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An Analysis of the Business Process Model and Notation Support in Robotic Process Automation Tools

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ABSTRACT

Robotic Process Automation (RPA) has gained a lot of attention in the past few years due to the increasing demand for solutions to improve the efficiency of business processes in organizations. Through RPA organizations are capable of developing robots that allow the automation of a large variety of their business processes. Some of the most common activities automated by RPA comprehend monitoring events, performing verification against a defined set of criteria and extracting data from files. Automating these activities allows the humans that previously performed them to focus on work that delivers more value to the organization. However, despite of its crescent relevance, RPA is a relatively recent area and many of its concepts remain open for discussion. One of these aspects is the notation used for specifying the behavior of robots. Currently the notation is not standardized and the vendor of each RPA application uses the notation that best suits its needs. Despite allowing vendors to create solutions designed for their target audience, not having a standard leads to more challenges with communication, analysis, testing, writing and maintenance involving the notations. This study provides an analysis of the language adopted by some of the most important RPA tools in the market through an investigation of the adoption of Business Process Model and Notation (BPMN) as a standard for designing automated process in RPA.

Keywords: Business Process Management. BPM. Robotic Process Automation. RPA. Business Process Model and Notation. BPMN. RPA Tools Analysis.

Uma Análise do Suporte da Business Process Model and Notation em ferramentas de Automação Robótica de Processos

RESUMO

Automação Robótica de Processos (RPA) vem ganhando bastante atenção nos últimos anos devido à crescente demanda por soluções para melhorar a eficiência de processos de negócio dentro de organizações. Através de RPA organizações são capazes de desenvolver robôs que permitem a automação de uma grande variedade dos seus processos de negócio. Algumas das atividades automatizadas por RPA mais comuns compreendem monitoramento de eventos, execução de verificações com base em um conjunto de critérios e extração de dados de arquivos. Automatizar estas atividades permite que humanos que previamente as executavam possam focar em trabalho que agregue mais valor à organização. Contudo, a respeito da sua crescente relevância, RPA é uma área relativamente recente e vários dos seus conceitos ainda estão abertos a discussão. Um destes aspectos é a notação utilizada para especificar o comportamento dos robôs. Atualmente a notação não é padronizada e o fornecedor de cada aplicação de RPA utiliza a notação que melhor serve às suas necessidades. Apesar de permitir que fornecedores criem soluções desenhadas para o seu público-alvo, a inexistência de um padrão leva a mais desafios com comunicação, análise, teste, escrita e manutenção envolvendo as notações. Este estudo provem uma análise da linguagem utilizada por alguns dos fornecedores de ferramentas de RPA mais importantes do mercado através de uma investigação da adoção da Business Process Model and Notation (BPMN) como padrão para modelar processos automatizados em RPA.

Palavras-chave: Gerenciamento de Processos de Negócio. BPM. Automação Robótica de Processos. RPA. BPMN. Análise de Ferramentas de RPA.

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LIST OF ABBREVIATIONS AND ACRONYMS

BPM	Business Process Management
BPMI	Business Process Management Initiative
BPMN	Business Process Model and Notation
RPA	Robotic Process Automation
OMG	Object Management Group

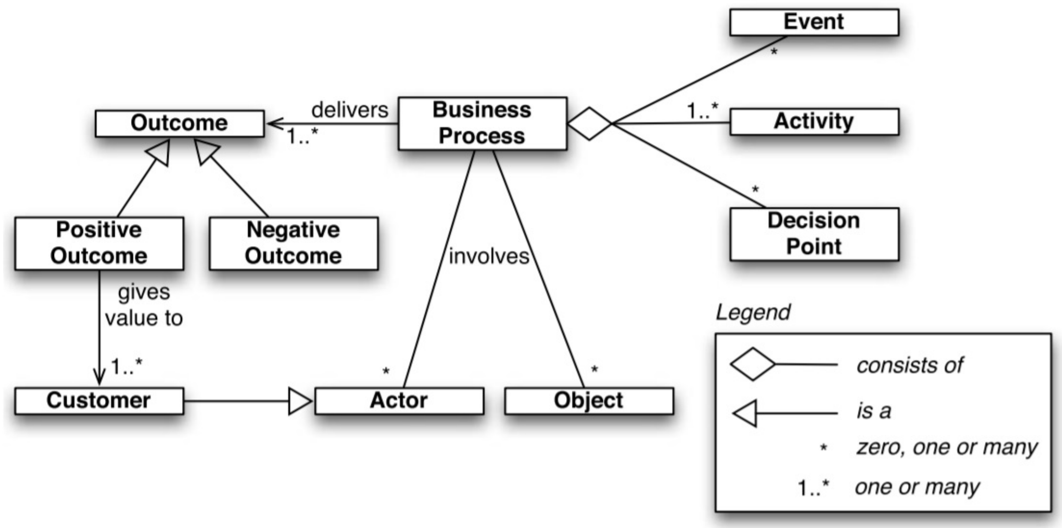
CONTENTS

1 INTRODUCTION

Every organization has a set of established activities that, together, correspond to the internal business processes (e.g. order processing, quality assurance, invoicing, medical assessment and trip booking) required to deliver services and products. Even though the management of these processes may seem straight-forward, depending of the complexity of the work to be performed, it can become a very complex task if not properly systematized. Dedicating some effort to analyzing and optimizing these processes can improve the efficiency of the entire organization's productivity and, due to the importance of this effort to organizations, studies emerged ever since industries began to appear (KARAGIANNIS, 2013).

A business process is composed by a set of activities, events, decision points. Events are actions that occur atomically - meaning that they have no duration - while activities are actions that require a certain time to be executed. These elements involve actors and objects and, collectively, they lead to an outcome that aggregates value to at least one customer(DUMAS, 2013). An illustration of the business process elements is presented in Figure 1.1

Figure 1.1: Business process elements

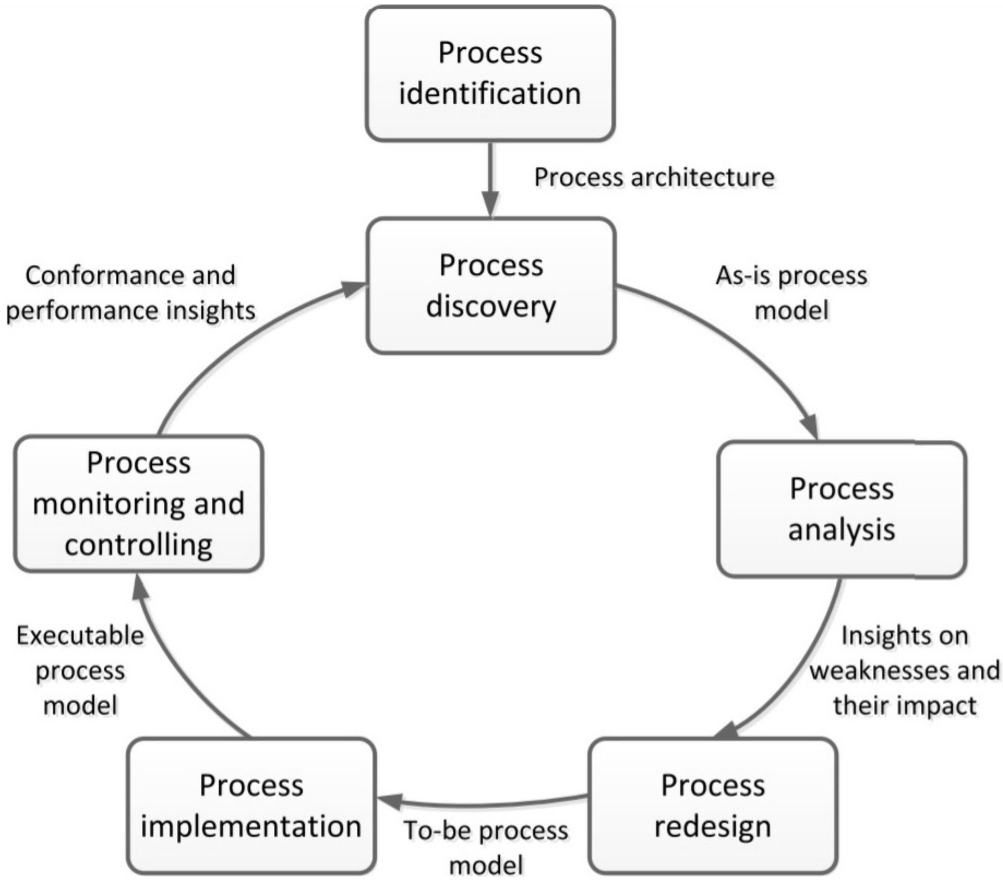


Source: (DUMAS, 2013)

Business Process Management (BPM) comprises a set of concepts, methods, techniques and tools that aim to discover, analyse, redesign, execute and monitor business processes (DUMAS, 2013). The main goal of engaging in BPM initiatives is to obtain positive outcomes from the processes (e.g. improved business agility and increased efficiency and reliability), maximizing the value of delivered products and services to customers and reducing the cost of production (DUMAS, 2013).

The adoption of BPM requires, initially, the identification of an organization's business processes. Once the processes are properly identified it is possible to start the cyclical steps, illustrated in Figure 1.2, as proposed by Marlon Dumas (DUMAS, 2013).

Figure 1.2: BPM life-cycle



Source: (DUMAS, 2013)

Dumas's approach to BPM divides the processes life-cycle into six phases, where five of them are cyclical in order to achieve a continuous improvement model, as follows:

- *Process Identification*: This is the first phase to be executed in order to adopt BPM practices. In this step a business problem is analysed and the processes required to solve it are identified and correlated. The outcome of process identification is an overview of all the processes and their relationships in a process architecture.
- *Process Discovery*: At this stage the state of each process is documented in the form of as-is process models, i.e. what the people in the organization understand about the work to be done.

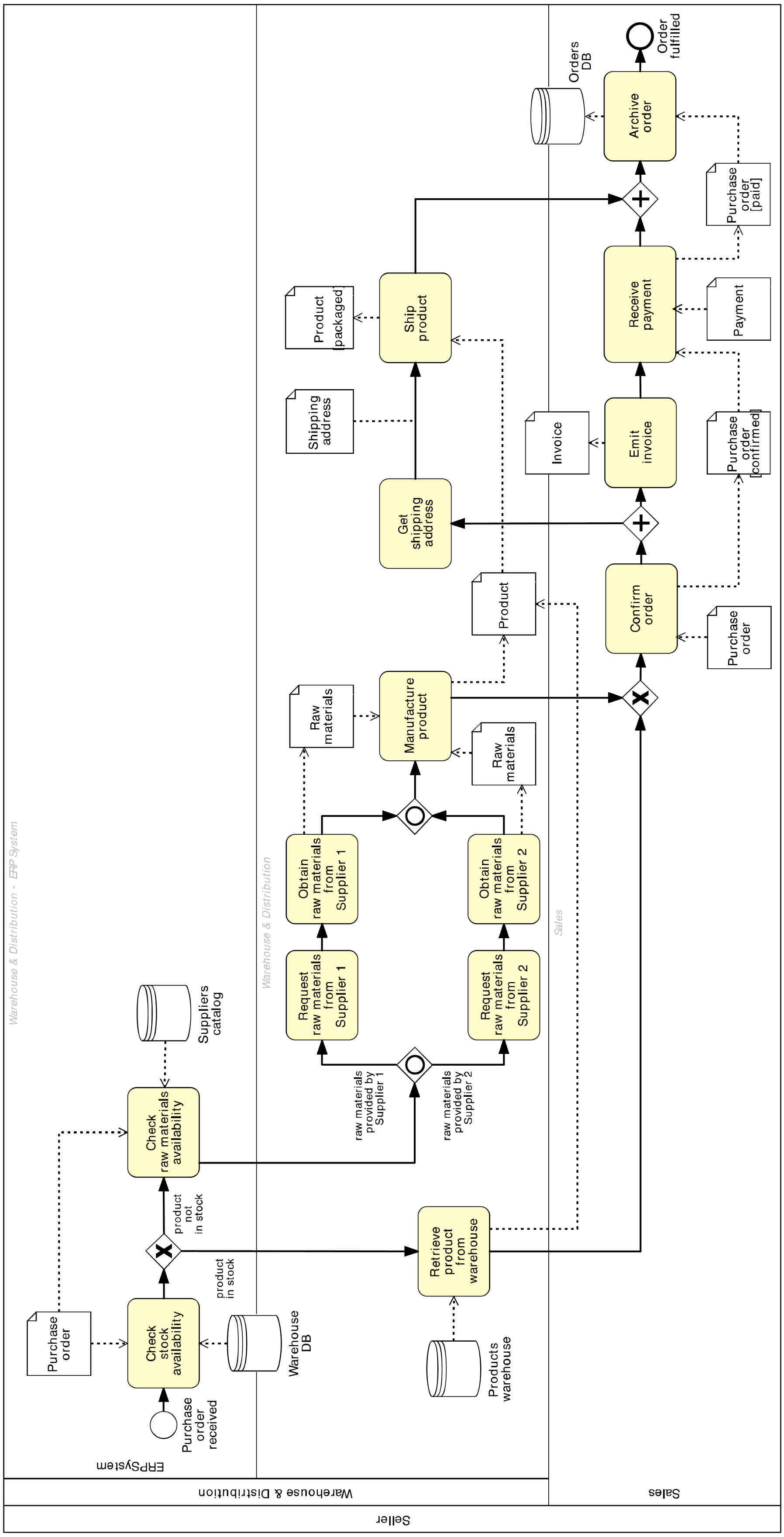
- *Process Analysis*: Here the as-is process models are refined and their issues are identified, documented and quantified if possible.
- *Process Redesign*: This phase uses the process analysis outcome to identify which changes could lead to an improvement of the processes and, therefore, help the organization to achieve its expected performance.
- *Process Implementation*: In this phase the as-is processes become to-be processes, meaning that the identified improvements are effectively implemented. This step allows the deployment of automated solutions for certain processes, which is where some RPA tools might come in handy.
- *Process Monitoring and Controlling*: The to-be model is deployed and performance data is collected to identify remaining or new issues that will be addressed in the next cycle.

