMN at all. Then I am sometime wondering should you want to express it in that detail. It will make it really complex and I understand boundary events but the people I provide training to work with they don't. | |
| **From practical perspective, do you think the representational requirements of unstructured process are significant? Do you suggest any modification?** | |
| There is difference in concept and its modeling notation. For example from conceptual point of view, if the activity is not optional then it is required we can make such distinction. But for the modeling the one symbol to represent one type of task would be enough while the other could be considered as default. From gartner research, there is Intelligent business operation, where you have collection of cases. Instead of considering what type of information is needed to make the decision we can consider | |

| |
|---|
| the history of cases depending on the context of case. The case has certain attributes and depending on the attributes 80 % of people who are holding the case with these attributes. They make the decision like say not provide money to claim. I think this requirement looks good. It is overwhelming. |
| **Do you think the BPMN Plus provide useful concept and constructs to model the unstructured process? What could have been included/ omitted?** |
| I think the optional and required activity is really powerful. For business rule, as a data object, I am not sure for that one because you still need to find a way on how you can name your business rules. If you have a lot of business rules then it is just a number and the number is not expressing anything. The business rules languages are not very familiar to me. I am not sure how it has more value than business rule task although you can give the name and meaning to business rule and can see the useful business rules on process model. The collaborative sub-process seems interesting but you should be more explicit that there is not ordering and dependability on activities defined in other sub-process. Re-execute activity is similar as BPMN. The goal is good. I think it is really good. But I would say a goal shouldn't belong to single activity. In such cases, you will have a lot of goals on your process model. Moreover, a goal should be able to belong to multiple sub-process or you can define that a goal can have only one associated sub-process. To model the goal would be nice thing for structured processes also. It is better to now to include the performer since, it is not really used. For role, I am thinking how I will define if an activity is performed by multiple roles with in a sub-process. It is also a problem with BPMN as if an activity is performed by multiple roles then from which lane it should belong. But it can be done with resource role without any visualization. Undo task is more belong to ICT perspective. I am not sure how will I use it. Because if you can that we have an activity that I can do again and again as a re-execute activity then I can say if something is changed I will do it again to change it. We usually use the compensation event for such task, but I would say it is very complex to use with cancel and send tasks. The Undo is interesting in that sense but I am still looking how can I use it. |
| **Do you think the BPMN Plus model is easy to understand and communicate? Compare to CMMN model?** |
| From the understanding perspective, I would say BPMN Plus model is easy to understand than CMMN. But, it can also be because I usually work with BPMN and it is very similar to me as compare to CMMN. The sequential flow in BPMN Plus is very intuitive as compare to the sentry and connector of CMMNs. CMMN is rarely used today as compared to BPMN. |

| **Does the extended concepts of BPMN Plus fits well with the existing BPMN concept? Do you see any similar and/or conflicting concepts?** |
| --- |
| I think we can model unstructured process with BPMN as you have mentioned. There are compensation events and ad-hoc process that provide very strong contructs for process exception handling. But, I cannot say these concepts are conflicting. They are different ways to model the process. Also consider the required task and optional task, if we define task with sequential flow we automatically regard it as required. So the required task distinction only exists when we are considering unordered process modelling. The concept to show the data authorization concept with data assess level is powerful concept although I think something similar also exist in BPMN. So, it is interesting to see how it is conflicted with BPMN. But I am not sure. This visualization of BPMN Plus is more powerful than the technical chapter of BPMN. |
| **Do you think it is feasible to provide the modeller support for BPMN Plus? Can you foresee any problems? Conflicts with BPMN semantics?** |
| From technical perspective of BPMN, I can't say if there are any conflicts as there are a lot of information regarding technology. BiZZdesign is not really focused in process execution as you showed Bizagi is we are more focused for process model and business overall understanding. From the point of providing the modeller support, I don't see any notations that cannot be implemented with BPMN. |

| **Interview 3** | |
|---|---|
| **Interviewee Role** | Business Consultant |
| **Interview Date** | 7th July 14:00-15:00 at Enschede |

**What is your understanding of unstructured process? Do you think companies are more focused on modelling and management of unstructured process now than ever before?**

Well, I think yes more than ever before not too much. I do get some questions about modeling the unstructured processes but what we see is a lot of people tend to, although in run-time process might be unstructured, but they still model it in structured way. And they don't mind they just say that I modelled it in structured way because this is actually how it should go and if sometimes its goes different then I don't think that it is big problem. Process modeling and designing is not done to put into a process engine as bizagi or other tool . Most companies just make the process models for communicating about the process and documenting the process, make transparent business processes for like sometimes legislations ask you to model these. Of course , I can understand if you are starting to model this and want to use this in some kind of engine to actually make this executable then it becomes more necessary to explicitly states what is unstructured and what is structured and if you are using it for communicational purposes you could do make structured process model and then they will may be just using some graphical things. So one can say these can be carried out unstructured or something like that. I think most of the time a lot of people just are not executing these models on process engines.

