



**FACULTY
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TECHNOLOGY
CTU IN PRAGUE**

ASSIGNMENT OF MASTER'S THESIS

Title: The evolvability of technologies with the help of robotic process automation (RPA) tools.
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Instructions

Under the current pace of technology changes, it starts to be a challenge for an organization to keep up with the latest technology. A possible solution to that is to build up a software separating models of business processes from the actual technology. These systems are typically found under an acronym BPMS (Business Process Management System) and help organizations to systematically guide its employees, prepare their daily agenda and gain an overview above the company processes. However, many routine administrative tasks fulfilled by employees are not driven by BPMS yet. Robotic Process Automation (RPA) is an answer to that. It helps companies to automate these tasks and build agents to execute them.

1. Review current RPA tools and BPMS
2. Propose how they can be integrated together
3. Implement a prototype demonstrating this integration
4. Evaluate and comment on your results

References

Will be provided by the supervisor.

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Master's thesis

The evolvability of technologies with the help of Robotic Process Automation

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May 28, 2020

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Declaration

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In Prague on May 28, 2020

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Abstrakt

S rozvojem digitálních technologií čelí podniky zvyšujícímu se tlaku na modernizaci svých nástrojů umožňujících jim držet s těmito změnami krok. Jedním z nejaktuálnějších řešení, které trh v oblasti digitalizace nabízí, je robotická procesní automatizace (RPA). Tato diplomová práce má za cíl navrhnout cestu efektivního využití RPA v dalším vývoji již existujících systémů, například Business Process Management System (BPMS). Pozornost je nejprve zaměřena na popis RPA a BPM řešení vybraných dodavatelů, analýzu jejich notací a zhodnocení přínosu pro podniky. Následně je zkoumána myšlenka integrace RPA se systémy BPM ve snaze identifikovat související výzvy a limitace. Práce je završena výstupem v podobě prototypu integrace RPA se systémem BPM.

Klíčová slova robotická procesní automatizace, RPA, business process management, BPM, systémy BPM, evolvabilita, podnikové procesy, automatizace.

Abstract

The continuous progress in the digital world creates a need for developing faster technologies that will help businesses to keep on track. One of the most trending solutions for digitalization present on the market is Robotic Process Automation (RPA). This thesis outlines how RPA can help existing systems, such as Business Process Management Systems (BPMS), to evolve faster. The text describes different RPA and BPM vendors, analyses their notations and overviews the benefits they bring to organisations. Further, it explores the idea of implementing integrated RPA and BPM solution, its challenges, and limitations. The product of this work is a prototype of an integrated RPA and BPM system.

Keywords robotic process automation, RPA, business process management, BPM, BPMS, evolvability, business process, automation.

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Introduction

1.1 Motivation - Why Robotic Process Automation ?

In recent years, there has been a growing trend of digitalization, where digital technologies are used to change the business model to provide new value opportunities. Many businesses are urged towards this trend to improve traditional working practices. According to Klynveld Peat Marwick Goerdeler (KPMG), consulting company, in the next 10 to 20 years, 47% of the jobs will be automated or replaced by robot labour [1]. Robotic Process Automation comes in very handy in this situation. Robotic Process Automation (RPA), as defined by Gartner,

“is a productivity tool that allows a user to configure one or more scripts known as ”robots” or “bots”, to activate specific keystrokes in an automated fashion. The result is that the bots can be used to mimic or emulate selected tasks within an overall business or IT process. These may include manipulating data, passing data to and from different applications, triggering responses, or executing transactions by combining user interface interaction and descriptor technologies [2].”

RPA helps organisations to quickly accelerate their digital transformation initiatives and cut the cost on repetitive work, which will allow them to reinvest the resources in more strategic and analytic activities, which in turn will help their business to grow.

However, RPA should not be seen only as a tool to automate tedious work and a mean to the vague digital transformation. When implemented in the right way, it could serve as an entry point to discover business processes. Business processes help the organisation to advance in terms of levels

of its Capability Maturity (CMMI)¹. Moreover, the models of business processes are often independent of any particular implementation environment [4], thus, helping the organisation to distinguish between its operations and its technology. Although, this is not in the scope of the thesis, it is argued, the properly captured business processes may help the organisation to improve in terms of evolvability - the ability to undergo adaptation, development, or an evolutionary change much faster [5], and that the organisation may replace ageing technologies better if its business processes are known and correctly managed. The evolvability itself is deeply investigated by Normalized Systems theory [6], however, I believe RPA can contribute here.

Next to the automation of tedious work, RPA should be seen as a bridge that helps to bring the organisation to a state when its operation is managed by Business Process Management (BPM) systems, and thus it gains all the related benefits that help it to evolve its technologies better.

Many multinational companies such as Deloitte, PwC, Capgemini, KPMG, EY and others, have already implemented RPA solutions and use it for their day to day tasks. These companies benefit by using RPA as it provides accurate, reliable, consistent outputs with high productivity rates [1, 7, 8, 9].

The implementation of RPA is fully compatible with systems that already exist in the business and therefore RPA finds application in various sectors such as healthcare, accounting, financial and customer services, and human resources by making work easier, in a reliable manner.

The scope of the thesis mainly focuses on exploring the concept of Robotic Process Automation and its use in the field of financial services, as well as the benefits it brings to companies. Further, I want to analyse how can RPA be integrated with already existing systems and whether it helps to quicken the manual work.

1.2 Challenges of RPA in Finance

As mentioned before, my interest is the application of Robotic Process Automation in the area of Finance and Digital Treasury and the challenges they are facing within the process of implementation. Since RPA has been becoming a big trend in the last few years, many consulting companies conducted surveys and studies in order to represent the development, application, implementation and the benefits it brings. Most of the statistics are in favour of using RPA automating processes in financial services.

Report issued by Grand Thornton “2019 CFO Survey report”[8] based on 378 senior finance executives from companies with revenue between 100 million

¹Capability Maturity Model Integration (CMMI) is a set of practices that help organisations to improve processes and increase productivity. It was developed by the Software Engineering Institute at Carnegie Mellon University as a process improvement tool for projects, divisions or organisations[3].

1.2. Challenges of RPA in Finance

and over 20 billion US dollars, 87% of executives agree that technology will impact the way their finance functions operates. According to their report, 40% of financial activities can be fully automated with the use of RPA. It is mentioned that 25% of the questioned CFOs have already implemented RPA in 2019, which shows significant growth compared to 2018 when only 7% had it while 23% plan to invest in RPA during the next 12 months.