In order to standardize the notation of business processes, the Business Process Management Initiative (BPMI), which later merged with the Object Management Group (OMG), developed the Business Process Model and Notation (BPMN) - a graphical language used to intuitively represent a organization's business process. The BPMN has been updated since then to version 2.0 (OMG, 2013), which is the target in this study.

In Fig. 1.3 an order fulfilment process is exemplified. This process is constituted by a sales department and a warehouse & distribution department. Purchase orders are received by warehouse & distribution and are then checked against the stock. If the product is in stock then it is retrieved from the warehouse. Next, sales can confirm the order by emitting an invoice and waiting for payment at the same time as the product gets shipped from the warehouse. At the end, the process is archived in the sales department. However, if products are not in stock, then the its availability of raw materials is checked and, once confirmed and the raw materials have been received, the warehouse & distribution department can continue with the manufacturing of the product. Once manufactured, the sales department can complete the order through the same steps as if the product was in stock.

In addition, business processes frequently contain activities that don't require human critical thinking (SYED et al., 2020) (e.g. filling forms on a website using information from a spreadsheet, manually updating client details in files or copying files from one directory to another based on their names). These activities can, in several cases, be automated by a robotic entity, i.e, a computer program capable of doing the work faster and with lower error rates. With that envisioned, a new field has emerged to explore the

Figure 1.3: Example of order fulfillment process



Source: (DUMAS, 2013)

automation of such laborious activities: Robotic Process Automation (RPA) (SYED et al., 2020).

BPM and RPA are approaches that may be used together within an organization's scope. The techniques encompassed by BPM can be used to defined and optimize tasks which may be candidates for automation using RPA (CASEY, 2020). While there are tools suitable for RPA, very little is documented about the support of BPMN - an ISO certified language highly adopted by the industry (OMG, 2013) - within RPA tools.

Considering that the RPA literature still contains multiple gaps, including no defined standards for the notation of automated processes (SYED et al., 2020) and that the BPMN was created to provide a standard understandable not only by domain experts but also by end users (CHINOSI; TROMBETTA, 2012), it is reasonable to imagine these two concepts working side by side in order to create tools that are easier to learn and use.

1.1 Hypothesis and Goals

Both BPM and RPA approaches tackle the optimization of business processes. While the BPM research tends to focus in the big picture, RPA in general refers to the automation of specific activities. However, the activities automated by RPA typically resemble a series of tasks that could be interpreted as a process, and processes are commonly described using the BPMN. Based on these observations, the following research questions (RQ) are raised regarding these two areas:

- **[RQ1:]** do RPA tools support designing bots using the BPMN as their modelling language?
- **[RQ1:]** if RPA tools don't offer such support, would it be possible to use the BPMN for this purpose?

Considering these *RQs*, we establish the following hypothesis (H): *it is possible to identify the support of BPMN language in RPA tools by analysing commercial available tools*.

The general goal of this work is to provide an analysis of how the commercially available RPA tools approach the BPMN language and discuss based on the current implementation of RPA tools if it could be possible to use the BPMN standard as a visual language to describe the automation of bots.

1.2 Organization

This work is organized as follows: chapter 2 presents the core concepts of BPM and the most common features available in BPMN; chapter 3 covers the basics of RPA research and its business applications, as well as what benefits it can provide to organizations that use it; chapter 4 presents an analysis of the support of BPMN in RPA tools and its results; chapter 5 presents the conclusions and directions for future work.

2 FUNDAMENTALS OF BPM AND BPMN

BPM is a concept that aims to holistically manage how work can be performed by organizations in order to provide products and services with consistent quality, allowing room for improvement of the business processes. Typical improvements that occur on these processes include reduction of costs, error rates and increase in efficiency (DUMAS, 2013). In order to model the processes a commonly used language is the BPMN. This chapter presents some of the most important features provided by the BPMN.

2.1 Business Process Model and Notation

BPMN is a fairly complex language with over 100 elements used to model business processes. Every element is described in the OMG specification (OMG, 2013). This section covers the main subset of BPMN objects that can be used for building process models, as follows:

- *Flow objects*: events, activities (tasks and subprocesses) and gateways;
- *Connecting objects*: sequence flow, message flow, association;
- *Swimlanes*: pools and lanes;
- *Artifacts*: groups and annotations;
- *Data*: data objects, data inputs, data outputs and data stores;

2.1.1 Connecting Objects and Tokens

In BPMN models, the execution state of a given process can be interpreted with the help of tokens. Tokens are a theoretical concept employed to facilitate the understanding of the BPMN processes and are not part of the BPMN elements. Analogously, their behavior is similar to a player piece traveling through the squares in a board game (STIEHL, 2016).

At the start of each process a new token is generated and it travels through the diagram. There are elements capable of splitting tokens into new parallel ones. Likewise, it is also possible to merge multiple tokens back into one. When a token arrives at the end event of a process it gets destroyed. Once all tokens have been destroyed it means that the process execution has finished (OMG, 2013).

The path followed by tokens through the process is determined by the sequence flows. Along sequence flows, there are some other connecting elements that carry important roles in the BPMN diagrams, like the message flows and association connectors (OMG, 2013). These connectors can be seen in the example from Fig. 1.3 linking all the elements across the process providing flow and data information.

Sequence flows indicate the order in which activities are executed in processes. Its symbol is a line with an arrowhead as in Fig. 2.1

Figure 2.1: Sequence Flow

Source: adapted from OMG (2013)

Message flows represent messages exchanges from a process to another. Used to indicate collaboration between the processes. Its symbol is defined by a dashed line with an empty arrowhead as in Fig. 2.2

Figure 2.2: Message Flow

Source: adapted from OMG (2013)

Associations are used to connect artifacts to the diagram elements. Its symbol is a dotted line without an arrowhead for text artifacts and a dotted line with an arrowhead for data flows in data objects, as in Fig. 2.3

Figure 2.3: Association

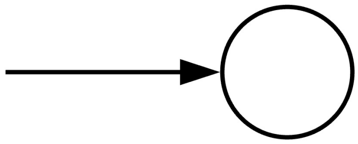
Source: adapted from OMG (2013)

2.1.2 Event

Events are elements that represent an occurrence in the process. These occurrences can either catch a trigger - i.e, something triggers the event leading to the execution of a sequential step - or throw a result - i.e, the event creates a trigger that may be captured by some other event. Based on when the events appear in the flow they are denoted as: Start, Intermediate and End. In the example from Fig. 1.3 two events can be observed. A start event, labeled "Purchase order received" and an end event, labeled "Order fulfilled".

Start Events denote the beginning of a process and are invoked when they catch a trigger. Once a trigger is caught the start event will generate a token and lead to the execution of the next steps of the diagram. These events are illustrated with a thin outline as in Fig. 2.4.

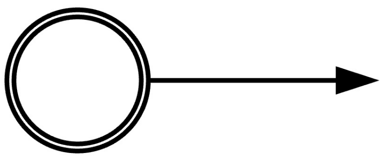
Figure 2.4: Start Event



Source: adapted from OMG (2013)

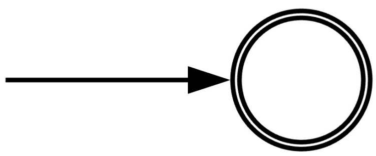
Intermediate events appear in the middle of the diagram and they can either catch or throw a trigger. These events are styled with a double thin outline. If the event has an outgoing arrow it means that it is catching a trigger (Fig. 2.5) and if it has an incoming arrow it means that the event is throwing information (Fig. 2.6).

Figure 2.5: Intermediate Event Catching Trigger



Source: adapted from OMG (2013)

Figure 2.6: Intermediate Event Throwing Trigger

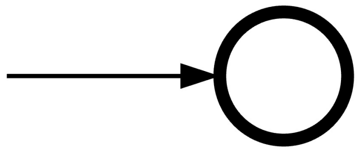


Source: adapted from OMG (2013)

End events are styled, as in Fig. 2.7 with a thick outline and, as the name suggests, they denote the end of a process. These events also throw a trigger that may be captured out of that scope.

Events also have a set of **triggers** that can be used, optionally, for several operations, including sending and receiving messages, setting timed flows, raising or catching

Figure 2.7: End Event

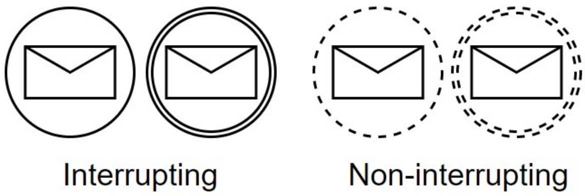


Source: adapted from OMG (2013)

errors and more. If the event has an associated trigger its marker is displayed withing the event symbol. Table 2.1 describes some common triggers used in BPMN diagrams.

Alongside with the triggers, events may also be denoted as interrupting or non-interrupting. Interrupting events indicate that the process throwing or catching the trigger is immediately stopped. When the event is non-interrupting, the process continues after handling the trigger. Fig. 2.8 illustrates the styling for interrupting and non-interrupting events.

Figure 2.8: Interrupting and non-interrupting events



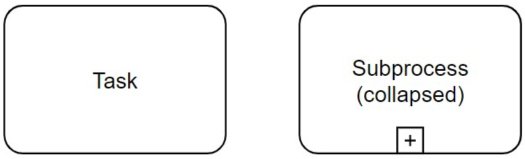
Source: adapted from OMG (2013)

2.1.3 Activity

Activities can be intuitively seen as work that is done by the participants of a process. An activity can be subdivided into several atomic activities (tasks) and non-atomic activities (subprocesses) (STIEHL, 2016). The notation for tasks and subprocesses is a rectangle with rounded corners, as seen in Fig. 2.9. In the example from Fig. 1.3 it is possible to observe multiple tasks across the diagram, such as "Check stock availability", "Manufacture product", "Ship product" and "Archive order".

Subprocesses can appear collapsed or expanded. When collapsed, they are marked with a plus sign. Tasks, on the other hand, are marked with an identifying icon depending on how they are supposed to be performed. The definition for each task type is presented in Table 2.2

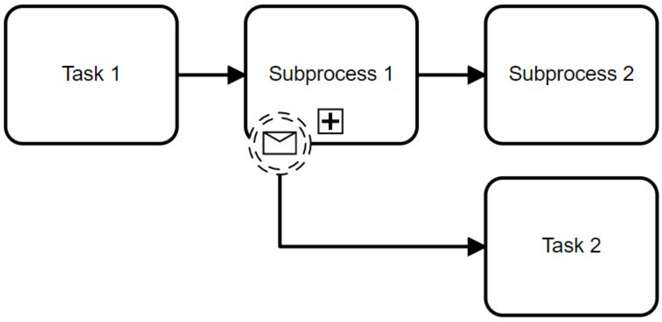
Figure 2.9: Task and Subprocess Notation



Source: adapted from OMG (2013)

It is also possible to assign a **boundary event** to activities. These events are placed right over the activity outline and mean that a trigger can be caught or thrown at any time during the execution of the activity. Fig. 2.10 shows an example of a subprocess throwing a non-interrupting message event.

Figure 2.10: Example of boundary event



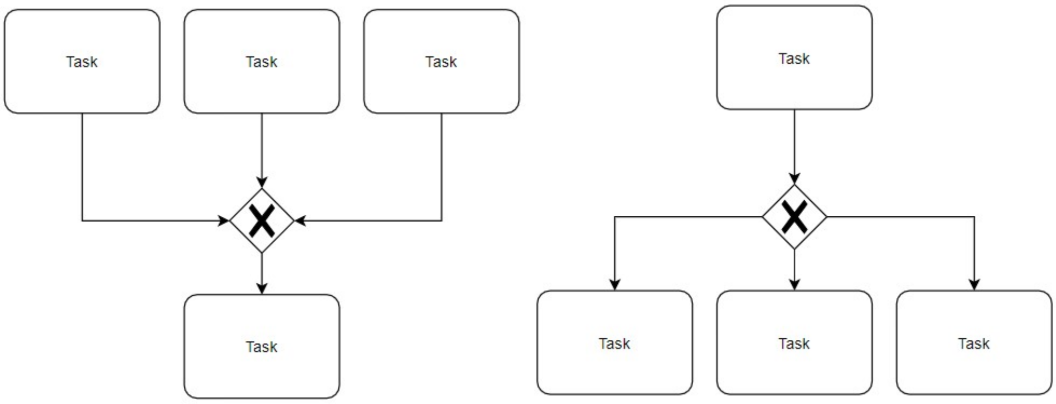
Source: adapted from OMG (2013)

2.1.4 Gateway

Gateways act as a mechanism to control branching and merging (DUMAS, 2013) in process flows. Gateways may either split the flow or join multiple flows back into one. The symbol for a gateway is a diamond shape and its inner icon defines what is the type of the gateway. As an example, the already known process from Fig. 1.3 illustrates three types of gateways: exclusive, parallel and inclusive. Moreover, there is one extra type named complex gateway. This subsection covers the gateway types available in the BPMN.

Exclusive gateways define that the execution should follow only one path of the diagram. Each path has a condition and these conditions need to be mutually exclusive. If multiple flows converge into one exclusive gateway, then whenever the condition for one of them becomes true, the flow continues. Fig. 2.11 depicts the notation of incoming and outgoing flows for exclusive gateways.

