



How to Model and Transform Executable BPMN Process Models

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Declaration of Authorship

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I hereby declare that I have written this Doctoral Thesis independently, that I have completely specified the utilized sources and resources and that I have definitely marked all parts of the work - including tables, maps and figures - which belong to other works or to the internet, literally or extracted, by referencing the source as borrowed.

Vienna, 1st January, 2022

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Abstract

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Contents

Abstract	vii
Contents	ix
1 Introduction	1
2 Automating Business Processes	3
2.1 Why automate Processes?	3
2.2 Executable vs Conceptual Process Models	4
2.3 Making Process Models executable	4
3 Evaluating and Optimizing Executable Process Models	11
3.1 Six Sigma Approaches	11
3.2 Other Qualitative Measures	13
3.3 Quantitative Analysis	13
3.4 Benchmarking Processes	13
4 Concept and Implementation	15
4.1 Architecture	15
4.2 Technologies	15
4.3 Interface	15
4.4 Selected Algorithms	15
4.5 BPMN Processing	15
5 Case Study	17
6 Conclusion	19
List of Figures	21
List of Tables	23
Listings	23
List of Algorithms	23
	ix

Glossary	25
Acronyms	27
Bibliography	29

CHAPTER 1



Introduction

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Automating Business Processes

The following chapter will provide an overview of the current research on executable Business Process Model and Notation (BPMN) models. First it will discuss the motivation behind process automation and using BPMN Workflow Management Systems and the benefit it might bring to an organization. Then it will state the differences between an conceptual BPMN model, that cannot be deployed on an Business Process Workflow Management System, and an executable BPMN model. Finally this chapter will list the steps necessary to turn an conceptual BPMN model executable.

2.1 Why automate Processes?

While process automation seems to be in itself a pursued goal, there are some quantifiable advantages of using a Business Process Management System Business Process Management System (BPMS) besides the possibility to automate certain process steps.

- **Shorten process lifetimes:** Managing processes manually requires handling tasks such as starting sub processes or handling handovers from one entity to another manually and can lead to unnecessary waiting periods between two operation tasks in the process. By implementing an Workflow Management System resource allocation and parallelization can be automated where possible to assure optimal use of process resources. [4]
- **Reduction in process cost:** By reducing process lifetimes and increase productivity due to better handling resources can reduce process costs [4] but due to the high price for Business Process Workflow Management Systems the overall cost does not have to decrease necessarily [5].
- **Workload reduction:** As stated earlier, managing processes needs to be done either by an Business Process Workflow Management System or manually which

creates additional workload for an organization. Workloads for employees executing the processes are also kept steady due to dynamic resource assignment. [2][4]

- **Enforce rules:** Defining the processes that is then directly executed and controlled by an Business Process Workflow Management System enables the organization to enforce the execution of the process at it is designed. Following Rules and Protocols can partially be automated and enforcing guidelines and laws in an organization becomes easier. [2]
- **Create Transparency:** Using an Business Process Workflow Management System provides insights to the actually processes that are executed in the organization. It makes it easier to determine the performance of the processes by providing historical information of completed process instances and provides insight of the current status of processes that are still in progress. [4]

2.2 Executable vs Conceptual Process Models

Process Models are inherently Business-oriented as their purpose is initially to define and visualize the processes happening in an organization. Business-oriented or conceptual BPMN model are meant to be read by domain experts and contain usually implicit information known to these domain experts [2]. They are usually incomplete, meaning that not every possible outcome of a process is modeled. In fact, usually only the best-case scenario, also known as the 'happy-path', of a process is modeled in an conceptual BPMN model [3].

Because of this, business-oriented models cannot be executed in an Business Process Workflow Management System as they are but have to be turned into an executable BPMN model. executable BPMN model are meant for IT-experts and should be a technical representation of the business process while still begin understandable by domain experts. They should leave no room for interpretation as they have to contain all the information necessary for the process to be executed using an Business Process Workflow Management System. Besides the visual information, executable BPMN model also need to contain execution properties like interface definitions and Variables that are used by the Process called Process Variables.[2]

An algorithm on how to efficiently turn an conceptual BPMN model executable as stated in the book *Fundamentals of Business Process Management* [2] is described in the next section.

2.3 Making Process Models executable

As stated earlier, BPMN models can not directly be executed by a BPMS but have to be converted from an conceptual BPMN model into an executable BPMN model.

There are different approaches how an executable BPMN model can be derived from a business-oriented conceptual BPMN model. In [2] performing such a transformation is broken down into 5 steps:

1. Identify the automation boundaries
2. Review manual tasks
3. Complete the process model
4. Bring the process model to an adequate granularity level
5. Specify execution properties

2.3.1 Identify the automation boundaries

The first step in turning an conceptual BPMN model in an executable BPMN model is to identify which steps can be automated using a Business Process Workflow Management System.