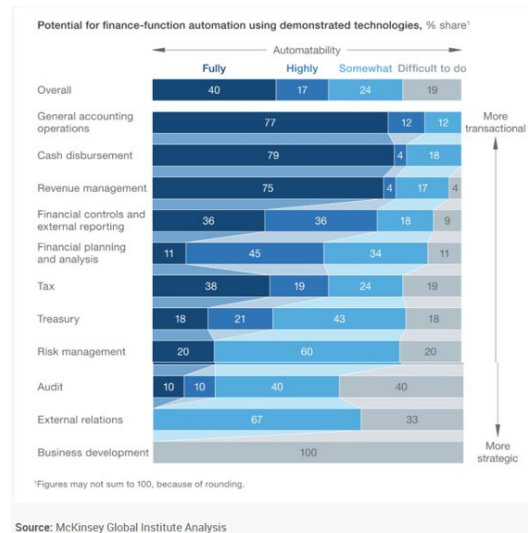


Figure 1.1: McKinsey Global Institute Analysis: Potential for automation in Finance

[10]

According to Deloitte “2020 Hot Topics IT Internal Audit in Financial Services” [9] the opportunities of automation in the area of finance are: automating of processes, automating controls testing and transforming metrics, and reporting. They point out that by using RPA tools the key benefits will be:

- Enhancing quality – removing error-prone manually intensive activities,
- Standardisation - codifying activities to reduce inconsistent performance,
- More timely and frequent insights – rapidly integrate data from multiple systems to provide more real-time view,
- Increase time for value-added activities – more time spent on high-value activities that increase the development and skills of the team,
- Reducing cost – reduce manual effort and reduce the cost of operating, testing, monitoring and reporting.

2019 Global Treasury Benchmark survey conducted by Pricewaterhouse-Coopers (PwC)[7] shows that more than 60% of the respondents see the potential of RPA in the next 3 years, which should increase productivity and allow insights that were once unattainable, also in cash flow forecasting and financial risk management. The most relevant areas in treasury where RPA finds application are:

- payment execution,
- deal confirmation,
- accounting,
- monitoring of payments,
- deal settlements,
- management reporting,
- financial reporting,
- deal execution,
- exposure capture and exposure analysis

The same survey also explores the challenges that companies generally face in the process of implementing RPA. One of the biggest obstacles is considered having no clear business use case and no long-term strategy. Missing standardisation of the processes as well digitisation of the same are another challenge that might need to be tackled. Once these challenges are faced and RPA is implemented successfully, companies can use it on a daily basis.

Even though many processes can be automated, it is crucial to keep in mind that there are finance tasks which are not very suitable for RPA, such as performing due diligence on acquisition targets, finding the lowest cost of funds or allocating an investment portfolio, anything that requires significant decision-making, or tasks that do not need to be executed frequently (e.g., annually) or with uncertain frequency. Processes with too bigger complexity are also not recommended to be automated.

1.3 Goals

In the scope of this thesis, the following steps will be followed to meet the final goal. The steps will be revisited and redefined, if needed, in more details after State-of-the-Art chapter.

1. Review Robotic Process Automation tools commonly discussed by consulting firms in a context of Finance,
2. Clarify common use cases in Finance and try to automate them by selected Robotic Process Automation tool,
3. Clarify the connection between Robotic Process Automation (RPA) and common Business Process Management (BPM) solutions,

4. Propose how the Robotic Process Automation and Business Process Management can be smoothly integrated,
5. Implement a prototype demonstrating an integration of RPA and certain Business Process Management Systems,
6. Evaluate and comment on the obtained results.

1.4 Structure of the Thesis

The thesis will be structured in few chapters, beginning with the Introduction part as Chapter 1, where I stated the motivation for choosing the topic, as well the goals I set to achieve in the scope of this thesis.

After the introduction part, the State-of-the-Art will follow next as Chapter 2. In this chapter, I will define Robotic Process Automation and review tools that are currently trending on the market. Further, will continue with reviewing Business Process Management solutions.

Chapter 2 should provide me with enough information to be able to revisit my goals and redefine them in greater details, in Chapter 3.

Next will be Chapter 4 - Analysis and design, where I will analyse the notation used by the RPA tool and BPMN 2.0 notation used by most of the BPM vendors on the market. Further, I will discuss how these notations are related, and if they provide options for collaboration. In the last part of the chapter will be presented the possible ways of integration of RPA and BPM systems. Also, I will conceptually explain the idea, which will be implemented in the next chapter.

In Chapter 5, which is the Case study, I will provide an example of a typical finance process in the introduction part. The same example will be automated later using some of the RPA tools, reviewed in Chapter 2. The next step will be to prototype the collaboration between RPA and BPM system. At the end of the chapter will be the testing part.

Before I finish with an evaluation of the work done in my thesis, I will provide a brief overview of related work and ideas for future work, in Chapter 6.

The thesis will be closed with Evaluation part, in Chapter 7, where I will evaluate whether or not my goals, from Chapter 3, were met and then Conclusion, in Chapter 8, which will be a summarization of the whole thesis.

State-of-the-art

In this chapter, I will introduce the State-of-the-Art of Robotic Process Automation and Business Process Management. I will review some of the existing tools on the market and narrow the scope of the thesis to the tools that I will use later in my work.

2.1 Review of Robotic Process Automation tools

Currently, on the market can be found many RPA tools for configuring and automating manual and repetitive tasks. Before comparing the leaders on the market between the RPA tools, a small reminder of what RPA is. *Robotic Process Automation* is the technology that allows automation of business processes by creating software robots (“bots”) in order to reduce human intervention within digital systems. The term *Robots* [11] refers to entities that mimic human actions in order to perform variety of repetitive tasks, while *Process* [12] is a set of activities that transforms the input into output.

2.1.1 RPA Robots

The Robots can be categorised as either *back or front office* robots [13]. Below, are listed some of the main differences between them.

Back office Robots:

- They do not require human intervention,
- Server-side initiation of robots,
- Triggered by a scheduled or monitoring,
- Mainly used in Order Management, Finance, IT,HR, Shared service centres,
- Drives cost down and reduces errors.

Front office Robots:

- User intervention is needed,
- Standalone,
- Triggered by user runs only under human supervision,
- Mainly used in Service desk, Call centres, Key accounts/control towers,
- Drives customer satisfaction.

Depending on the needs of automation, the user can choose a vendor that support both of them or only front office robots.

2.1.2 Defining Processes

A *Process* is always defined by four components: *Inputs*, *Process flows* – sequence of subprocesses, *Source applications* – applications used to perform the subprocesses, and *Outputs*.

As mention before, not every *Process* can be automated, so the question is "What makes a process to be a good candidate for automation?". In order to see whether a process can or cannot be automated, some rules need to be followed. Mainly they can be determined based on the *process fitness* and *automation complexity* as distinguished by a methodic introduced by Fingent, IT company developing IT business solutions [14]. They use the process fitness to categorise tasks into different categories.

- *Rule-based* – The decisions made (including data interpretation) in the process can be captured in a pre-defined logic. The exception rate is either low or can be included as well in the business logic.
- *Automatable and repetitive processes* - there are processes that have been already automated using other technologies than RPA.
- *Standard input* - input in the process should either be electronic and easily readable or readable using a technology that can be associated with RPA.
- *Stable* - Processes that have been the same for a certain period of time and no changes are expected within the next months.

As for the automaton complexity, they name several factors upon which the process automation depends [14], such as:

- *Number of screens* - The higher the number of screens, the more elements have to be captured and configured prior to the process automation.