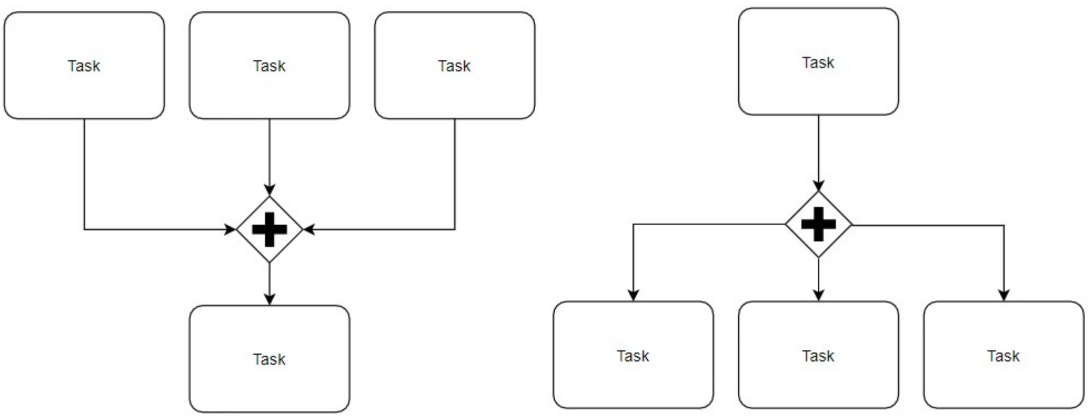
Figure 2.11: Exclusive Gateway



Source: adapted from STIEHL (2016)

Parallel gateways provide a method for creating multiple parallel flows. When a parallel gateway receives an incoming token it signals all outgoing flows to be executed in parallel regardless of their conditions. For multiple flows converging into a parallel gateway, the expected behavior is to continue the execution only when all defined incoming flows arrive at the gateway. Fig. 2.12 illustrates parallel gateways.

Figure 2.12: Parallel Gateway

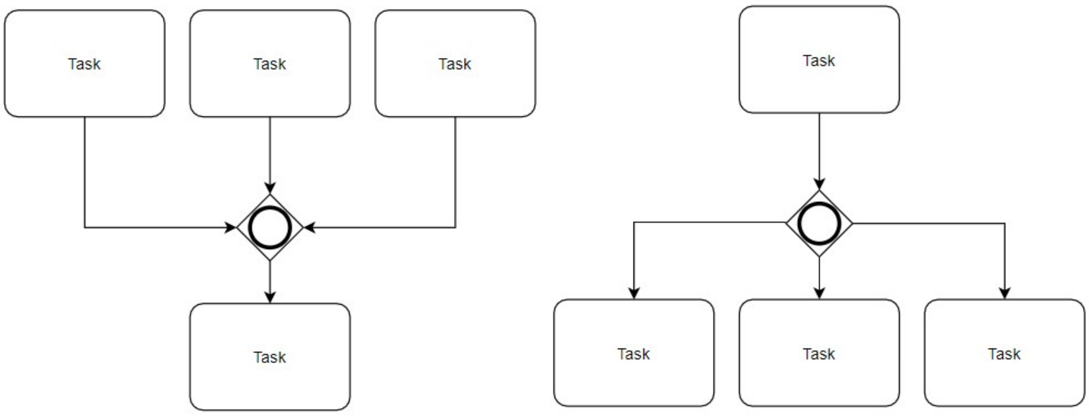


Source: adapted from STIEHL (2016)

Inclusive gateways allow the execution of multiple flows, but only if their conditions are met. It is also possible to define a default path so that the execution may continue even if none of the conditions are true. If the inclusive gateway is used for incoming flows then the gateway is informed of how many flows may still arrive and it waits for all of them before proceeding. Fig.2.13 depicts inclusive gateways.

Complex gateways covers the scenarios that cannot be implemented by the other

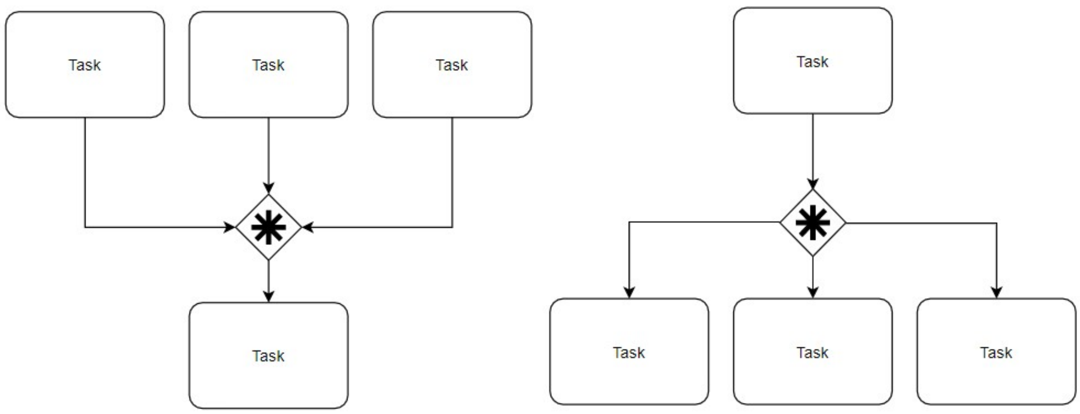
Figure 2.13: Inclusive Gateway



Source: adapted from STIEHL (2016)

gateways. For example: it is possible to define n-of-m mergers, which means that the gateways waits until n of the m incoming paths arrive. Fig.2.14 shows the notation for complex gateways.

Figure 2.14: Complex Gateway



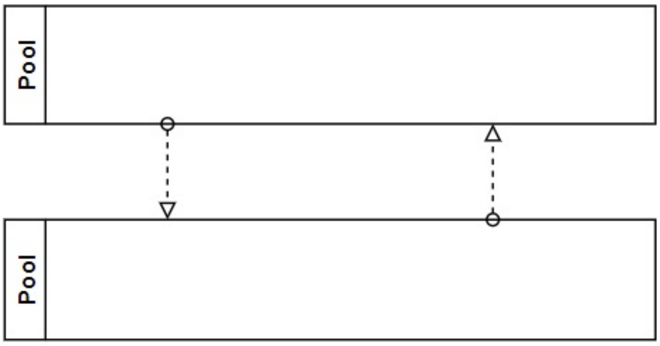
Source: adapted from STIEHL (2016)

2.1.5 Swimlanes

Swimlanes are used to denote the organization units in a process. They essentially group the entire process and distinguishes the responsibilities of each participant. The concept of swimlanes comprises pools and lanes. The known example process from Fig. 1.3 depicts the pool "Seller" that contains lanes "Warehouse & Distribution" and "Sales". Furthermore, the Warehouse & Distribution lane is subdivided into one lane for steps specifically assigned to the Warehouse & Distribution ERP System and another for general purposes.

Pools contain the complete sequence flow of a process. They represent each participant in the big picture and are also used to illustrate the collaboration between multiple processes with the help of message flow connectors. Fig. 2.15 illustrates message sharing across different pools.

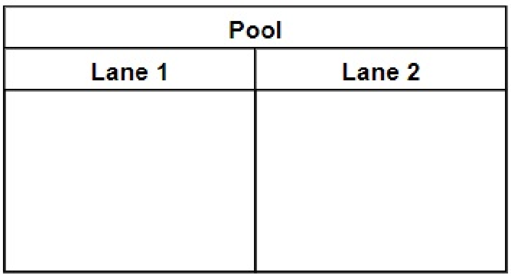
Figure 2.15: Pool



Source: adapted from OMG (2013)

Lanes are partitions used to organize activities within pools. Generally lanes correspond to a business's organization unit or role. This means that all activities inside a lane are performed by its associated role or unit. Fig. 2.16 illustrates a pool divided in 2 lanes.

Figure 2.16: Pool with 2 lanes



Source: adapted from OMG (2013)

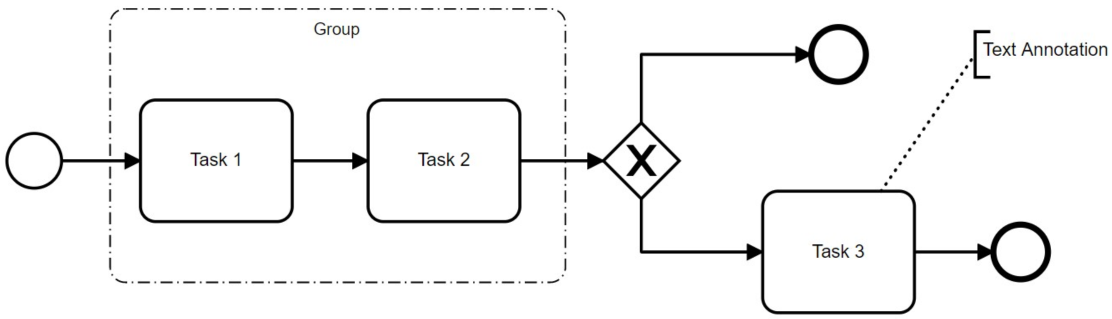
2.1.6 Artifact

Similarly to what software developers experience with programming languages, proper organization is very important for a BPMN project that is maintainable and easy to understand. Artifacts provide additional information that doesn't affect the sequence flow, but can be very helpful for documenting the project.

The goal of **groups** is, as the name suggests, grouping elements together for better legibility and documentation. A box styled with round corners and dot-dashed outline is used to illustrate groups. It can be used for tagging a set of tasks that need to be reviewed, for example.

Alongside, **text annotations** can also be used for improving the legibility of the project. They are attached to elements using an association connector. Their goal is to provide extra information about other elements, but they don't pose any functional purpose to the diagram other than being a facilitator to the reader. Fig. 2.17 shows a simple diagram using a group and a text annotation.

Figure 2.17: Example diagram with group and text annotation



Source: adapted from OMG (2013)

2.1.7 Data

As most real life applications, business processes may require handling data at some point. BPMN provides mechanisms to inform that the process is exchanging data with some agent - a database, for example. The purpose of data elements is to represent the information required or created by the process during its execution. Besides that, the type of data element used indicates if the information is stored temporarily or persistently. The example from Fig. 1.3 contains several instances of data objects (e.g. "Purchase order", "Raw materials" and "Product") and four instances of data stores ("Warehouse DB", "Suppliers catalog", "Products warehouse" and "Orders DB").

Data objects provide details of the information used during the execution of certain tasks, such as text fields, data collections, complex data structures and so on. The information in data objects is only available while the process is being executed. When the information is required by the process it is called data input and, when the process generates information it is called data output.

Data stores provide a persistent data layer for activities to read from and write at. This means that, unlike in data objects, the information saved in a store is preserved even outside the process scope. The information exchanged with a data store persists even after the process that created or consumed that information is no longer running. Fig. 2.18 shows the notation for data elements.

Figure 2.18: Data Store and Data Object

Source: adapted from OMG (2013)

2.2 Chapter Summary

The Business Process Model and Notation is an ISO standard designed for business process analysis and graphical modelling. Unlike activity diagrams from the UML, the BPMN encompasses a wide variety of elements that allow detailing complex process semantics in an intuitive way.

The goal behind the creation of the BPMN was to provide a complete standard understandable by professionals such as business managers, developers, business analysts and any business stakeholder. This standardization facilitates the communication among the different parts involved in the business processes.

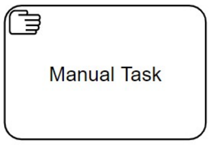
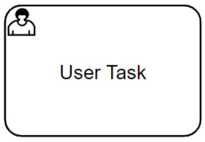
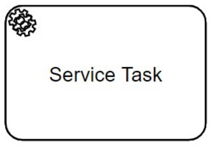
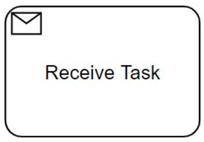
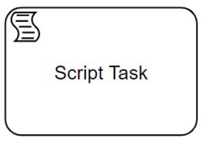
The BPMN is a standard adopted by several BPM tools (PAWAR, 2011). However, finding references of the BPMN being used outside of the BPM scope has proved itself to be a difficult challenge, but this work was motivated by the possibility of the BPMN being applied to other areas tangent to BPM.

Table 2.1: Some Event Types and Triggers

Event	*Trigger*	*Description*	*Symbol*
Start	Message	Message triggers are received by a participant and triggers the start event, leading to the start of the process.	
Start	Timer	Timer triggers indicate a date-time, or a recurrence, that will lead to the start of the process.	
Start	Conditional	Conditional events are triggered whenever a conditional expression changes from false to true.	
End	Message	In this case, the message is sent to a participant at the end of a process.	
End	Error	This trigger signals an error and interrupts the execution of the process.	
Intermediate	Message	In the case of intermediate events the message can be either thrown or caught.	**Throw**  **Catch** 
Intermediate	Timer	Not every intermediate event trigger can be thrown or caught. The timer trigger, for example, can only be caught by and intermediate event and acts as a delay mechanism to the process.	**Catch** 

Source: adapted from OMG (2013)

Table 2.2: Task Types

Task Type	*Description*	*Symbol*
Manual	Manual tasks indicate that the task is executed without the aid of automation utilities. Usually means that a person needs to manually perform an operation.	
User	User tasks requires the participation of the end user in the process. The user performs the task with the assistance of an application.	
Service	Service tasks are performed by some automation utility.	
Receive	Receive tasks wait for an external message to arrive before beginning the execution.	
Send	Send tasks send a message to external participants once the activity is complete.	
Script	Script tasks denote that a process engine will execute some sort of script to automate the resolution of simple problems. Once the script completes this task ends.	
Business Rule	Business rule tasks are generally used to prepare decision logic for gateways.	

Source: adapted from OMG (2013)

3 ROBOTIC PROCESS AUTOMATION

With the availability of cheaper and powerful computing systems in the past few years we started experiencing a giant adoption of digital processes in several types of industries, such as banking, insurance, healthcare, telecommunication and manufacturing. However, the IT solutions available to the market are notorious for their constant evolution and renovation. This has led several early adopted IT systems to become obsolete despite still being heavily utilized. Updating or replacing these legacy systems is, in several cases, an unfeasible task as they tend to be hard to maintain. Furthermore, access to them is often only available through an user interface instead of application programming interfaces (SYED et al., 2020), making the integration with newer systems less straight-forward.