Tasks which can inherently be automated are called Automated tasks [2, p. 317]. Taking a look at the BPMN 2.0 standard an Automated task can be one of the following Task types:

- **Service Task:** A Task that invokes a service. Can be a Webservice or a application code.
- **Send Task:** Used to send a message to an external participant (A participant that is not part of the process)
- **Receive Task:** Used to receive a message from an external participant
- **Script Task:** Executes a Script that can be interpreted by the BPMN Workflow Management System
- **Business Rule Task:** Executes a rule. (e.g. provides input for a business rule engine and gets the output of that calculation)



(a) Service Task (b) Send Task (c) Receive Task (d) Script Task (e) Business Rule Task

Figure 2.1: Automated Tasks according to the BPMN 2.0 standard [6]

Usually not every step of a Process can be fully automated. Processes can also have **Manual Tasks** and **User Tasks**. A **User Task** is a Task performed by a User with the aid of an Business Process Workflow Management System while a **Manual Task** does not use any help from a business process execution engine.

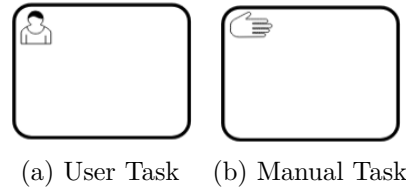


Figure 2.2: Manual and User Tasks according to the BPMN 2.0 standard [6]

2.3.2 Review manual tasks

As mentioned earlier Manual Tasks are not automated and do also happen without the aid of a Business Process Workflow Management System. In this step we need to analyse if the identified manual tasks in our BPMN-model can be incorporated into the Business Process Workflow Management System. This can be done in two ways:

- **Automate the task:** Depending on the nature of the task that is currently performed manually, it might be possible to fully automate the task or to model the task as a Receive Task where the modelled task waits for a message that indicates the physical manual tasks completion.
- **Turn it into a User task:** If the task cannot be automated or the organization lacks the resources to automate the task yet, it might be possible to turn the Manual Task into a User Task. One possibility could be to dedicate a person in charge of the manual task to notify the BPMN Workflow Management System on the completion of the task via a worklist handler. [8]

In the case that neither an Automated task nor an User Task is suitable for modelling the Manual Task one might also consider isolating the task and modelling the rest of the process. If this is also not possible due to the manual task being crucial for the expressiveness of the model it might be reconsidered if this process can or should be executed using a Business Process Workflow Management System[3, p. 228]

2.3.3 Complete the process model

Usually conceptual BPMN models are not complete and leave out certain informations that are seen as implicit knowledge or as not important by the person modelling the process but might be crucial if a complete picture of the process is needed for automation.

A common flaw in many conceptual models is ignoring errors and only implementing the 'happy path'. The 'happy-path' is the best-case scenario that can happen in the execution

of a process. While it might be sufficient for a conceptual BPMN model, showing the process for a customer order, to not show what happens in case the product is out of stock or what happens if the payment does not work, a executable BPMN model has to take into account what happens in case an error occurs.

It is also necessary to model the input and output data of our tasks in this step using Data Stores and Data Objects.

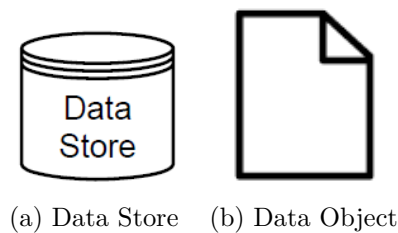


Figure 2.3: Data store and Data Objects according to the BPMN 2.0 standard [6]

2.3.4 Bring the process model to an adequate granularity level

The granularity of tasks modelled in an conceptual BPMN model does differ from the granularity needed in an executable BPMN model. The goal of process automation is not to automate as much as possible but to have a centralized BPMN Workflow Management System that does not only decide what task has to be done when but also who needs to be doing this task. [3]

Therefore consecutive tasks that are done by the same participant should be clustered together as one task to minimize handovers that have to be unnecessarily processed by the BPMN Workflow Management System. [2] However there are some exception to this rule:

- Tracking progress: In order to know how much the process has advanced it can be useful to split certain parts even if they are done by the same person.
- Handling exceptions: If for a set of tasks that it performed by the same participant different erros and exceptions can occur, it might be useful to keep these tasks separated.
- Managing Resources: Sometimes consecutive tasks are performed by participants that have the same role, but need to be done by two different participants. For example: two different people need to sign the same document in a process. In this case it is also necessary to disaggregate the task accordingly.