- *Type of applications* - Some applications are more easily automated (such as the Office suite or browsers), others heavily increase the automation effort (Mainframe, for example).
- *Business logic scenarios* - An automation's complexity increases with the number of decision points in the business logic.
- *Type and number of inputs* - standard input is desirable. Non-standard input can be of different complexity grades, with free text being the most complex.

By using the above explained factors, Fingent sorts the process into four categories:

- *No RPA* -process that cannot be automated with the help of RPA tools,
- *Semi-Automation* - not completely automated,
- *High-Cost RPA* - use complex tech or require programming skills,
- *Zero-Touch Automation* - Processes that are digital and involve a highly static system and process environment, so that they can be easily broken into instructions and simple triggers can be defined

2.1.3 RPA Vendors

Recently IT Central Station published a practical guide for choosing RPA vendors based on product reviews, ratings, and comparisons, all made from real users and validated by their triple authentication process [15]. Vendors that are trending on the market are:

- UiPath,
- Blue Prism,
- Automation Anywhere,
- IBM RPA
- WorkFusion,
- Pega Systems,
- KOFAX,
- SAP Contextor

When selecting a vendor, the customer must always choose accordingly to the capabilities of the RPA solution and try to match the business process automation needs. Some of the parameters that help in the process of choosing a vendor that is more suitable for the needs of the customer are the following parameters:

- *Technology* – in which technology is the RPA tool build. Has to be platform-independent and should support any application and platform.

- *Interface* – how easy is the tool to use. Complex interface will cause a delay in the process of implementation. (Prefer drag and drop, auto-capture, image recognition, etc.)
- *Management* – how effectively and easy the Robots can be managed. Should provide a high level of visibility and control in terms of process monitoring, change, development, and re-use.
- *Security* – how safe are Robots compared to humans.

According to Forrester Research "The Forrester Wave: Robotic Process Automation, Q4 2019" [16], the leaders on the market are UiPath, Blue Prism and Automation Anywhere. Another report issued by PwC "Digital masters" in November 2019 [17], reports that companies, based on the survey results, favour the same RPA vendors. Therefore, I will focus on these three RPA market's leaders, each offering widely used tools with similar functionalities and structure, but with own advantages and drawbacks.

2.1.3.1 UiPath

UiPath is the fastest-growing enterprise software company in history and in 2019 was named a leader in the Gartner Magic Quadrant for Robotic Process Automation Software [18]. Briefly, they were founded in 2005 in Bucharest, Romania under the name "DeskOver". Later, in 2013 they launched the desktop automation product and finally, in 2015 they introduced the enterprise platform along with new name UiPath [19].

The main goal of the company, according to their CEO, is having a robot for every person [19].

"Bill Gates used to talk at Microsoft about a computer in every home. I want a robot for every person" - Daniel Dines, CEO of UiPath

UiPath is built on the Microsoft .Net platform, therefore offers deep integration with Microsoft Office, Office365, and Dynamics 365, as well as PowerBI. The tool is available for customers to deploy in Microsoft Azure and has out of box integration with various Azure Services, including Azure Cognitive Services, enabling more intelligent RPA solutions to be created. Unfortunately, UiPath product is only available for Windows OS [20]. Technologies that are covered within UiPath:

- Desktop automation,
- Web automation,
- GUI automation,
- Screen scraping,
- Citrix automation,
- Mainframe automation,

- SAP automation,
- SAP S/4HANA migration,
- Excel automation,
- Macro recorder.

UiPath Platform offers all the components needed to design and develop automation projects, execute the instructions automatically and manage your Robot workforce. The main components are UiPath Studio, Orchestrator, and UiPath Robot.

1. **UiPath Studio** helps to design and model automation workflows from pre-build Activities. It is available for developers, Studio, or business users, StudioX Preview. UiPath Studio offers many predefined operations that allow interaction with a variety of desktop applications, web browsers, and OCR engines.
2. **UiPath Orchestrator** is a web application, that provides an overview of the processes and allows the user to manage the Robots. Its main uses are control, management, and monitoring.
3. **UiPath Robot** is used for executing workflows and instructions sent locally or via Orchestrator. There are two types of Robots:
 - Attended – is triggered by events, and needs human interaction. Always operates on the same workstation.
 - Unattended - run unattended in virtual environments and can automate any number of processes.

UiPath platform offers many possibilities of automation and the main reason why customers choose this vendor is due to “ease of use for less-skilled business users, computer vision, simplified automation development based on Microsoft Workflow foundation, orchestrator multitenancy, and support for high-density robotics”, as described in ”Ovum Decision Matrix: Selecting RPA”, study published by Ovum TMT Intelligence [21].

2.1.3.2 Blue Prism

Blue Prism is another vendor that develops Enterprise Robotic Process Automation software that automates end-to-end operational activities. It was developed in 2001 by a group of process automation experts as a tool, that focuses on back-office [22]. It is considered that the term Robotic Process Automation (RPA) was invented by Blue Prism [23].

Blue Prism uses technology based on Microsoft .NET framework and any type of platform and applications that are supported by this. It provides easy drag and drop interface, while for more complicated tasks, the user needs C# knowledge. The product architecture is *client-server* based with a main

focus on back-office automation (unattended robots). Can be used to automate software developed in Java and web and Windows applications. Same as UiPath, Blue Prism supports only Windows OS. Their digital Workflow operating system is composed of:

1. **Object Studio** used for building automated processes via drag and drop interface. Blue Prism uses Objects, which represent events and actions needed for process modeling.
2. **Digital workforce** represent the autonomous software Robots, that execute the automated processes. The digital workforce is enhanced with AI and cognitive capabilities.
3. **Control Room** is an application used for assigning processes to Robots. Allows scaling Digital Workers on-demand.

According to the Ovum Analysis [21], Blue Prism has a modular architecture with component APIs and scores high when it comes to security, monitoring, and dynamic capacity management. Though, customers complained that in some cases are required more technical skills.

Unfortunately, Blue Prism web page does not offer in-depth information regarding the specification of their products nor documentation that is available to users.

2.1.3.3 Automation Anywhere - AA

Automation Anywhere is another of the popular RPA vendors offering powerful and user-friendly RPA capabilities to automate complex tasks. As the company itself says, their goal is

“To enable companies to operate with unprecedented productivity and efficiency by automating any part of the enterprise that can be automated with the most intelligent and intuitive Robotic Process Automation platform we call “The Intelligent Digital Workforce” [24].”

AA combines conventional RPA with intellectual elements like natural language understanding and reading any unstructured data in order to automate ends-to-end business operations for companies. It is a web based Management System, that uses a Control Room to run Automated Tasks. AA architecture has 3 primary components:

- **Control Room** - web based platform that controls AA bots,
- **Bot creator** - desktop based application for creating bots,
- **Bot Runner** - machine used for running the bots.

Control Room, besides for observation of bots and analytic overview, can be used for user and license management. It also allows source control, making it easier to share the code for the bots across different systems. Other important components of AA are:

- **Bot Insights** - show statistic and display graphs to analyse the performance of every bot in the system.
- **Bot Farm** is integrated with AA Enterprise and allows creating multiple bots.
- **Bot Store** is a marketplace that offers lots of pre-built bots for every type of business automation.