The usage of these legacy systems frequently require manual operations done by a human user. These type of operations tend to be repetitive and are, in more modern contexts, usually done by services exchanging messages through APIs, without the need of a person to mediate the transactions. One of the goal of RPA is to introduce an agent capable of assisting with these interactions without the need for a human to manually input data in legacy applications (SYED et al., 2020)

RPA is a technology that comprises software known as 'bots' which aim to reproduce some actions performed by humans in computing systems (SYED et al., 2020). These tasks performed by the bots are typically rule-based, well structured and repetitive (SYED et al., 2020). However, some definitions also mention more advanced bots capable of adapting to different circumstances (HORTON, 2015).

RPA bots may pose a direct impact on an organization's business processes. The goal of this chapter is to present information about the benefits and challenges of the adoption of RPA strategies within a business.

3.1 Benefits of RPA

Some organizations that have successfully adopted RPA practices were able to achieve significant improvements in several areas (e.g. increased operational efficiency, more quality of service and better risk management and compliance). Automation by bots can reduce the time required for certain tasks, reduce the cost with human resources and, overall, improve their productivity (SYED et al., 2020). The bots are capable of overcoming a human's performance mainly due to the fact that they work continuously

(KROLL et al., 2016), 24 hours a day, 7 days a week.

Besides delivering more performance, bots are also less susceptible to making mistakes. Their accuracy allied with the non-stop work makes RPA an attractive solution for organizations aiming to achieve better quality of the delivered service, since with these improvements they are able to offer more reliability and continuity of service (LACITY; WILLCOCKS, 2018).

The adoption of RPA solutions, when compared to other forms of automation or large enterprise systems, is cheaper and easier to configure and maintain (LACITY; WILLCOCKS, 2016a). The reason for its simplicity is that RPA automates established practices performed by humans in already existing systems and interfaces. It does not require any new complex integration or system.

Furthermore, RPA also contributes with auditing the activities performed in the system, since all the work performed by the bot is logged to guarantee that regulatory requirements are met. RPA can also be used for monitoring compliance rules on transactions performed by humans (e.g. updating client information or handling third party files).

3.2 Challenges of RPA

The implementation of RPA in the context of an organization can impose several challenges. The promise of cheap and quick solution to improve efficiency may seem tempting, but it is important to analyse the readiness of both the organization and its processes before proceeding with the RPA adoption (KIRCHMER, 2017). RPA organizational readiness can be analysed based on three characteristics: business drivers, the nature of existing technology and degree of maturity (SYED et al., 2020).

The viability of using RPA requires the candidate organization to be driven by cost reduction, quality improvement, efficiency and better compliance goals. Without these business drivers the widespread adoption of RPA within the organization might become a big challenge. (TARQUINI, 2018). The ideal technological context for RPA is within organizations with multiple different systems with a high coupling level among them (e.g. organizations with newer systems integrated with legacy systems that cannot be retired). (DILLA; JAYNES; LIVINGSTON, 2017). Furthermore, since RPA is a relatively new concept, an organization willing to implement RPA solutions shouldn't be too risk-averse and needs to be willing to become an early-adopter (BURNETT et al., 2018).

Implementing an RPA solution can be more difficult than planned and the organization must be ready to deal with such situation.

Additionally to the business's organizational characteristics being in check, it is also important that its business processes are suitable for RPA. Some processes or activities are unsuitable and trying to apply RPA to them may lead to a higher development effort while also inhibiting RPA outcomes (SYED et al., 2020). In order to identify which processes are more suitable, the analysis by Syed et al. (2020) suggest a series of characteristics indicating that a process is a strong candidate for RPA.

- *Highly rule-based*: The decision logic requires unambiguous business rules for every eventuality. I.e. conditional paths within the process should not have conditions that may be open to the actor's interpretation, such as "is good" or "is enough".
- *High Volume*: The activity needs high transaction volumes to justify its automation. Creating a bot is generally not worth if the activity is not executed frequently.
- *Mature*: The activity needs to be well established (i.e. it needs to be unchanged for some time), consolidated (everything the process requires is already known) and understood by the organization members.
- *Easy to achieve and show impact*: The activities must belong to an area with manual costs that are easily identifiable, such as an operations team responsible for registering new users into the system database, for example.
- *Has digitised structured data input*: All data must be structured and digital. The bots are essentially computer programs that perform operations given a set of inputs. If the inputs are not digitized it is not possible to feed them to the bots.
- *Highly manual*: Activities that don't require much human intervention and can be automated, such as filling forms in websites or generating reports.
- *Transactional*: RPA is very well suited for tasks susceptible to human error. Transactional operations, such as transferring money, frequently suffer from data being incorrectly handled, which is a problem highly mitigated by bots.
- *Standardized*: Initial stages of RPA implementation are easier for processes which executions follows a predefined path consistently. In later versions of the automation it is possible to cover scenarios with multiple decisions and error handling, but for initial versions it is recommended to keep it simple.
- *Low-levels of exception handling*: Too many exceptional behaviors lead to a complex coverage scenario. Uncovered cases will lead the bots to abort or delay the

operation.

- *Highly repetitive*: Automating repetitive activities leads to a better return of investment since less staff is required for performing these tasks.
- *Less complex processes*: If the process is too complex (i.e. the process requires high levels of decision making) then the bot becomes much harder to implement. Simple processes are preferable.
- *Well-documented*: Since bots are running at a keystroke level it is crucial that the processes documentations are as accurate as possible. More documentation facilitates programming the bots.
- *Interacts with many systems*: When humans needs to interact with multiple systems the error rate usually increases. Therefore, such processes are generally good candidates for RPA.

3.3 The Potential of RPA

As mentioned in section 3.1, RPA is capable of offering a series of benefits to organizations. These benefits are achievable due to a set of potential capabilities associated with RPA adoption. There are capabilities that focus on the work of each employee and on the organization and its processes.

On the Employee level of capabilities, due to the automation of routine tasks, associates are able to dedicate more time with work that delivers higher value to the organization, since they won't be spending energy with low-effort repetitive tasks (HORTON; WITHERICK; GORDEEVA, 2017). Furthermore, RPA also allows the creation of new roles for employees in jobs linked to sophisticated data analysis, consulting and robot management (ASATIANI; PENTTINEN, 2016).

On the organisation level, RPA offers a series of potentials. The research by Syed et al. (2020) proposes capabilities such as increasing transparency, standardisation and compliance, harnessing process intelligence for decision-making and ensuring flexibility, scalability and control of the supporting software. Robots act in a controlled and standard way. This allows transparency and facilitates the identification of process deviations, thus leading to more standardization and compliance. The bots are also capable of self-monitoring, which can allow better data collection for process optimization. With the collected data it is possible to review the process and pinpoint steps that need to be improved. Furthermore, robots are more flexible than humans regarding working-hours, besides, they are much cheaper to replicate for scalability purposes and they also don't require individual support with their work environment.

3.4 RPA Methodologies

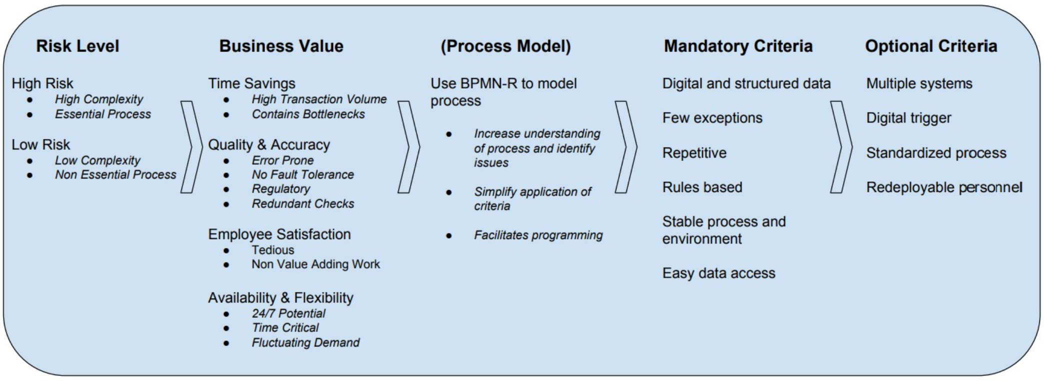
Due to the fact that RPA is a new field, its implementation strategies are not completely consolidated. The closest available literature regarding its methodologies are presented as reports of RPA implementations by early-adopter organizations.

In general, implementing solutions using RPA should be part of an organization's long-term strategy (BURGESS, 2018), as it is important to, before considering automation, optimizing the process as much as possible. Automating an inefficient process may become a detriment to the overall productivity in the long-term. In some cases, it's even required to redesign a process in order to maximise RPA capabilities (LACITY; WILLCOCKS, 2016b).

The recommendation regarding selection of tasks to automate is starting with small and low-risk activities, then progressively increase the number and complexity of automated activities (HORTON; WITHERICK; GORDEEVA, 2017). In general, low and medium complexity tasks are the best candidates for automation. Higher complexity tasks can be automated but the job is trickier and should be left for later (LAMBERTON, 2016).

Authors Agaton and Swedberg (2018) propose a 5 step suitability framework designed to assist the identification of processes qualified for RPA. Fig. 3.1 illustrates the steps of their framework. Each step works as a funnel and only the processes that match their criteria advance to the next step. The definition of each step follows:

Figure 3.1: RPA Suitability Framework



Source: (AGATON; SWEDBERG, 2018)

- *Risk level*: the automation of processes that are essential or complex should be avoided unless the organization has experienced people who understand the process very well and have worked in similar projects before.
- *Business value*: only automate processes if this operation can deliver high business value, like time savings, better quality and accuracy, employee satisfaction and more flexibility.
- *Process model*: the authors present this step as optional since modelling processes can be quite time consuming, but it can deliver benefits useful on the next steps such as enhancing the understanding of the process, finding its issues, assessing its complexity and facilitating the creation of a bot. The authors also use an extension to BPMN named BPMN-R (AGATON; SWEDBERG, 2018), but this is not obligatory.
- *Mandatory Criteria*: the process has to be repetitive, rule-based, stable and with few exceptions. Its data needs to be digital and easily accessible.
- *Optional Criteria*: the process is triggered digitally, it accesses multiple systems, it is standardized and the personnel working with it can be reassigned to new tasks.

3.5 RPA Technologies and Vendors

Due to RPA being a relatively new area there aren't many academic studies focused on its technological perspective. The well established commercially available RPA applications are all closed-source and, therefore, academic research focused in product development is very limited. (SYED et al., 2020). With that said, the goal of this section is to provide an overview of what the literature offers in terms of RPA technological advances.

The RPA industry has a considerable number of solution providers, such as Workfusion[1], Contextor[2] and Redwood Software[3]. However, the three market leaders are UiPath[4], Automation Anywhere[5] and Blue Prism[6] (HAJJAR, 2021). In general, these applications offer three core components: a modelling tool, a management console which

[1]https://www.workfusion.com/
[2]https://contextor.eu/en/?lang=en
[3]https://www.redwood.com/
[4]https://www.uipath.com/
[5]https://www.automationanywhere.com/
[6]https://www.blueprism.com/

helps administrating the robots and the robots themselves (ANAGNOSTE, 2017). Moreover, RPA bots are generally categorized as attended and unattended. Unattended bots are completely autonomous and can be applied to processes with tasks that don't change between instances, such as screen scraping and optical character recognition. On the other hand, attended bots can be used to replicate smaller task automation for individual personnel, allowing active monitoring of the automated activities and reducing the chance of errors. The implementation and usage of attended bots is far simpler and faster (TARQUINI, 2018).

One common issue with RPA implementations is that using bots to integrate multiple systems tends to be an approach less robust than systems designed to be integrated from the scratch. However, RPA is a strategy meant to be applied under specific circumstances, as mentioned in section 3.4 of this work. Regardless, RPA implementations on their first iteration usually are a minimally viable version to deliver the product. Over the next iterations, it evolves into a more robust project (GRUNG-OLSEN, 2017).

Another important technological aspect of RPA is that the intelligence of bots is open to growth and evolution with the advancements in artificial intelligence research. At the present time RPA focuses on simple and well-defined tasks due to the numerous challenges posed by automating complex tasks with procedural code. However, with machine learning the automation of complex tasks can be done in a fairly robust manner. (AALST; BICHLER; HEINZL, 2018)

3.6 Related Works

While RPA is a field that has grown a lot in the past few years, there aren't many academic studies on this topic. Most studies correlating BPMN and RPA focus on using BPMN to analyze processes in order to achieve an optimized scenario for RPA. Kirchmer and Franz (2019) provide a study on the challenges of adopting RPA for process improvement and how BPMN can be used to assist on it. Still in this context, Agaton and Swedberg (2018) identify issues while using BPMN for the selection of processes to automate, while also providing an alternative method.

Furthermore, Aguirre and Rodriguez (2017) compares BPMN modeling packages with RPA solutions and mentions that RPA tools tend to offer a drag-and-drop interface, much like several BPMN applications, pointing that both technologies are accessible to users inexperienced with programming languages.

Based on the literature that was identified mentioning BPMN and RPA tools, no scientific research regarding the support of the BPMN in RPA has been found. Therefore, this analysis consolidates a research challenge that we tackle in this work with the expectation of bringing BPM and RPA technologies closer together.

Table 3.1 presents an overview of the works discussed in this section.