2.3.5 Specify execution properties

The final step in turning an conceptual BPMN model executable is to specify the details of the implementation details of our BPMN model. While the changes performed up to

this step had an impact of the graphical representation, the execution properties are not graphically embedded into BPMN but are encoded into the Extensible Markup Language XML (XML) representation of the BPMN-model. [2] A schematic representation of the structure if BPMN is provided in 2.4. For the full specification of the BPMN-XML the XML-schema can be found on the OMG-Website[1].

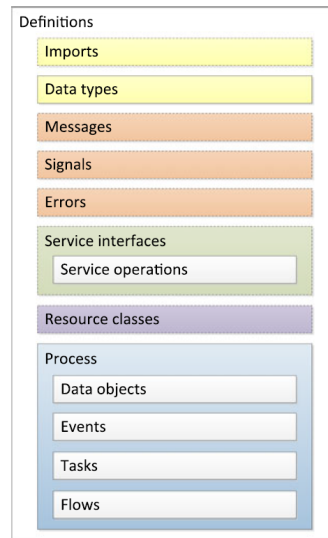


Figure 2.4: Structure of the BPMN format [2]

Process Variables

In order to use data in different elements of our process, we need process variables that can be read, created and modified during the processes execution. Every Process variable has a **data type** that can either be simple (strings, integers, doubles, booleans, dates, times, ...) or complex (composed of other types). A complex Type needs to be described as an XML Schema Definition XSD (XSD)-Schema File.

```

<xs:element name="person">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="name" type="xs:string"/>
      <xs:element name="address" type="xs:string"/>
      <xs:element name="city" type="xs:string"/>
      <xs:element name="country" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
  
```

Listing 2.1: The XML-Schema Definition for a complex type 'person'

```
<person>
  <name>Dragana Sunaric</name>
  <address>Wiedner-Hauptstrasse 5</address>
  <city>1040 Wien</city>
  <country>Austria</country>
</person>
```

Listing 2.2: An instance of the complex type 'person'

The definition of common Errors, Messages and Escalations that are thrown or listened to by Events and Tasks are also part of the execution properties. Every Element has at least an **id** that identifies the given Element and a descriptive **name** of the element. [6]

Messages

```
<message id="Message_ID" name="Message_NAME"/>
```

Errors

Errors additionally have an **errorCode** that specifies the given Error. Events can listen for this specific error code and trigger when it is thrown.

```
<error id="Error_ID" name="Error_NAME" errorCode="Error_CODE"/>
```

Escalations

Similar to errors, escalations additionally have an **escalationCode** that specifies the given Error and can be listened to by events.

```
<escalation id="Esc_ID" name="Esc_NAME" escalationCode="Esc_CODE"/>
```

Input and Output Variables

As mentioned earlier, Process Variables are active during the whole Process life-cycle. Apart from this data that can be accessed globally, it is also possible to define input and output values for each Task or Event in our process-model. These values are only visible within the Task or Event and have to be defined as an XSD-Schema File (similarly to complex process variables). [2]

Service Tasks

In order for service tasks to call external application or web-services, the interaction with the given service has to be defined in the process model. Connected services need to provide a service interface that describes the available service-operations and their

parameters as well as return values. Service-operations can be synchronous, meaning the process instance waits for the operation to finish and to return a value or error code, or asynchronous, meaning the process does not wait for a response and carries on with the process after calling the service. Based on the service interface definition, input and output variables have to be defined for the service-call. The Business Process Workflow Management System does this by copying the above mentioned Input values of the Task into the service call and if necessary, copy the output values of the service call into the output values of the Service task. [2]

CHAPTER 3

Evaluating and Optimizing Executable Process Models

3.1 Six Sigma Approaches

The first set of analysis and optimization techniques discussed in this chapter originate from the Six Sigma initiative. The name Six Sigma originates from the interval of 6σ in the normal distribution that indicates the aimed success rate of 99.99966% [7][10]. A representation of the statistical meaning can be seen in figure 3.1. Apart from the goal to decrease the error rate, 6σ is also a methodology for systematically improving process quality [9].