Depending on the customer's needs for automation, AA provides three types of Bots. If the task that needs to be automated is rule-based and repetitive, then should be used **Task Bots** [25]. Task Bots find use in areas such as document administration, HR, claims management, IT services, and more. These bots are good for immediate improvement in productivity, error reduction, and cost saving. Next are *Meta bots*, which represent automation building blocks, designed in such way that updates or changes in application will cause only minimal edits. Last are *IQ BOT*, advanced tool which can learn on its own and perform a task according to it. They work on the concept to organise an unstructured data while improving its skills and performance.

According to company's web page [25], AA claims to provide features such as intelligent automation for business and IT tasks, rapid automation of complex tasks, reduction of human errors with 100% accuracy, etc. Same as UiPath and Blue Prism supports only Windows OS.

2.1.3.4 Microsoft Power Automate

Microsoft Power Automate, previously know under the name Microsoft MS Flow, is a cloud based workflow engine that allows user to easily automate processes with connected sources, such as MS Office 365 [26].

This is a pretty easy, user-friendly tool, which can be used both by IT professionals or employees in Finance or HR since it does not require coding experience.

Power Automate is useful in automating work processes or tasks between preferred applications and service, such as getting immediate alerts to important notifications or emails, getting notifications on a mobile device, saving document attachments in emails to One Drive or SharePoint, etc.

It offers different flows for task and process automation, such as:

- *Automated flow* - allows to create a flow for automating task after it has been triggered by event,

- *Button flow* - lets users run repetitive tasks from anyplace via their mobile device,
- *Scheduled flow* - perform automation of tasks on a schedule,
- *Business process flow* - defines a set of steps for people to follow,
- *UI flow* - record and automate the playback of manual steps on legacy software.

UI Flows was Microsoft's latest feature added to Power Automate, which provides RPA capabilities [27]. This feature is a "point-and-click" operation that transforms manual tasks into automated workflows and is mainly aimed for Desktop and Web applications without APIs. UI Flows are right now in preview version and require paid Power Automate account [27]. They can be used on Windows 10 or Windows Server 2019, as from browsers only supports Microsoft Edge (latest version) and Google Chrome.

2.1.3.5 Summary

Robotic Process Automation allows organisations to automate task across applications and systems by replacing repetitive tasks performed by humans, with a virtual workforce. Main benefits are reducing costs, saving precious time and resources, increasing scalability, providing real-time visibility and discovering of bugs. Most of the RPA tools on the market are drag-and-drop and almost no programming skills are needed to configure a software Robot. Thus, any non-technical staff can set up a "bot" or even record their steps to automate the process.

Still, RPA has some disadvantages, such as limitation of Robot to the speed of the application, also small changes made in the automation application will require Robots to be reconfigured.

RPA generally targets large companies, though small to medium-sized organisations can deploy RPA to automate their business with very high initial costing.

When selecting RPA vendor one should base the decision on whether or not the tool allows easy reading and writing business data into multiple systems, which type of tasks are being mainly performed (rules-based or knowledge-based processes), whether the tools work across multiple applications, does it provides built-in Artificial Intelligence (AI) support to mimic human users, etc.

2.2 Review of Business Process Management solutions

“Business Process Management (BPM) is a discipline involving any combination of modeling, automation, execution, control, measurement and optimisation of business activity flows, in support of enterprise goals, spanning systems, employees, customers and partners within and beyond the enterprise boundaries [28].”

To better understand the definition given above, I will provide a short explanation of what every step means as described in “What is BPM” by Nathaniel Palmer [28]. *Modeling* a process means defining and representing a process so that it is supported in every step of the communication. *Automation* in most of the cases means providing a software solution that executes the process. *Execution* means that instances of a process are performed, by following the BPM model. *Control*, either strict or loose, means that there is some aspect of making sure that the process follows the designed course. Under *Measurement* is understood the effort taken to determine how well the process is working. *Optimisation* means that the discipline of BPM is an ongoing activity that builds over time to steadily improve the measures of the process. Business Process Management should be done in the context of an enterprise and not only a part of it. Therefore, when aiming for improvement the improvement should affect the whole enterprise process not only part of it, otherwise, it is not seen as an improvement. Also, customers are part of the business process and should be included in the end-to-end interaction, together with the employees and partners.

Business process management is end-to-end decision-making workflow, unlike RPA which deals with discrete repetitive tasks that typically occur at the beginning of the process. The important difference is that RPA is more of a system-to-system interface that provides task-level automation, while BPM has business-level of automation.

Few acronyms might pop up when searching Business Process Management and they should be well understood since not all refer to the same. Depending on the context BPM might also imply Business Process Modeling, which in Business Process Management means the activity done in order to represent the process. One of the most used techniques for Business Process Modeling is Business Process Modeling and Notation or shortly BPMN. BPMN is a standard that provides a graphical representation of the business process in BPM [4]. Business Process Modeling and Notation will be further discussed in the Chapter 4.

Business Process Management Systems (BPMS) is software used to automate, analyse, organise and improve existing business processes [29]. BPMS software lets the user map existing processes, ensure communication efficiency and look for further improvements. It is crucial to point out that BPMS are

not meant to be used as one time solution, rather for continuous use. Currently on the market can be found many BPMS and choosing the most suitable one depends on customer's needs and the size of the company. In the scope of my thesis, I will focus on BPMS that offer integration with RPA tools.

2.2.1 Camunda BPM

Camunda is an open-source BPM platform that provides tools for creating and modeling workflows, deploying and executing process models, and completing of workflow task assigned to specific user [30]. Initially, Camunda was formed as a Business Process Management consulting company and gradually switch to software development [30]. Camunda BPM platform consists of many tools such as:

- **Modler** - a desktop application used for designing BPMN diagrams as well as Decision Model and Notation (DMN) decision tables [31].
- **Cockpit** - tool for monitoring of processes, analysing and solving technical problems.
- **Tasklist** - application allowing end users to work on assigned tasks.
- **Workflow engine** - tool for deployment of workflows and their execution. Can be used as orchestration service, event handler or for human task management. By using BPMN parser, the engine is able to translate BPMN 2.0 XML files to Java Objects [31].
- **Decision engine** - used for executing Decision Model and Notation (DMN) decision tables. Can be used as a stand-alone application via REST² or Java application or as pre-integrated with the Workflow engine [31].

According to Camunda's marketing page, they offer integration with RPA tools, which they consider helpful for monitoring end-to-end business process [33].

2.2.2 Bizagi BPM

Bizagi in one of the best vendors on the market for Deep Digital Process Automation, as shown by the report issued by Forrester in 2019 [34]. Another annual report for Intelligent Business Process Management, by Gartner, named Bizagi "Challenger" [35].

Bizagi platform consists of Modeler, Studio and Automation. Modeler, as the name itself suggest, is aimed for modeling, publishing and simulating

²REST is acronym for REpresentational State Transfer and defines an architectural style for distributed hypermedia systems [32].