Table 3.1: Overview of related works

Authors	*Title*	*year*	*Overview*
Santiago Aguirre and Alejandro Rodriguez	Automation of a Business Process Using Robotic Process Automation (RPA): A Case Study	2017	Analysis of the user interfaces in RPA tools
Björn Agaton and Gustav Swedberg	Evaluating and Developing Methods to Assess Business Process Suitability for Robotic Process Automation - A Design Research Approach	2018	Issues of using BPMN to identify processes eligible for automation.
Mathias Kirchmer and Peter Franz	Value-Driven Robotic Process Automation (RPA)	2019	Challenges in RPA adoption and how to use the BPMN to facilitate it.
Lucas Carraro	An Analysis of the Support of the Business Process Model and Notation in Robotic Process Automation Tools	2021	Analysis of the applicability of the BPMN in existing RPA tools.

Source: the authors

3.7 Chapter Summary

The research regarding Robotic Process Automation is relatively new and it was born with the intent of improving the quality, security and scalability while reducing costs and increasing the speed, accuracy and consistency of business processes.

With the recent popularity growth that RPA has received, several tools have been commercially released to assist businesses with their automation needs. Considering that these tools are meant for the automation of certain tasks in business processes, we expect to find some level of support to the BPMN specification in RPA tools.

4 RPA TOOLS ANALYSIS

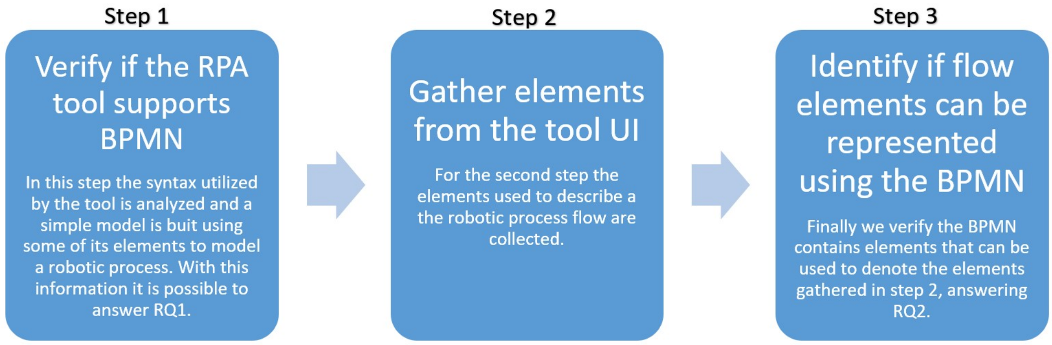
In this chapter we analyse the availability of specific features (e.g. simple bot creation interface, internal support to BPMN and integration with external BPM software) in the top 3 RPA tools based on market presence: Automation Anywhere, UiPath and Blue Prism, according to the study by Hajjar (2021). The goal of this analysis is to understand if these tools provide any kind of compatibility for modelling bot automation using elements defined by the BPMN and, if they don't support the BPMN, should it be possible to represent some of their current functionalities with BPMN elements?

4.1 Analysis Methodology

For this work the methodology described in this section if proposed. In order to analyse the user interface for building bots in the RPA tools a free or trial license was required to each application. With access to the applications, the first step is checking if any of them provide explicit support to modelling robotic processes using the BPMN. If the application does not support the BPMN we proceed to the next steps. With this initial step we are able to answer RQ1.

Next we need to identify what are the possible ways of defining an automation using each UI. Considering that one of the capabilities of the BPMN is describing process flows, the next step is identifying the flow modelling elements provided by each tool. Once the flow elements are consolidated, it is verified if the BPMN contains elements that could potentially be used to represent them, answering RQ2. Figure 4.1 illustrates the steps for this work's methodology.

Figure 4.1: Methodology



Source: the authors

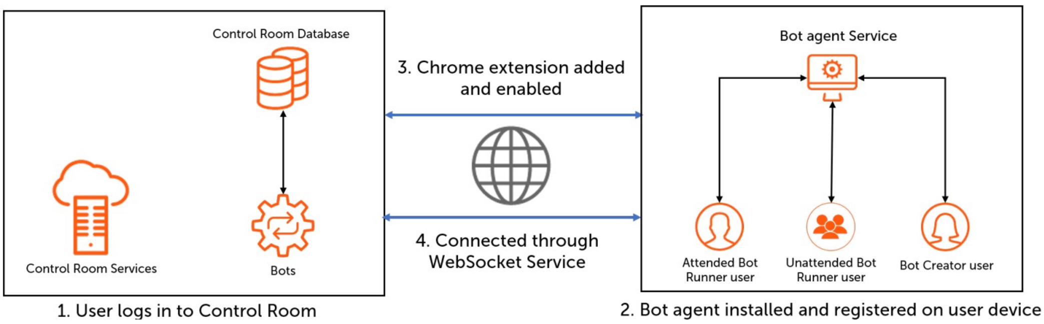
The following sections provide an explanation of the bot modelling syntax used by Automation Anywhere, UiPath and Blue Prism. Based on this analysis, we answer the research questions and verify if the hypothesis is true.

4.2 Automation Anywhere Community Edition

Initially born in the United States as Tethys Solutions, the company founded in 2003 by Ankur Kothari, Mihir Shukla, and Neeti Mehta was, in 2010, renamed to Automation Everywhere with the purpose of making RPA accessible to everyone. Since then the application has grown a lot and incorporated several new features (e.g. Bot Store, Bot Insight tools, revamped user interface and an ever-growing list of actions to enhance bot capabilities) (MULLAKARA, 2019).

The chosen version for this research is the community edition since the company doesn't provide an academic license for the enterprise version. Automation Everywhere comprises two core elements: a web-based control room and a bot agent. The control room is a space that allows the user to create and manage bots. These bots are executed by the bot agent, which is a lightweight application installed in the target device. (Automation Anywhere, 2020). Fig. 4.2 illustrates the communication between a bot agent and the control room.

Figure 4.2: Integration between Control Room and Bot Agent

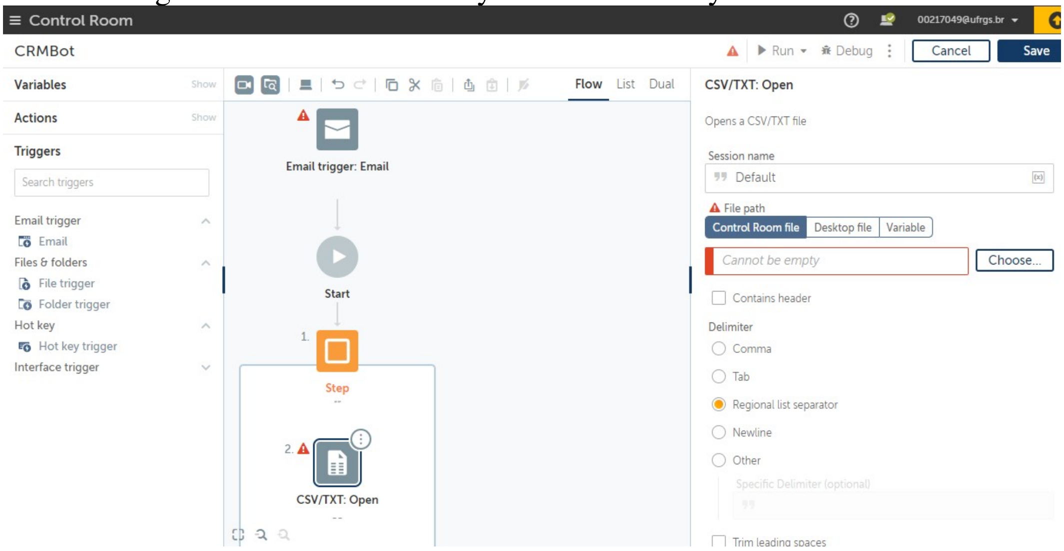


Source: (Automation Anywhere, 2020)

The bots are created in Control Room and then are saved to the Control Room Database. When the automation is triggered, a message is sent to the bot agent service. The bot agent service trigger the bot runner which delegates the instructions to bots running at scale. This communication is done by the WebSocket service. It is also required to have a browser extension installed to enable certain features in control room, such as action recording and playback.

The bot editor UI comprises a left menu containing the set of features available for the construction of the bot, a middle window with the bot flow diagram and a right menu that displays the properties of features selected by the user. Fig. 4.3 displays a screenshot of Automation Anywhere user interface.

Figure 4.3: Automation Anywhere community edition bot editor

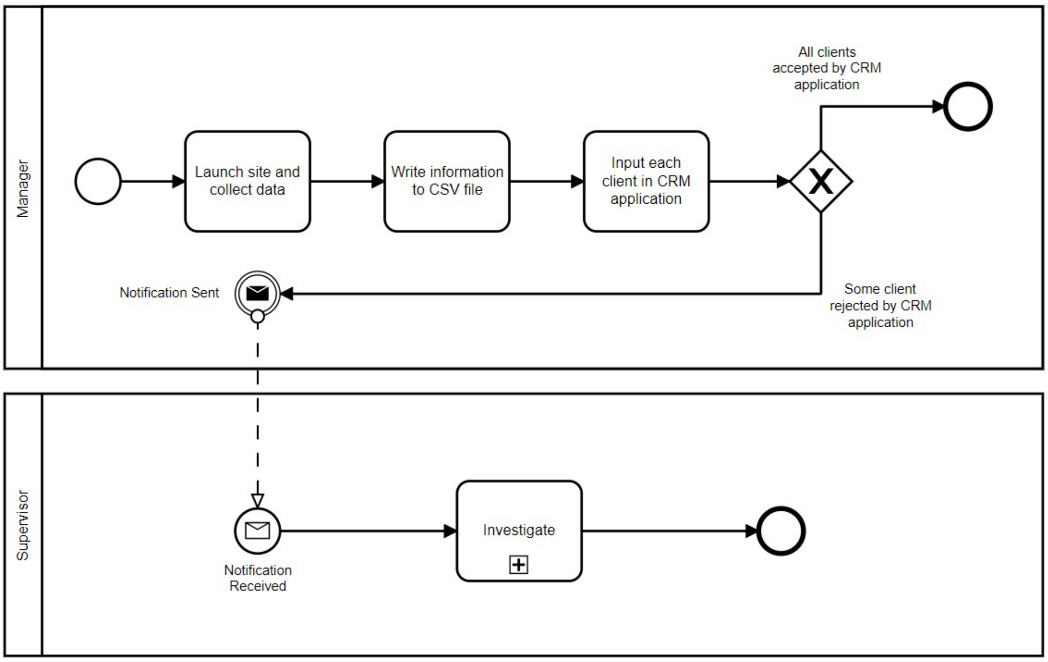


Source: the authors

The user interface is very intuitive and simple to use. Every possibility for bot action, trigger or variable can be dragged from the left menu to the flow diagram. By dropping an element in-between other elements the UI automatically connects them in a sequential order (from top to bottom). When an added element is clicked the right menu displays all of its properties. In the left menu it is possible to configure all details of how each action should be executed by the bots.

Automation Anywhere offers a series of tools to facilitate the development of bots (e.g. reading data from a database, collecting data from web pages elements, controlling mouse actions, running JavaScript, simulating keystrokes, running commands on terminals and much more). One common use-case for RPA automation is gathering data from a source (e.g. an e-mail or an HTML table) and using the collected information to fill and submit a form in a user interface. As an example, let's imagine the following scenario: An organization provides trip reservations for their customers. The customers share their details with a relationship manager through a web portal and the manager consults the information through the web portal as well. The manager collects the information and consolidates everything into a CSV file, then he uses the consolidated information to populate multiple forms in their CRM application. If the CRM application rejects any customer then the manager sends the list of rejected customers to a supervisor. This process performed by the manager could be illustrated, in a simplified way, disregarding outstanding scenarios, as the BPMN diagram in Fig. 4.7

Figure 4.4: Example BPMN diagram of customer registration



Source: the authors

In Automation Anywhere the process executed by the manager can be represented using a flow diagram. Each activity can be represented by an element called step, the exclusive gateway is performed using and "if" and an "else" elements and the message events are mimicked by the "send email" action, as demonstrated in Fig.4.5

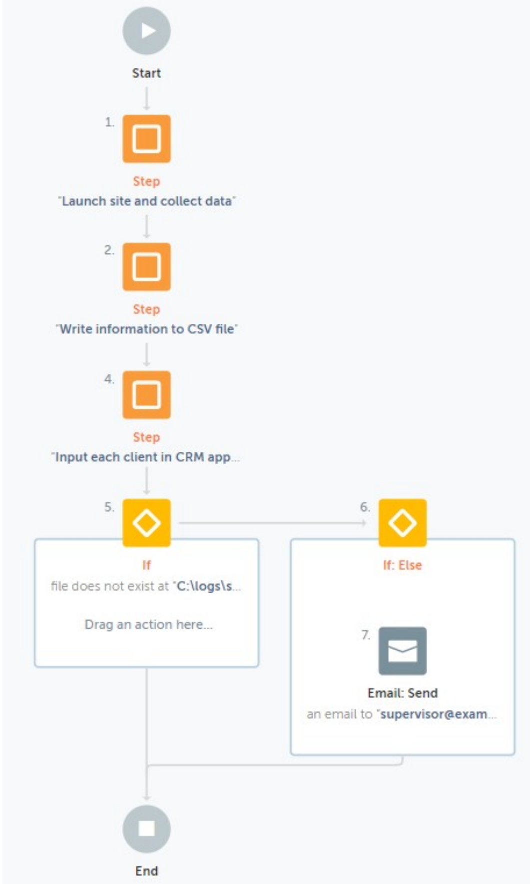
In this automation, by expanding the "Launch site and collect data" (step 1), it is possible to see a list of actions that the bot will perform. Figure 4.6 shows the list of actions and their representation in the diagram format. In this case, there are only two actions, which could be interpreted as BPM tasks executed by the bot: open the browser and save the table information in a variable.

While steps and BPMN activities share some organizational similarities (both can be used to encapsulate tasks performed by the actor), it cannot be said that a step encompasses all the functionalities available in BPMN. In fact, the application of a step in Automation Anywhere is closer to a BPMN group than an activity, since its only purpose is to label the sequence of events.