**Based on your experience, do you find it difficult to model the unstructured process (parts) with BPMN?**

No, I could use the ad-hoc process. Most of the time the extended BPMN constructs are sufficient enough. Because for example, there are different ways to model things if you look at the goal concept you defined . A way to do this in BPMN is to define is non-defined intermediate event that's is not exactly the same as goal you modelled but it comes very very close. So, then shall we introduce another concept if you could already use commonly known concept i.e. non define intermediate event. So, therefore, I think we can do quite well with BPMN while modeling process. What I do like is optional part , this collaborative process that's very hard to model in BPMN. These would be very welcome extensions of BPMN language.

**From practical perspective, do you think the representational requirements of unstructured process are significant? Do you suggest any modification?**

The things stated that these should be the requirements of unstructured process because it's a unstructured process but with some structured in it as well.

| |
|---|
| I think the things you stated here are requirements are ok and I think you should also try to apply it to some real cases study and some real processes and then see how the process model change if you apply all your suggestions to process model. What you did is you also chooses BPMN but you didn't took the whole BPMN, you left out some of BPMN extended elements and I think that some of these elements are really needed to make a good process model. For example, you left out the event based gateway and I think It one of the most powerful concepts from BPMN which helps you to define e.g. what to do in such situations if you sent something to customer and he have to react in two weeks and if he is not reacting with in two weeks then what you should do then. I don't know any other language which has power to express it. I think you should have a look on BPMN concepts that you left out and why not just adding your own. You can still use the whole BPMN set like we have now with three different level like descriptive level, analytical level and executional level. BPMN has these three levels. But then customer could still choose to say that I am just using BPMN plus but only on the from the BPMN part just only a subset. So, I will not let beforehand to leave out part of BPMN. But regarding the requirements they are ok. |
| **Do you think the BPMN Plus provide useful concept and constructs to model the unstructured process? What could have been included/ omitted?** |
| We have discussed the business rules task as the process has a lot of rules which can make the process model overcrowded. I really like the collaborative sub-process. Optional tasks are a nice concept but the notation needs to be more expressive. May be using the dotted line. Re-execute is already a BPMN concept. Required activity is really needed. For goal, take a look at the non-defined intermediate event. For performer and role. Making it explicit concept in BPMN but in BPMN we already use resource role concept.You can already relate it to sub-parts to subprocess and activities or to specific lanes if you want. Role and performer are not new concepts. You just provide the visualization. I am not sure if it is helps in readability on process convex. But with lanes you can assign a role to lane and then it implies that resource role is responsible in performing the activities stated in the lane. However it is not how it defined in BPMN specification. The process model can also be modelled without lanes then we assign resource role to activities and sub-process. In BiZZdesign architect the resource role can be defined with color views. The decision task is more or like an extension of another task type. In BPMN, we have already many tasks. The decision task can be combination to other tasks e.g. human task, service task, etc. Decision task is then very useful task. |

| **Do you think the BPMN Plus model is easy to understand and communicate? Compare to CMMN model?** |
| --- |
| Compare to CMMN, it is way easier to read. There is still a flow going on and people are always looking for and they need to know where to start reading the model. There is one of problem for CMMN that you really need to have some background in the language to understand as CMMN model and while if you look to common BPMN you don't really need firm background BPMN to understand the BPMN process model. So, ofcourse I think BPMN Plus process model little hard to understand then BPMN process model but it is easier to read than CMMN process model. |
| **Does the extended concepts of BPMN Plus fits well with the existing BPMN concept? Do you see any similar and/or conflicting concepts?** |
| Yeah, We discussed compensation and undo activity can be similar. The goal and intermediate event also look bit similar. Intermediate event can be alternative but not exactly similar. Not only extend the language may be write a method telling people on how you to use or misuse the concepts of BPMN or BPMN Plus to show something on process model. Just methodology saying how to use current concept to model it. But I don't see any concept to be conflicting. |
| **Do you think it is feasible to provide the modeller support for BPMN Plus? Can you foresee any problems? Conflicts with BPMN semantics?** |
| From just point of view making this part of modeller I don't think there is going to be hard to actually implement it. The problem is BPMN has this exchange format. It could be hard to fit it in Exchange formats, as long as it is sub-class of existing BPMN concept the problem won't be that big. But if you really add a new concept which is not a sub-class of existing BPMN concept then I think in exchange format nobody else actually importing them these file can do with these newly introduce concepts. So, I can foresee some problem over there. I think we have also implemented some control that check if all the lines and sequence flows are in place I think then we probably want to say that it is not ordinary BPMN process model then it should check different things as compare to simple process model. I don't see any conflict with BPMN semantics since BPMN is already there we just make an extension to it. |

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