2.2. Review of Business Process Management solutions

business processes. It supports the BPMN 2.0 standard and is available as a desktop application, free of charge [36]. It has a drag-and-drop intuitive approach which makes it easy to use. It has five main elements, which can be seen on Figure 2.1, *Toolbar*, *Ribbon*, *Palette*, *Element Properties*, and *View*. The palette contains all the BPMN graphical elements such as Activities, Events, Gateways, etc.

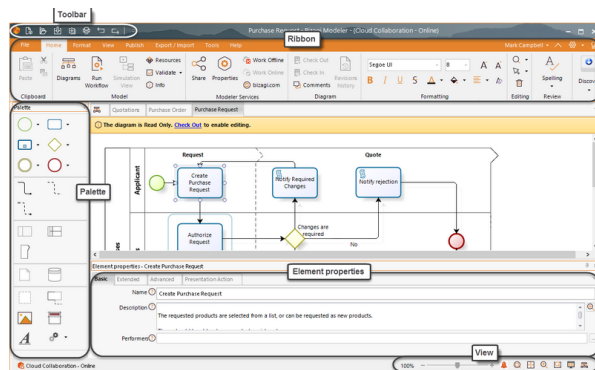


Figure 2.1: Bizagi Modeler User Interface

[36]

Bizagi Studio is used to transform the process models into enterprise applications. At the time of writing of my thesis Bizagi Studio, unfortunately, was unavailable for downloading. The third element of Bizagi platform is Automation, which represents Intelligent Process Automation platform that allows running of applications created Studio.

For integration with existing systems, Bizagi can interact via native connectors or by using SOA³ and REST layers.

When it comes to integration of RPA tools, Bizagi points out that currently on the market they are the only BPM platform that provides native integration for the three leading RPA vendors, UiPath, Blue Prism and Automation Anywhere [38].

2.2.3 IBM BPM

IBM Business Process Manager is a full-featured business process management platform, specifically designed to enable process owners and business users to engage directly in the improvement of their business processes [39]. IBM offers on-premises and cloud configurations and supports mobile devices. It operates

³As defined by Thomas Erl, Service-Oriented Architecture (SOA) is “is a form of technology architecture that adheres to the principles of service orientation. When realised through the Web services technology platform, SOA establishes the potential to support and promote these principles throughout the business process and automation domains of an enterprise [37].”

with a single process server, includes tools for process design and execution, and provides capabilities for monitoring and optimising work.

IBM BPM has *Express*, *Standard* and *Advanced* edition of the product for different users and different needs of the enterprise.

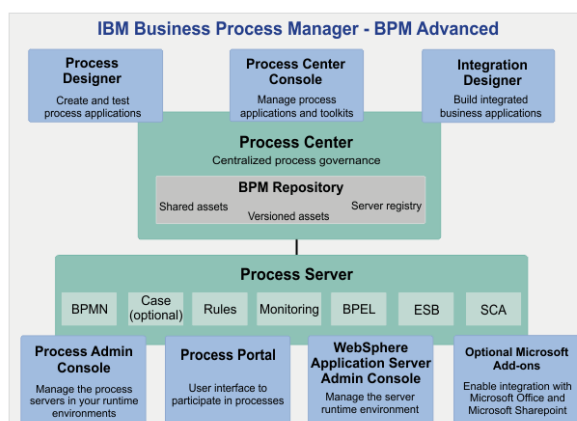


Figure 2.2: IBM BPM Advanced configuration

[39]

On Figure 2.2 is shown a typical IBM Business Process Manager Advanced configuration. As described in IBM BPM documentation [39], BPM repository manages the business processes and their associated artifacts, all the tools for authors, administrators, users, and the run time platform. Process designers create process applications, which are containers for process models that are stored in the repository. Then, process applications from Process Center are deployed to the Process Server. IBM BPM supports subclass of BPMN 2.0 standard, which includes the following BPMN 2.0 task types: *None*, which is abstract task in the BPMN 2.0 specification, *System task*, known as service task in the BPMN 2.0, *User task*, *Script*, *Decision task*, equivalent to the business rule tasks in BPMN 2.0, intermediate message events in IBM BPM provide similar functions to the BPMN send task and receive task [39].

For end-to-end automation of systems and human activities, IBM provides four types of integration with RPA. Depending on tasks that need to be executed in the process, bots can start a process, complete a human or system task, or a bot can be started by the process [40].

2.2.4 Corima with Yala BPM

Corima is a client-server platform for integration of various business applications developed by COPS company. Since the company mainly focuses on banking and corporate treasure, they developed a suite of financial applications called corima.cfs [41], what is considered to be a Treasury Manage-

ment System (TMS). The applications are ranging from Liquidity Planning, Cash Management, and Cashflow Management to Risk Management, and specialised customer-specific solutions. Corima platform contains a set of libraries that help to keep all applications visually consistent and to have the same approach for auditing, database patching, logging, etc.

Lately, because of the emerging need for automation in the area of Finance [7, 17], COPS decided to integrate BPM functionalities with the help of Yala BPM. Yala is a lightweight BPM system that can be easily integrated with other existing systems. It provides a modelling environment, task management, and various analytics of business processes[42]. Yala supports the Business Process Modeling and Notation standard by Object Management Group (OMG) and provides BPMN simulation capabilities. It also supports Decision Model and Notation (DMN) and Case Management Modeling and Notation (CMMN).

Needless to say that Corima cannot be considered to be a BPM system similar to Bizagi or Camunda. Instead, it is a platform that only adds BPM functionalities to its existing applications. However, so far, Corima cannot benefit from RPA tools that might bring other possibilities to automate certain routine activities at financial departments. Therefore, I got an opportunity to propose such integration and to prototype it in a context of an existing system.

2.2.5 Summary

To summarise, the implementation of BPM systems is a complex process due to the need for integration across the whole organisation. This type of implementation might cause significant changes, that take much longer time, unlike RPA. Though, the benefits it brings to the organisation are of great value. Survey conducted by RedHat, showed that more than 50% of companies are implementing BPM, because it provides cost reduction [43]. Participants in business processes experience improvements in productivity, understanding and communication [44].

Though, as main benefits of BPM are considered: sustainability - processes can be improved to meet the changes of the organisation [45], increased adaptability and flexibility, efficiency, etc [46]. Besides, BPM systems provide with capabilities for analysing customer and partner's behaviour, therefore, can improve the quality of service [46].

2.3 Summary

I tried to provide as much as possible information regarding both concepts Robotic Process Automation (RPA) and Business Process Management (BPM). Both RPA and BPM help companies to speed up the digitalization process. It is important to remember that they can be combined to obtain better results,

but RPA does not replace BPM systems nor is able to provide the end-to-end business process automation.

RPA rather focuses on task-level automation and defines more specific workflows. On the other hand, BPM has more generic workflows and represents a foundation platform for companies, by orchestrating between users, data and systems. While BPM aims for integration between systems, RPA only provides with basic integration capabilities. Combined with BPM, RPA can be very powerful tool, which will provide the human replacement for the User Tasks in the business processes.