Furthermore, Automation Anywhere also has a concept of triggers, but they behave in a completely different way if compared to the BPMN. Triggers in Automation Anywhere merely work as tools to initiate the bot. They cannot be used with the same diversity as it is possible in the BPMN.

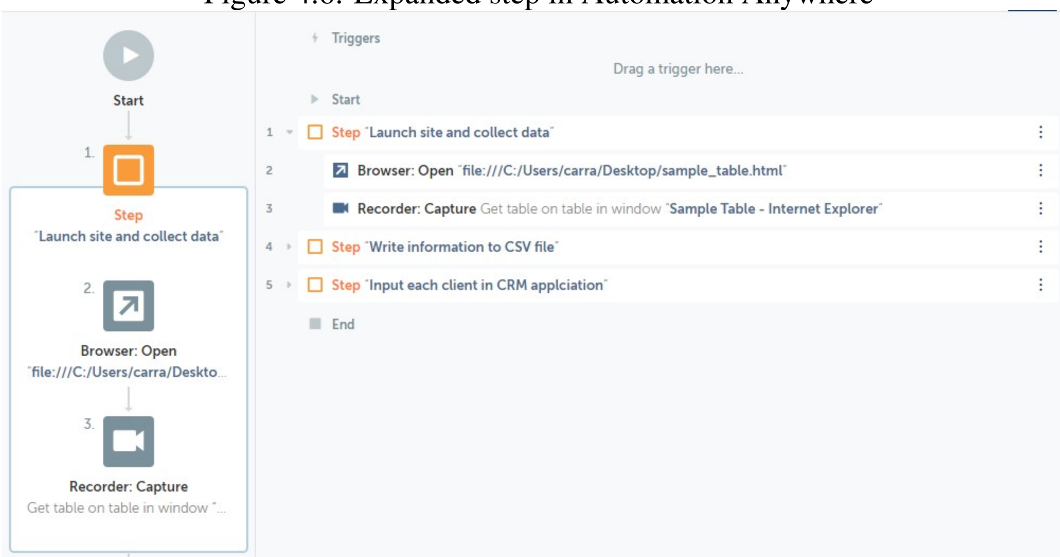
However, while Automation Anywhere isn't directly compliant with the BPMN, they do have a partnership with the Bizagi BPM tool (Bizagi, 2021). This integration

Figure 4.5: Customer registration bot in Automation Anywhere



Source: the authors

Figure 4.6: Expanded step in Automation Anywhere



Source: the authors

allows using RPA as a complimentary technology to business processes defined using BPMN in Bizagi, allowing the BPM software to invoke an automation defined in Automation Anywhere on demand. This integration is only available with the Automation Anywhere enterprise edition.

Based on this analysis, it is possible to notice that the automation diagrams described using Automation Anywhere are essentially a business process performed by a robot and each action described in the steps can be seen as a task. In table 4.1 we compare some of the elements available in Automation Anywhere and possible elements from the BPMN that can be used to represent them.

Table 4.1: Automation Anywhere elements and BPMN analogy

Element	*BPMN Potential Alternative*
Loop / continue / break	Gateways
Try / Catch / Finally / Throw	Event triggers
If / Else If / Else	Gateways
Trigger Loop / Handle / Break	Gateways and event triggers
Wait	Timer events
Triggers	Event triggers
Step	Activities (tasks and subprocesses)

Source: the authors

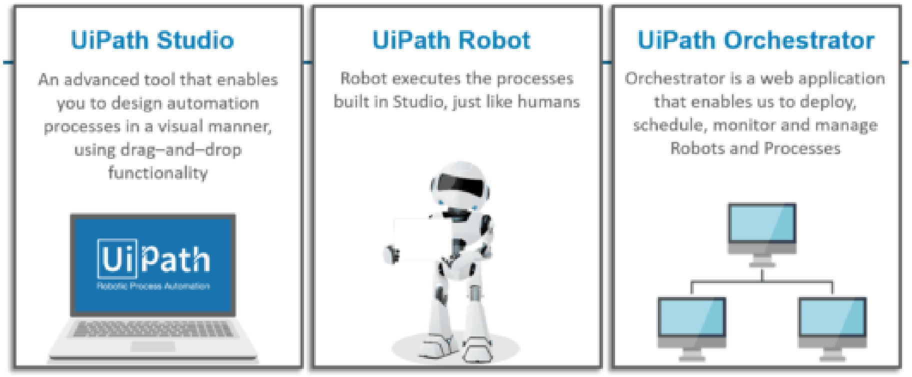
4.3 UiPath Studio Community Edition

UiPath, first named DeskOver, is a company created in 2005 by Daniel Dines and Marius Tirca in Romania (TAULLI, 2019). Their initial focus was building automation libraries and software development kits for organizations such as IBM, Google and Microsoft. With their automation expertise, in 2012 UiPath started working on their RPA platform. By April 2016, UiPath had released its Front Office and Back Office Server suites and made available the UiPath Studio Community Edition (GHEORGHE, 2019).

We chose the community edition of UiPath platform for this analysis as it offers all the bot building functionalities available in the paid versions. The UiPath platform mainly offers 3 components that are used to manage the entire life-cycle of the robots: UiPath Studio, UiPath Robot and UiPath Orchestrator, as illustrated in Fig. 4.7

UiPath Studio offers a guided user interface that allows users to build automation workflows using pre-built activities (KAPPAGANTULA, 2020). Studio provides three levels of workflow complexity levels: sequences, flowcharts and state machines. Sequences are basically building blocks for executing sequential tasks. Flowcharts allow

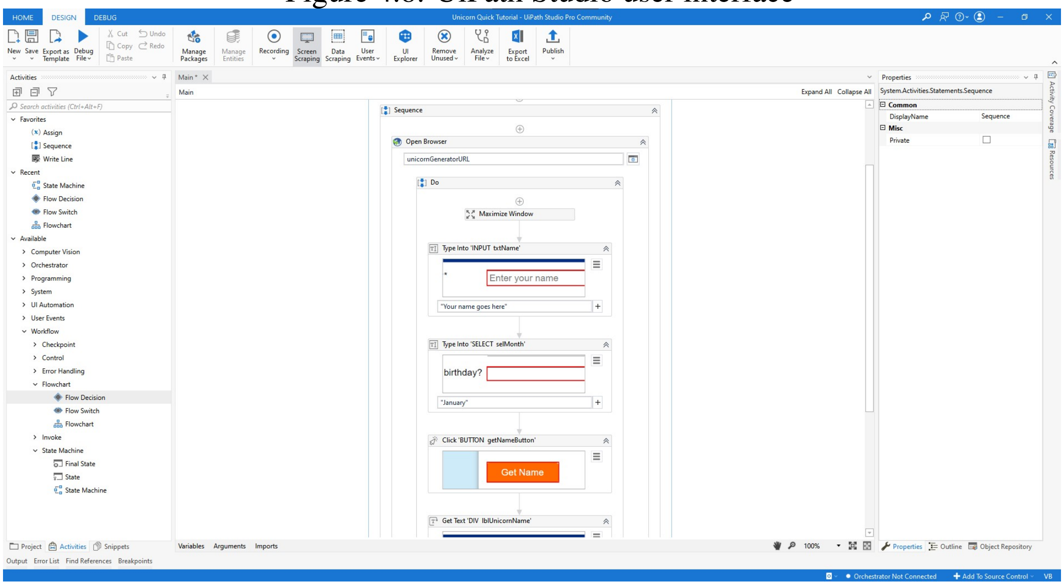
Figure 4.7: UiPath platform components



Source: (KAPPAGANTULA, 2020)

adding alternative task paths based on flow blocks. State machines allow the definition of multiple paths based on a set of states and conditional state transitions. All these workflow strategies can be used concomitantly. With these elements it is possible to build multiple configurations for a process diagram. Besides that, Studio also counts with recorders for user actions, debugging tools, exception handling utilities and optical character recognition technologies. Fig. 4.8 depicts the UiPath Studio user interface.

Figure 4.8: UiPath Studio user interface

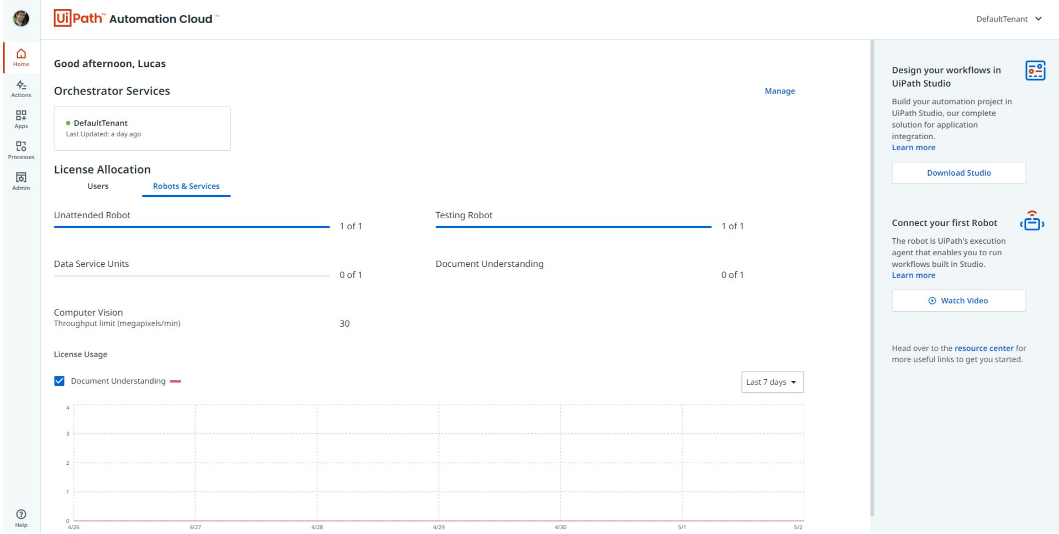


Source: the authors

The UiPath Robot is the application responsible for running the automation created in UiPath Studio. The robots are fundamental in the life-cycle of an automation, as once the automation is fully developed and tested, it can be deployed to more than one robot at once. It is possible to run multiple instances in multiple hosts of the UiPath Robot simultaneously, providing scalability to the automated process (UiPath, 2021).

Finally, UiPath Orchestrator, named as UiPath Automation Cloud, is the product responsible for managing the robots. It allows instancing robots to platforms and assigning automation projects created using UiPath Studio to them. The orchestrator also provides details and statistics about the active robots and their jobs. Fig. 4.9 shows the user interface of the UiPath Automation Cloud.

Figure 4.9: UiPath Automation Cloud user interface

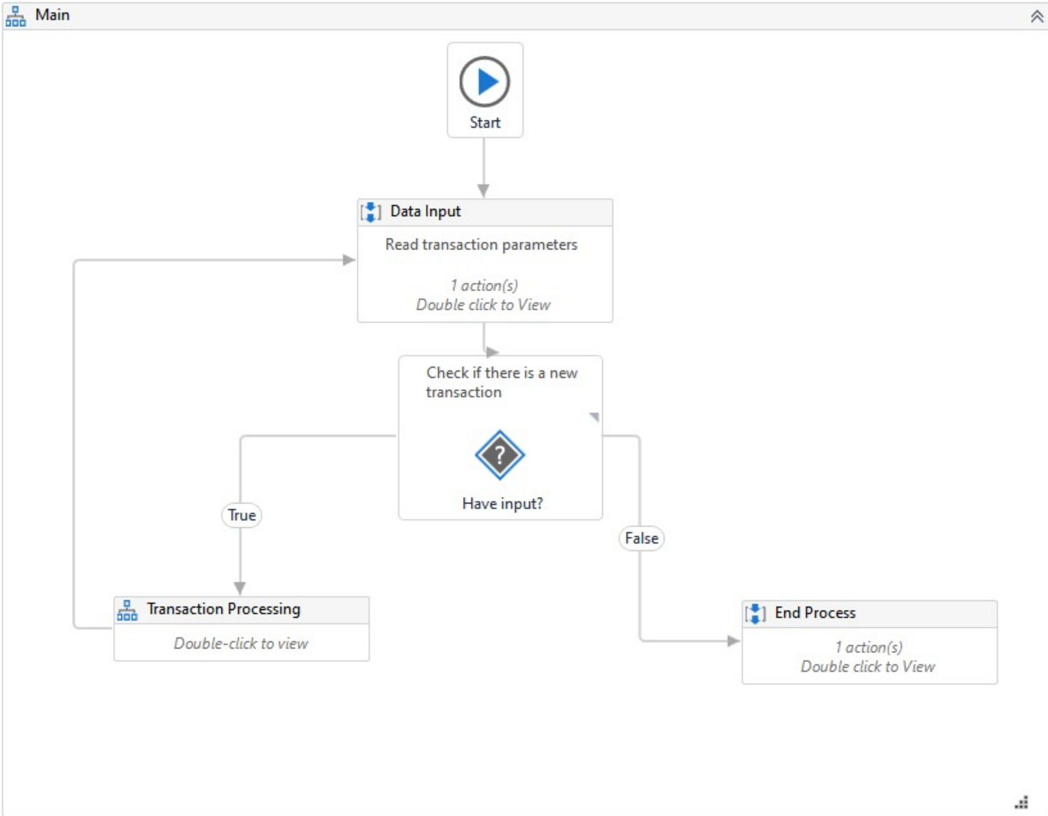


Source: the authors

With the elements available in UiPath studio it is possible to model a process using flowcharts. The flowchart features some elements similar to the ones used by the BPMN. For example, it is possible to create a conditional flow using the Decision or Switch elements. The Flow Decision element allows defining a binary flow based on the logical value of a specified Boolean expression. The Flow Switch element allows defining multiple paths based on the value of a defined expression of a wide variety of data types (e.g. integer, string, array and even custom types like data table). These elements can partially mimic the behavior of divergent exclusive gateways specified by the BPMN. Also, flowcharts support inner flowcharts, i.e. It is possible to call a different flowchart inside the main flowchart. This can be used to define a BPMN subprocess using the UiPath Studio interface. Fig. 4.10 shows an example of a simple process flowchart in UiPath Studio.