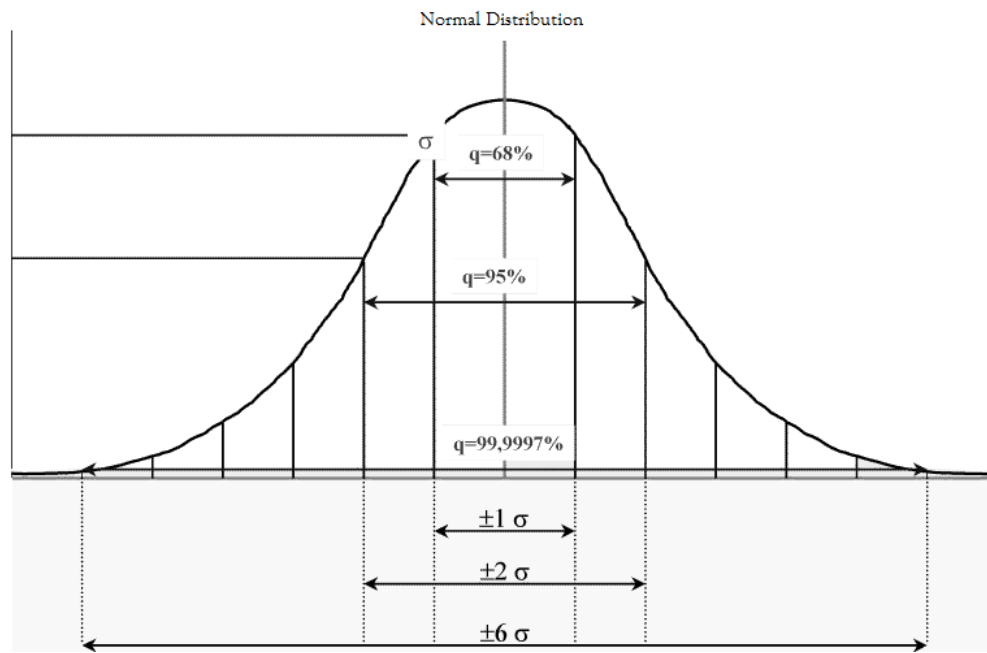


Figure 3.1: The standard normal distribution showing the 6σ interval (graphic from [10])

3.1.1 Process Map

3.1.2 Check Sheets

3.1.3 Pareto Analysis

3.1.4 Cause and Effect Diagram

3.1.5 Root Cause Analysis

3.1.6 Quality Function Deployment (QFD)

3.2 Other Qualitative Measures

3.2.1 Value Added Analysis (VAA)

3.3 Quantitative Analysis

3.3.1 Performance Measures

3.3.2 Flow Analysis

3.3.3 Queues

3.3.4 Simulation

3.4 Benchmarking Processes



Concept and Implementation

- 4.1 Architecture
- 4.2 Technologies
- 4.3 Interface
- 4.4 Selected Algorithms
- 4.5 BPMN Processing

CHAPTER 5



Case Study

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CHAPTER 6

Conclusion

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List of Figures

2.1	Automated Tasks according to the BPMN 2.0 standard [6]	5
2.2	Manual and User Tasks according to the BPMN 2.0 standard [6]	6
2.3	Data store and Data Objects according to the BPMN 2.0 standard [6] . .	7
2.4	Structure of the BPMN format [2]	8
3.1	The standard normal distribution showing the 6σ interval (graphic from [10])	12

List of Tables

Listings

2.1	The XML-Schema Definiton for a complex type 'person'	8
2.2	An instance of the complex type 'person'	9

Glossary

'happy-path' The best-case scenario in a process. 4, 6

Automated task A task that can be automated in a BPMN Workflow Management System. 5, 6

BPMN Workflow Management System A software for executing workflows specified as BPMN models. 3, 5–7, 23

Business Process Management System see BPMN Workflow Management System. 3, 25

Business Process Workflow Management System see BPMN Workflow Management System. 3–6, 10, 23

Business Rule Task “provides a mechanism for the Process to provide input to a Business Rules Engine and to get the output of calculations that the Business Rules Engine might provide”[p. 163][6] . 5

conceptual BPMN model A BPMN model describing a business process that cannot be directly executed on a Business Process Workflow Management System. 3–7

Data Object “Data Objects representing a Collection of Data”[p. 206][6] . 7

Data Store “A DataStore provides a mechanism for Activities to retrieve or update stored information that will persist beyond the scope of the Process”[p. 208][6] . 7

executable BPMN model A software for executing workflows specified as BPMN models. 3–5, 7

Manual Task “A Task that is expected to be performed without the aid of any business process execution engine”[p. 163][6] . 6

Process Variables Process variables are managed by the BPMS engine to allow data exchange between process elements. 4

Receive Task “designed to wait for a Message to arrive from an external Participant”[p. 161][6] . 5, 6

Script Task “executed by a business process engine. The modeler or implementer defines a script in a language that the engine can interpret”[p. 164][6] . 5

Send Task “designed to send a Message to an external Participant”[p. 159][6] . 5

Service Task “Task that uses some sort of service, which could be a Web service or an automated application”[6, p. 158] . 5

User Task “A typical “workflow” Task where a human performer performs the Task with the assistance of a software application”[p. 163][6] . 6

XML Extensible Markup Language - Defined by W3C[?] . 8, 21

XSD XML Schema Definition - Definition of the structure of a XML File[?] . 8, 9

Acronyms

BPMN Business Process Model and Notation. 3–8, 23

BPMS Business Process Management System Business Process Management System.
3, 4

XML Extensible Markup Language XML. 8

XSD XML Schema Definition XSD. 8

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