Goals revisited

In Chapter 2, I provided an overview of Robotic Process Automation as a concept and reviewed a few RPA vendors, as well as for the Business Process Management and some BPM systems. The general conclusion was that both RPA and BPM can work together to improve the customers' experience and bring faster improvement in the process of digitalization of the company. I also stated previously that they do not have the same goal in the Digital Automation process, RPA is more for automation of manual tasks, that are rule-based and repetitive, while BPM focuses on end-to-end business process automation, in which user interaction is included. Most of the BPM systems available on the market are trying to keep up with the trend of using RPA, therefore are trying to integrate it with their existing systems.

I feel confident enough to say that after some research I gained enough information to revisit my goals, previously defined in the Section 1.3 and redefine them more specifically.

- G1** Select Robotic Process Automation and Business Process Management notations for future work and inspect them.
- G2** Analyse how to combine Robotic Process Automation with already existing Business Process Management Systems.
- G3** Introduce Case study example in the area of Finance, suitable to be automated with Robotic Process Automation tools.
- G4** Demonstrate how the Case study can be automated by using one of the already reviewed RPA tools, such as UiPath or Microsoft Power Automate.
- G5** Implement a prototype tool that helps integrate UiPath and Corima BPM.
- G6** Evaluate the work and summarise the gained knowledge.

Analysis and design

The focus of this chapter is to see how can RPA and BPM systems be combined. Therefore, I will need to do a more in-depth analysis of RPA and BPM notation. Knowing the notation of both systems helps understand the modeling of processes and the designing of optimised workflows. Generally will be reviewed the layout diagrams - which are used for mapping activities, and the representation and flow of data. Since UiPath gained a lot of attention in the last years as one of the best RPA tools available on the market [18], and it offers a free Community edition of UiPath platform, I chose to work with this RPA vendor. After the notation overview, the next step will be to see how RPA tools can be successfully combined with existing BPM systems.

4.1 Inspect notation of UiPath

Process mapping, in UiPath, is done through workflow development in UiPath Studio. In order to map activities UiPath offers four layout diagrams: *sequences*, *flowchart*, *state machine* and *global exception handler*.

4.1.1 Sequences

Sequences are best suited for small processes where the activities follow each other, providing a seamless flow for linear processes [47]. Sequences can be used as a standalone automation, as a part of a state machine flowchart or can be reused throughout the project. In UiPath Studio, the user can add a Sequence activity to the Designer panel to create a new sequence, or simply drag an activity from the Activities panel and Studio automatically adds a parent sequence to it.

4.1.2 Flowchart

Flowcharts in UiPath are better for connecting activities because they display the workflow in a plain two-dimensional manner [47]. They are best suited for decision points within a process by using multiple branching logic operators. The arrows between the activities are useful for avoiding chaotic interweaving activities. Unlike sequences, they can be used to create complex business processes and connect activities in multiple ways, can also be used for mapping small projects, as well as can be part of other projects.

4.1.3 State Machine

A State Machine is a more complex flowchart with conditional arrows called transitions, which enable adding of conditions needed to switch between states [47]. They are represented by arrows or branches between states. State Machines are mainly used for high-level process diagrams of transactional business processes. This type of automation uses a finite number of states in its execution. To enter or exit a state, an Activity must be used in order to trigger it.

4.1.4 Global Exception Handler

The Exception Handler is a workflow designed for small and large automation projects and mainly used to identify execution errors [47]. It helps to determine whether errors occur in the workflow. The UiPath allows only one Exception Handler to be used in an automation project, but only for processes, not for library projects.

4.1.5 Choices

When the user does the work manually, naturally some decision have to be made depending on the outcome from the previously executed task. In process automation these decisions can be implemented by using the Choices [47]. UiPath Studio offers *If Activity*, *Flow Decision*, *If Operator*, *Switch Activity* and *Flow Switch*. Picking the most appropriate representation of a condition has a big impact on the visual structure and readability of a workflow.

1. **If Activity** - splits a sequence vertically in then and else branch and is perfect for short balanced linear branches. Nested If statements are to be avoided to keep the workflow simple.
2. **Flow Decisions** - are good for showcasing important business logic and related conditions like nested If statements or If... Else If constructs.
3. **If Operator** - is used for smaller local conditions or data computing, and it can sometimes reduce a whole block to a single activity.

4. **Switch Activity** - is generally used in convergence with the If operator to streamline and compact an If... Else If cascade with distinct conditions and activities per branch.
5. **Flow Switch** - selects the next node depending on the value of an expression. Flow Switch is somewhat equivalent of the procedural Switch activity in flowcharts. It can match more than 12 cases by starting more connections from the same switch node.

4.1.6 Data

Regarding the Data in UiPath, depending on the visibility and the life cycle, there are Arguments and Variables [47]. Arguments are used to pass data from one workflow to another and they are visible anywhere in the workflow file, while the Variables are bound to a container, where they are defined and can only be used locally. The best practice suggests that the Variable should be bound to the innermost scope, in order to avoid cluttering of variables in the Variables panel in UiPath Studio. In case of having the same name for two Variables, it is used the one from the innermost scope, but this is bad practice and should be avoided in the design of workflows.

4.1.7 Comments and Annotations

Besides the above-mentioned components, in the workflow design, the user can also add Comments and Annotations [47]. The *Comment activity* and *Annotations* should be used for describing the interaction or application behaviour, for better understanding of the process.

4.2 Inspect notation of BPMN

Business Process Model and Notation (BPMN) is a well-known standard developed by Object Management Group (OMG) [4], in order to provide notation that is understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. In this way, they managed to create a "bridge" connecting the business process design and its implementation. BPMN standard is a way to ensure that XML languages designed for the execution of business processes can be visualised with a business-oriented notation.

Similar to flowcharts, BPMN diagrams use a set of standard symbols, where each shape has a specific meaning and business context that is most appropriate. For easier understanding, BPMN organised the graphical aspects of the notation into specific categories [4].

The five basic categories of elements are: **Flow Objects**, **Data**, **Connecting Objects**, **Swimlanes**, and **Artifacts**

4.2.1 Flow Objects

Flow Objects are the main graphical elements that define the behaviour of a business process. There are three Flow Objects: *Events*, *Activities* and *Gateways*.

1. *Events* - are "something that happens" in the course of the process. They affect the flow of the process by either triggering it or being the result of the process. Events are represented as circles with open centres to allow internal markers to differentiate different triggers or results. BPMN defines three types of Events, shown on Figure 4.1, based on "when" they affect the flow: *Start*, *Intermediate*, and *End* events.

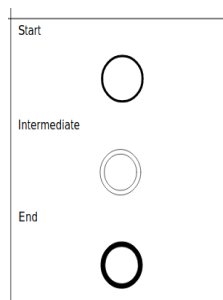


Figure 4.1: Type of Events in BPMN

[4]

- *Start event* - represents the first step of the process and is marked as a circle.
 - *Intermediate event* - represents any event that happened between Start and End event. It is denoted by double circle.
 - *End event* - signals the final step in the process. Represented as bold circle.
2. *Activity* - describe the kind of work being done by the company in a particular process instance. They can be either automatic or non-automatic. In BPMN activities are represented by rounded rectangles and there are two types: *tasks* and *sub-processes*.
 - *Task activity* - is the most basic level of activity, that cannot be broken down into simpler activity.