Despite of these similarities between some elements (listed in table 4.2), it is not possible to say that UiPath Studio is compliant with the BPMN. The website documentation has no references regarding the BPMN (UiPath, 2021) and, based on the analysis done for this study, there is no way of directly specifying any BPMN element in UiPath Studio. However, as Automation Anywhere, UiPath also offers integration with BPM applications, such as Bizagi and Appian. This integration allows the BPM application to

Figure 4.10: UiPath Studio flowchart



Source: the authors

execute bots defined by UiPath by passing the required parameters.

4.4 Blue Prism Trial

Blue Prism is a company from the United Kingdom founded in 2001 with the goal of creating a digital workforce for business process outsourcing. Blue Prism plays an important role in the RPA community and was arguably the group who coined the term RPA (MULLAKARA, 2019).

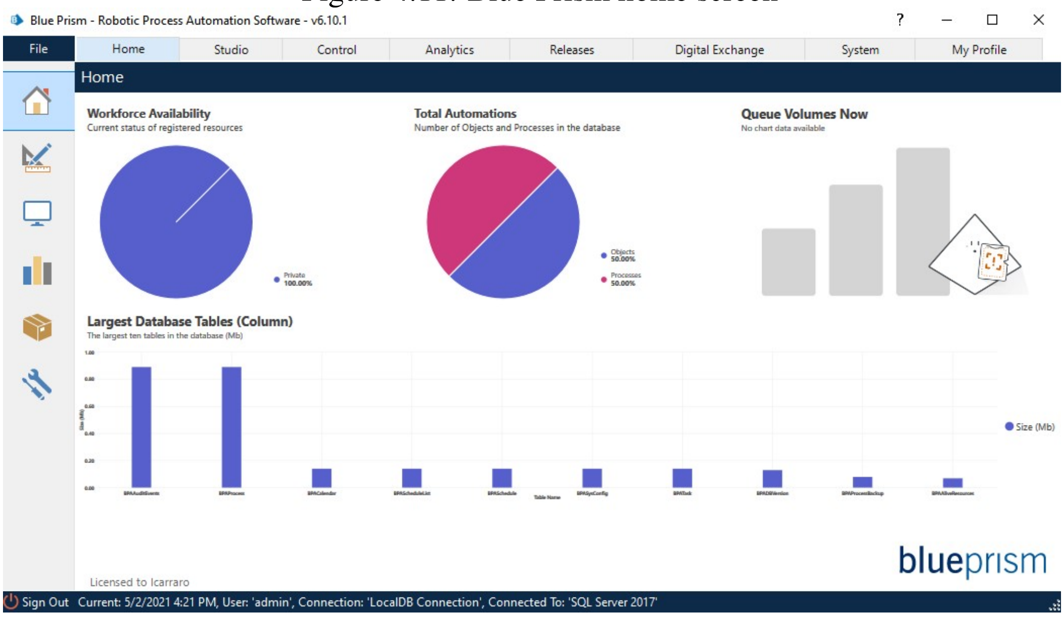
Currently there are no free versions of the Blue Prism application, but they do offer a free 30 day trial for users interested in their product. For this analysis we are evaluating the trial version of the software that, according to the vendor website, offers the same features as the full version. With this version it was possible to test their RPA software which mainly comprises 3 tools: the Process Studio, the Object Studio and the Application Modeller. Besides these core tools, Blue Prism also presents a summary report of the bots in its home screen. Fig. 4.11 illustrates a screenshot of the Blue Prism home screen.

Table 4.2: UiPath elements and BPMN analogy

Element	*BPMN Potential Alternative*
Check false/true	Gateways
Switch	Gateways
Delay	Timer events
Do While / While / For Each	Gateways
If	Gateways
Parallel	Gateways
Parallel For Each	Gateways
Sequence	Activities (tasks and subprocesses)
Try Catch / Throw / Terminate Workflow	Event triggers
Flow Decision / Flow Switch	Gateways
Flowchart	Activities (tasks and subprocesses)

Source: the authors

Figure 4.11: Blue Prism home screen

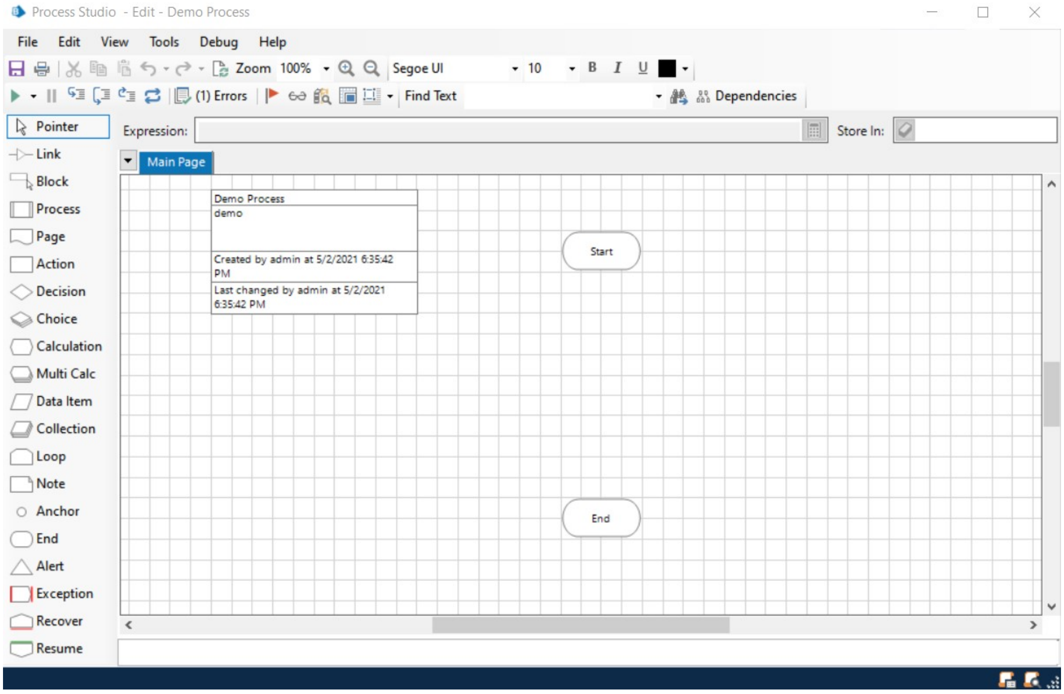


Source: the authors

Object Studio and Application Modeller are two features that Blue Prism created to facilitate the integration of their robots with external applications. Application models are responsible for informing Blue Prism how to interpret the elements in the UI of external applications. These models are used to define a flowchart within the objects. Objects are, essentially, an algorithm that tells the robot how to handle the external application interface. The Object Studio is used for creating these algorithms in the form of flowcharts.

Similarly to the Object Studio, Blue Prism also offers the Process Studio. The purpose of Process Studio is, as the name suggests, to define business processes and tell the bot what it should do with the objects created in the Object Studio. Essentially, this is where the business logic of the automation is written. Fig. 4.12 shows a screenshot of the Process Studio UI.

Figure 4.12: Blue Prism Process Studio



Source: the authors

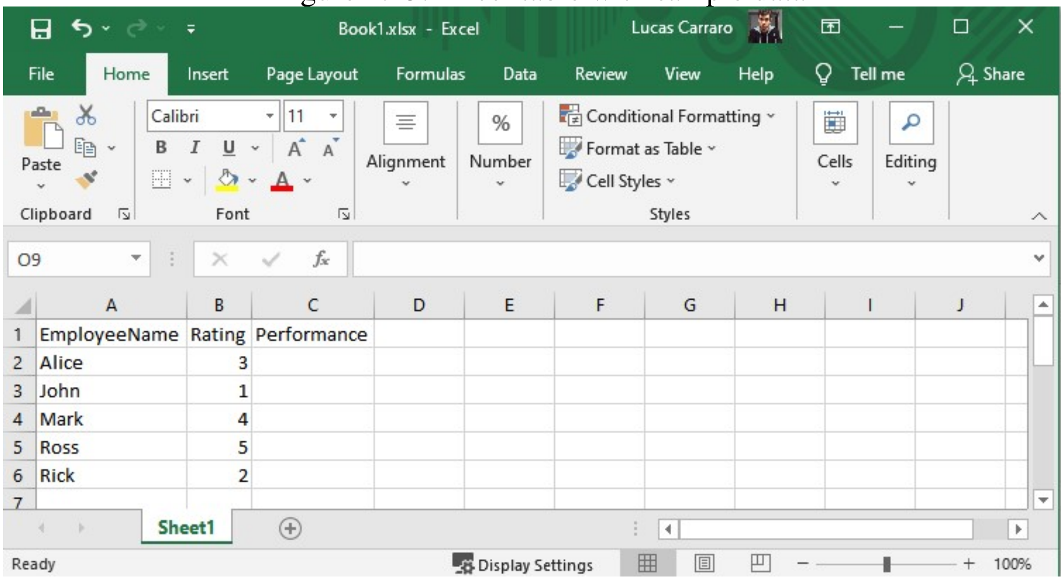
Both Process Studio and Object Studio offer a GUI based on flowcharts. For this analysis we are going to focus on the Process Studio as it is the feature responsible for modelling business processes within Blue Prism. In order to verify the functionality of Process Studio, a simple automation was built to populate a column in an Excel spreadsheet based on the values of a different column. The goal of this automation is to iterate over the rows of the spreadsheet illustrated in Fig. 4.13 and populate column "Performance" based on the correspondent value in column "Rating".

The robot should open the spreadsheet and for each row fill the "Performance" cells with the following values: "Awesome" for rating 5, "Great" for rating 4, "Ok" for rating 3, "Average" for rating 2 and "Bad" for rating 1. The process flowchart for this automation is represented in Fig. 4.14

Once the execution of the automation is triggered, the bot starts running and opens the excel document. Then it proceeds to the interpretation steps when it starts writing in the required cells. After completing the writing, the bot saves the document and closes the worksheet. The column ends up populated in the worksheet as shows Fig. 4.15

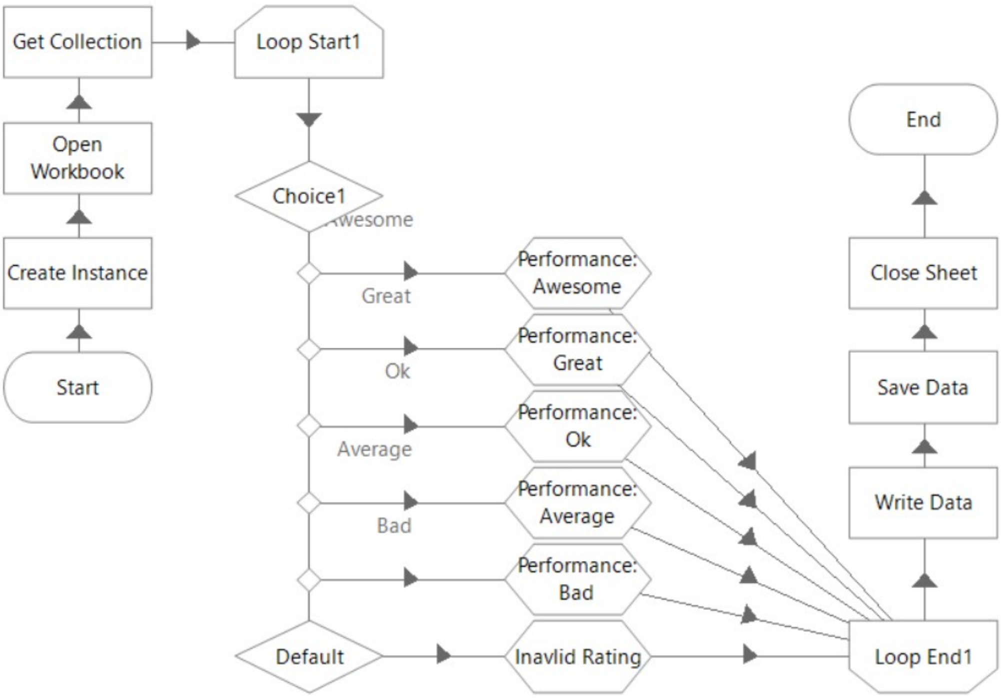
As seen in figure 4.14, Blue Prism uses a flowchart to design its bots. Therefore, it can be said that Blue Prism does not directly support the BPMN standard. However, as

Figure 4.13: Excel table with sample data



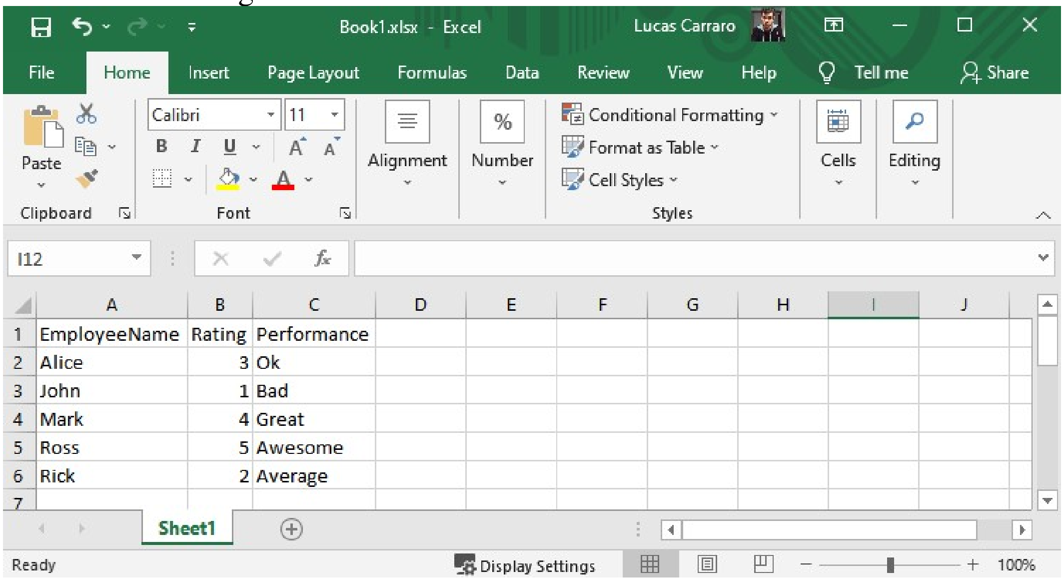
Source: the authors

Figure 4.14: Example of automated process in Blue Prism



Source: the authors

Figure 4.15: Excel table after the automation ended



Source: the authors

the other analysed tools, Blue Prism also offers integration support with third party BPM applications such as Appian and Bizagi. Table 4.3 lists some of the modelling elements available in Blue Prism and BPMN elements that could potentially be used to represent them.