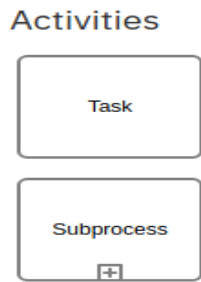


Figure 4.2: BPMN Activities types

[4]

- *Sub-process activity* - is a compound activity or better said a group of tasks that fit together. It can be represented as *Collapsed sub-process* or *Expanded sub-process*. The Collapsed sub-process has a lower level of detail (no visible details in the diagram) and it has a "plus" sign in the lower centre of the shape to show more details. The Extendable sub-process is large enough to display all the tasks that fully describe the sub-process.
3. *Gateways* - is used for control of separation and recombination of flows within a BPMN process diagram. It has several control types: *Exclusive*, *Event-based*, *Exclusive event-based*, *Parallel event based*, *Inclusive*, *Complex*, and *Parallel*. The symbols used for representing each of the gateways are shown on Figure 4.3.

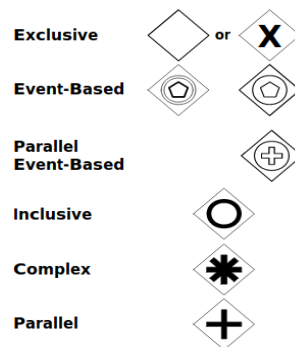


Figure 4.3: Types of Gateways in BPMN

[4]

- *Exclusive* - evaluates the state of the business process and breaks the flow into one or more mutually exclusive paths.

- *Event-based* - is similar to an exclusive gateway, only one path in the flow is possible, but in the case of an event-based gateway, is evaluated which event has occurred, not which condition is being met.
- *Exclusive event-based* - starts a new process instance with each occurrence of a subsequent event.
- *Parallel* - it is not event-dependant or on any conditions. Instead, parallel gateways are used to represent two concurrent tasks in a business flow.
- *Parallel event-based* - allows for multiple processes to happen at the same time, but unlike the parallel gateway, processes are event-dependent.
- *Inclusive* - breaks the process flow into one or more flows.
- *Complex* - only used for the most complex flows in a business process.

4.2.2 Data

Data can mean data that is placed into the process, data obtained from the process, data that needs to be collected, or data that must be stored [4]. It can be represented with these four elements:

1. *Data Objects* - provide information about what activities require to be performed. It can be either single object or collection.
2. *Data Inputs* - represents data requirements on which tasks in the business process depend on.
3. *Data Outputs* - demonstrates information produced as the result of a business process.
4. *Data Stores* - represents the ability to store or access data that is associated with a business process.

4.2.3 Connecting Objects

Connecting objects are lines that connect flow object in the BPMN diagram and show how the activities are related to each other [4]. There are three different types of connecting objects:

1. *Sequence Flow* - represents the order in which the activities are executed. It is a basic line that connects elements together and without it the process map is invalid. As it can be seen on Figure 4.5 the Sequence flow can be *normal*, *conditional* or *default*.

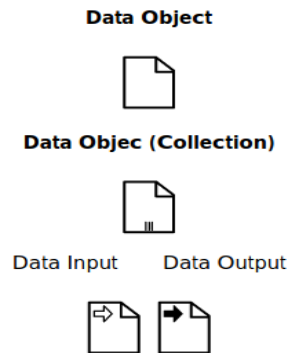


Figure 4.4: Representation of Data in BPMN

[4]

2. *Message Flow* - represents message from one process participant to another. It shows a request or sharing of information between different participants without indicating strict action. This is the only kind of flow that can be used between pools and lanes (organisations and departments).
3. *Associations* - shows the relationship between artifacts and flow objects. Usually used to tie documents, databases, and other artifacts together with activities. An arrowhead on the Association indicates the direction of the flow.

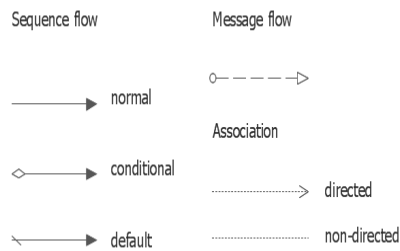


Figure 4.5: Connecting Objects in BPMN

[4]

4.2.4 Swimlanes

Swimlanes are used to organize aspects of a process in a BPMN diagram. They are very useful in revealing delays, inefficiencies, and the workers responsible

for each step in a process. In a BPMN diagram, the canvas map consists of *Pools*, used to represent different organisations or entirely separate processes, and *Lanes*, used to represent different teams or individuals within the same organisation. These elements can be arranged either horizontally or vertically.



Figure 4.6: Swimlanes in BPMN

[4]

4.2.4.1 Pool

Pool is the biggest unit in a diagram that represents the participant or "who is doing the task" in a collaboration. It can be represented as white or black box, depending whether it display any internal details of the process that will be executed or not. Mainly pools are used to represent: company, department or customer. Within the pool can be contained lanes, events, tasks, etc, but the pool should always contain one process.

4.2.4.2 Lane

Lane is sub-partition within a process or even within the pool, mainly used to organise and categorise activities. According to Camunda [48], Lanes can be used to represent: positions in the primary organisation, roles in the secondary organisation, general roles, departments, IT applications, differentiating manual and automated steps, etc.

4.2.5 Artifacts

Artifacts represent additional information that augments and describes the process. There are two standardised artifacts, *Text Annotations* and *Groups*, although, modeling tools can add as many artifacts as necessary. On Figure 4.7 are shown the symbols used for each of the Artifacts.

- *Text Annotation* - allows the modeler to describe additional flow parts of the model or notation.
- *Groups* - organise tasks or processes that have significance in the overall process. This type of grouping does not affect the sequence flow.



Figure 4.7: Artifacts in BPMN

[4]

4.2.6 BPMN Collaboration Diagram

BPMN *Collaboration Diagram* is represented by two or more *Pools*, each being a participant in the Collaboration process [4]. In this type of diagram, participants usually exchange messages between the pools by using Message Flows. Pools can be either empty without any details, "black box", or can display all the Activities within the process, as shown on Figure 4.8, known as "white box".

Collaboration diagrams are used when a process depends on more than one participant and there is no central control over the process. As shown on Figure 4.8, both participants can start the process, but at some point they will need to receive data from the other, collaborate. By using Collaboration diagrams I can demonstrate the combination of RPA with BPM systems.

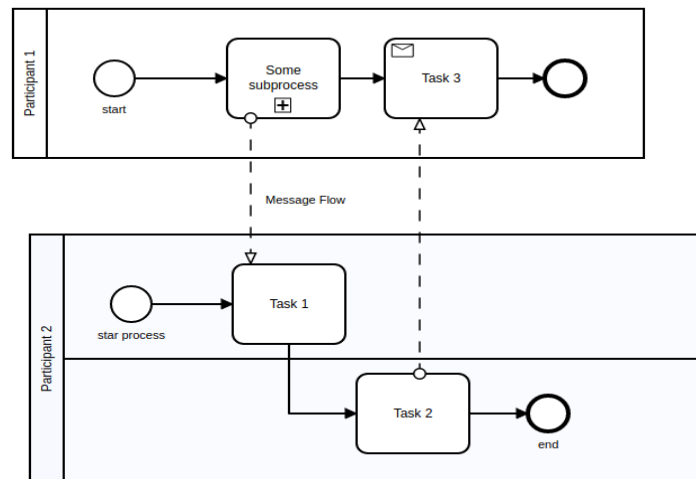


Figure 4.8: BPMN Collaboration Diagram

4.3 Relations between UiPath and BPMN notations

When it comes to relations between the notation used in RPA and BPM, based on the information in Section 4.1 and Section 4.2, can be said that they are rather different than similar, both in style and capabilities.