Table 4.3: Blue Prism elements and BPMN analogy

Element	*BPMN Potential Alternative*
Loop	Gateways
Action	Tasks
Process	Subprocesses
Page	Subprocesses
Decision	Gateways
Choice	Gateways
Exception	Event triggers

Source: the authors

4.5 Analysis Summary

Through the analysis of Automation Anwyhere, UiPath and Blue Prism, it was observed that none of the tools explicitly use the BPMN as their modelling language. However, after experimenting with the modelling elements provided in the UI of each tool, it became evident that the actions executed by RPA bots are essentially the tasks performed by an actor in a business process. The bots are, after all, supposed to replace humans in specific tasks. The main difference is that tasks performed by humans are more subjective and bots require them to be systematically explained.

If a task says "delete files from received list" a human knows how to do it based on its expertise. However, bots require these tasks to be refined. They need the tasks to be decomposed into mechanical steps such as "read list", "find files", "delete files". Something that is seen as atomic at the BPMN level (task) becomes a series of instruction at the RPA level.

With the intent of simplifying the writing of instructions for robots, each RPA vendor has chosen a modelling language they considered appropriate for their purposes. However, based on the observations made in this work, their choices demonstrated several similarities with the features provided by the BPMN. In general, the visual representation of the bot's work provided by each vendor demonstrated to be reproducible using BPMN elements. Yet, the approach adopted by all of the analysed vendors in regard to supporting business processes is allowing specialized tools to integrate with their platform, calling the bots to execute specific tasks on demand.

Table 4.4 lists some characteristics of each analysed RPA tool, such as supported syntaxes, source availability, support to integration with BPM tools and correlation between their design language and the BPMN elements. The source availability is an important factor for the tools since closed-source products can limit the progress of scientific investigations regarding the applications. The BPMN correlations overview column presents a summary of the suggested BPMN elements that could be used to represent some elements in each RPA tool. The last column indicates if the RPA tool supports integration with external BPM tools - an important capability since, based on the observations done in this work, it seems that, currently, the adopted approach by the industry to unite BPM and RPA is via API calls between dedicated applications.

4.6 Chapter Summary

The commercially available RPA technologies are all relatively new and have changed a lot in the past few years. As RPA doesn't have a standardized specification, the notation for an automated process is still open to the software developers. In the vendors websites, each unique UI is generally presented as intuitive and easy to use by non-tech-savvy customers. Despite not supporting BPMN directly, the applications analysed in this work seem to be at least partially inspired by the BPMN elements.

Based on the individual analysis of the applications, it was verified that the way each of them specify the actions performed by the bots could probably be modelled by BPMN diagram. The reasons why none of the vendors adopt the BPMN as their modelling choice remain unknown.

There are discussions about standardization of business processes before they are ready for automation, but there is still a lot of space for discussions regarding the RPA notation. Fernando (2019) discusses the importance of standardizing the business processes for RPA readiness, but that is as far as the found discussions go.

Table 4.4: Overview of the RPA tools

Tool	*Source Code*	*Supported Syntaxes*	*BPMN Correlations Overview*	*Supports Integration with BPM tools*
Automation Anywhere	Closed Source	Sequence flow	loops and if-else elements could be represented with gateways; try-catch and aait blocks could be represented with event triggers; trigger loops could be represented using a combination of gateways and event triggers; wait blocks could be represented using timer events; step blocks could be represented as activities.	Yes
UiPath	Closed Source	Flowchart, state machine and sequence	Delay elements could be represented as timer events; check false/true, switch, do-while, for each, if, parallel, parallel for each and flow decision/switch blocks could be represented with gateways; try-catch, throw, and terminate workflow elements could be represented with event triggers; sequence and flowchart blocks could be represented with activities.	Yes
Blue Prism	Closed Source	Flowchart	Loop, decision and choice elements could be represented using gateways; process and page elements could be represented with subprocesses; action elements could be represented with tasks.	Yes

Source: the authors

5 CONCLUSION

This work presented an analysis of the modelling paradigms adopted by the 3 major RPA software vendors and a comparison of these paradigms with the standard defined by the BPMN. One of the main challenges faced throughout this research is the fact that RPA, despite being in the industry for a while, is a relatively recent academic field and many of its concepts are not an agreement among the community.

Based on the literature analysis it was concluded that RPA and BPM are two areas that share the goal and values of improving the efficiency of businesses by optimizing their processes. RPA, however, focuses on reducing the costs of certain repetitive tasks in processes, while the BPM scope is much broader and aims on organizing and optimizing entire processes and their interactions.

After analysing each RPA application individually and their approaches to the definition of an automated task, it became clear that the way bots behave is very similar to the way an employee performs its work. The purpose of the bot, after all, is to replace humans in repetitive activities. With that in mind, there is a chance that using the BPMN to model the behavior of RPA bots is in fact possible.

Considering the analysis in this work, it was possible to answer RQ1, RQ2 and confirm H. We can state that none of the analysed tools directly offer support to the BPMN and that the approach adopted by all of them regarding cooperation with BPM efforts is through an integration with BPM specialized tools. Furthermore, based on a superficial analysis of the elements provided in each tool, it was also possible to identify behavioral similarities with the elements available in the BPMN.

The academic contributions of this work include investigating the adoption of one of the most important business process modelling standards - the BPMN - by the RPA community and also beginning to understand how feasible it would be to model RPA bots using the BPMN considering the current implementation of the RPA tools. It is relevant mentioning that, among the several definitions open for debate in RPA research, the modelling of robotic processes is one of the topics with least contributions and that could deliver high value to the field.

The results of this work can be an asset to the specification of a BPMN extension targeted for RPA applications and it also serves as a bridge to link BPM and RPA researches. The literature analysis showed that both areas work very closely but there is a scarce number of articles directed to correlating the concepts of one area to the other.

As a future work, this study could be extended to a deeper analysis of the challenges faced in adopting the BPMN as a standard for RPA bot design. If the BPMN is capable of representing flow elements available in multiple RPA tools, then it might as well be suggested as a standard for modeling robotic processes. With the BPMN acting as a standard for both BPM and RPA fields it would be possible to unify the tools and deliver more value to customers.

REFERENCES

AALST, W. M. P. V. D.; BICHLER, M.; HEINZL, A. Robotic process automation. **Business & Information Systems Engineering**, v. 60, n. 4, p. 269–272, 2018.

AGATON, B.; SWEDBERG, G. 2018. Available from Internet: <https://hdl.handle.net/20.500.12380/255664>.

AGUIRRE, S.; RODRIGUEZ, A. Automation of a business process using robotic process automation (rpa): A case study. In: FIGUEROA-GARCÍA, J. C. et al. (Ed.). **Applied Computer Sciences in Engineering**. Cham: Springer International Publishing, 2017. ISBN 978-3-319-66963-2.

ANAGNOSTE, S. Robotic automation process - the next major revolution in terms of back office operations improvement. **Proceedings of the International Conference on Business Excellence**, 2017.

ASATIANI, A.; PENTTINEN, E. **Turning robotic process automation into commercial success – Case OpusCapita**. 2016. Available from Internet: <https://journals.sagepub.com/doi/abs/10.1057/jittc.2016.5>.

Automation Anywhere. **Automation Anywhere Version A2019.20 On-Premises**. 2020. Available from Internet: <https://aa2019packagesdkfordocumentation.s3-us-west-2.amazonaws.com/A2019-on-premises/A2019.20-on-premises.pdf>.

Bizagi. **Automation Anywhere bot integration**. 2021. Available from Internet: <https://help.bizagi.com/bpm-suite/en/index.html?automation-anywhere-bot-integr.htm>.

BURGESS, A. **The Executive Guide to Artificial Intelligence: How to identify and implement applications for AI in your organization**. [S.l.]: Springer International Publishing, 2018.

BURNETT, S. et al. **Defining Enterprise RPA**. [S.l.]: Everest Group Research, 2018.

CASEY, K. **How do Robotic Process Automation (RPA) and Business Process Management (BPM) fit together?** 2020. Available from Internet: <https://enterprisersproject.com/article/2020/11/how-do-robotic-process-automation-rpa-and-business-process-modeling-bpm-fit-together>.

CHINOSI, M.; TROMBETTA, A. **BPMN: An introduction to the standard**. 2012. Available from Internet: <https://www.academia.edu/816323/BPMN_An_introduction_to_the_standard>.

DILLA, R.; JAYNES, H.; LIVINGSTON, L. 2017. Available from Internet: <https://irpaai.com/wp-content/uploads/2015/05/Robotic-Process-Automation-June2015.pdf>.

DUMAS, M. **Fundamentals of business process management**. [S.l.]: Springer, 2013.

FERNANDO, L. **Business Process Standardization with RPA**. 2019. Available from Internet: <https://forum.uipath.com/t/business-process-standardization-with-rpa/146350>.

GHEORGHE, G. **The story of UiPath - How did it become Romania's first unicorn?** Business Review, 2019. Available from Internet: <https://business-review.eu/news/the-story-of-uipath-how-it-became-romanias-first-unicorn-164248>.

GRUNG-OLSEN, H.-C. **A Strategic Look at Robotic Process Automation**. 2017. Available from Internet: <https://www.bptrends.com/bpt/wp-content/uploads/011-09-2017-ART-Strategic-Look-at-Robotic-Process-Automation-Grung-Olsen.pdf>.

HAJJAR, A. J. **RPA Market Size and Popular Vendors in 2021**. 2021. Available from Internet: <https://research.aimultiple.com/rpa-market/>.

HORTON, R. **The robots are coming: Moving beyond traditional methods of automation**. 2015. Available from Internet: <https://www2.deloitte.com/uk/en/pages/finance/articles/robots-coming-global-business-services.html>.

HORTON, R.; WITHERICK, D.; GORDEEVA, M. **The Robots are Ready. Are You? Untapped Advantage in Your Digital Workforce**. 2017. Available from Internet: <https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/technology/deloitte-robots-are-ready.pdf>.

KAPPAGANTULA, S. **UiPath RPA Architecture – A Deconstruction of the Components of UiPath**. 2020. Available from Internet: <https://www.edureka.co/blog/uipath-rpa-architecture/>.

KARAGIANNIS, D. Business process management: A holistic management approach. **Lecture Notes in Business Information Processing Information Systems: Methods, Models, and Applications**, 2013.

KIRCHMER, M. 2017. Available from Internet: <https://insights.btoes.com/risks-robotic-process-automation-pragmatic-solution-or-dangerous-illusion>.

KIRCHMER, M.; FRANZ, P. Value-driven robotic process automation (rpa). In: SHISHKOV, B. (Ed.). **Business Modeling and Software Design**. Cham: Springer International Publishing, 2019. ISBN 978-3-030-24854-3.

KROLL, C. et al. Robotic process automation - robots conquer business processes in back offices. 2016.

LACITY, M.; WILLCOCKS, L. P. Robotic process automation: The next transformation lever for shared services. 2016.

LACITY, M.; WILLCOCKS, L. P. Robotizing global financial shared services at royal dsm. tech. rep. 2016.

LACITY, M.; WILLCOCKS, L. P. Innovating in service: The role and management of automation. **Dynamic Innovation in Outsourcing**, 2018.

LAMBERTON, C. **Get ready for robots - Why planning makes the difference between success and disappointment**. Ernst & Young, 2016. Available from Internet: <https://eyfinancialservicesthoughtgallery.ie/wp-content/uploads/2016/11/ey-get-ready-for-robots.pdf>.

MULLAKARA, N. **The Remarkable History of Robotic Process Automation (RPA)**. 2019. Available from Internet: <https://nandan.info/history-of-robotic-process-automation-rpa/>.

OMG. **Business Process Model and Notation (BPMN), Version 2.0.2**. 2013. Available from Internet: <http://www.omg.org/spec/BPMN/2.0.2>.

PAWAR, S. Bpmn tools - a comparative analysis to improve interoperability. 2011.

STIEHL, V. **PROCESS-DRIVEN APPLICATIONS WITH BPMN**. [S.l.]: SPRINGER INTERNATIONAL PU, 2016.

SYED, R. et al. Robotic process automation: Contemporary themes and challenges. **Computers in Industry**, 2020.

TARQUINI, T. **Practical Robotics in Insurance – The Future is Here Already**. John Wiley & Sons, Ltd, 2018. Available from Internet: <https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119444565.ch52>.

TAULLI, T. Robotic process automation (rpa): An easier path to ai. **Artificial Intelligence Basics**, p. 91–102, 2019.

UiPath. **The UiPath Activities Guide**. 2021. Available from Internet: <https://docs.uipath.com/activities>.