As example I will use the workflow diagram modeled in UiPath for the case study, which is presented in the Chapter 5. On Figure 5.2 can be seen one typical workflow diagram in UiPath. Each box representing an operation of automation, such as login, read or send an email, process .pdf files, etc. For determining the next steps in the flow are used branching conditions and loops. From the Figure 5.2 can be said that the notation style of UiPath is more of visual programming.

On the other hand, diagrams mapped using BPMN focus on Tasks and the person assigned for their execution. The purpose is mainly to show the responsibility of users within the organisation, without any details of implementation or logic. It gives a better overview of who is doing what, how they obtain their tasks, and so on.

As for similarities, they have a graphical representation of the automation, both carry data from one to another sequence, and allow sending and receiving data from other systems.

To conclude, in RPA diagrams is visible the exact operation to be executed in each step, while mapping with BPMN does not show any details regarding implementation, only shows the flow of responsibilities.

4.4 How to combine RPA with BPMS

Even though, both RPA and BPM seek process automation, these two concepts have different area of influence, thus, they are not in conflict. In the State-of-the-art, Chapter 2, I even pointed out that BPM systems, try to integrate RPA tools, in order to stay up with the trend. In the following section, I will investigate how this integration is done by analysing examples that I managed to find on Bizagi and Camunda's blog page. This should provide me with useful information that I can use for my further work.

4.4.1 Starting RPA process in Bizagi BPM

As mentioned before, in Section 2.2.2, Bizagi offers integration with more RPA vendors. On their web page can be found a short example explaining how this integration can be done. The process, that they are automating, is recruitment process normally done manually by Human Resources employee and includes reading of .pdf file, and extracting data [38].

Bizagi collaborates with RPA systems by using a special Task type named "Bot Task", which is an Activity in the process model that will be executed by RPA Robot, shown on Figure 4.9. The user needs to set the Bot option and choose between UiPath, Blue Prism and Automation Anywhere. All parameters are set via pop-up window activity and without any programming. In the scope of this tutorial, was not provided any explanation regarding the "Bot Task" implementation.

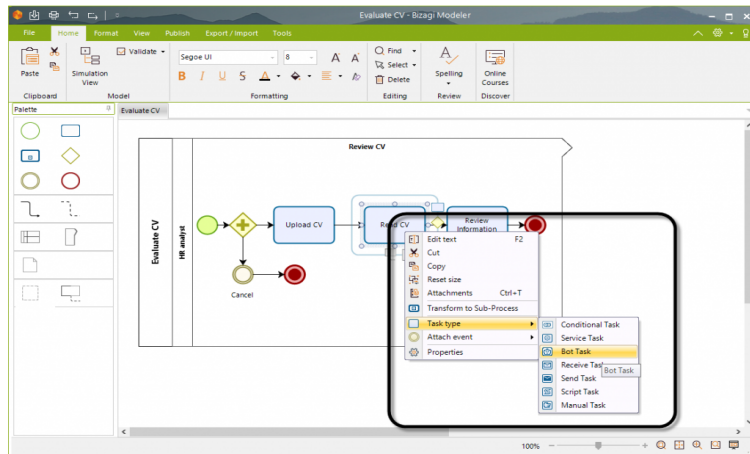


Figure 4.9: "Bot Task" Activity in Bizagi

[38]

After choosing the RPA vendor, next is selecting the right Robot that will execute the process. Also, the user must configure the data integration, by selecting input and output attributes from the data model. When triggering the RPA Robot from Bot Task, the process execution is done asynchronously, meaning other activities continue to be executed while the Robot is executing the RPA process [38].

As it can be seen, Bizagi is able to use RPA tools to automate some of the repetitive User tasks, by triggering the RPA process.

4.4.2 Starting RPA process in Camunda BPM

Next, I will present an example given by Camunda BPM, regarding RPA integration in end-to-end workflow automation, in which they explain how to get the best out of both tools [49].

The process for automation includes legacy systems without APIs, such as Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP). Since updating the BPM system would take a longer time, they use RPA as a short-term solution for entering customer's data and creating a new order.

On Figure 4.10 is shown BPMN diagram with two Service tasks, each triggering RPA process. On the diagram are shown all the steps that RPA Robot will execute. The author uses BPMN notation to demonstrate the process in more graphical, even though, RPA tools do not use BPMN for modeling workflows.

Seeing the diagram on Figure 4.10, seems that RPA can complete both CRM and ERP task without the need of having BPM system. Mike Winters, writer of the article, explains that “Camunda BPM manages the business process as a whole while RPA handles rote manual tasks within a process that can not be completed programmatically [49].”

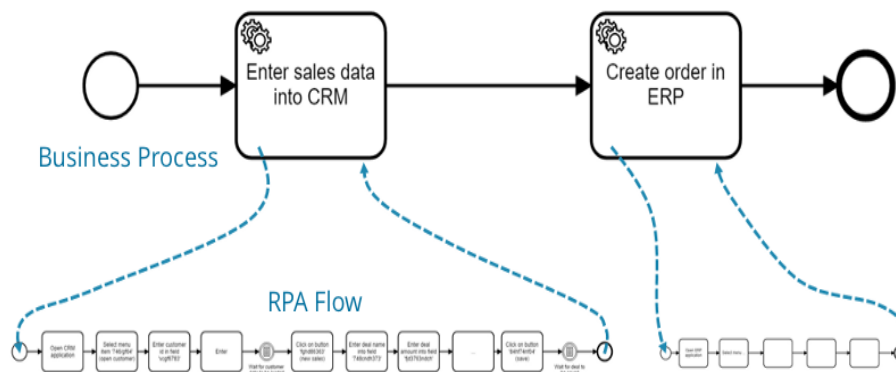


Figure 4.10: RPA as a part of a BPM process

[49]

Camunda offers integration with RPA tools via *External task* pattern, which uses REST API for communication. Same as in previous example, RPA process is triggered from BPM system.

4.4.3 Starting BPM process from RPA workflow

Both examples, exhibited in the previous sections, show how BPM systems manage to use RPA functionalities in the process modeling. Integrating RPA capabilities means that they are able to trigger an automated process, that has been previously deployed. The integration can be also done the other way around. RPA can start the execution of BPM process. If the BPM system provides API for interaction with third-party applications, then in that case, in the process modeling in RPA can be defined an activity that will start the process, or start or complete a task. In this way, RPA is able to deal with all the exception that might arise, as well as gains ability to handle activities that need user confirmation.

4.4.4 Combining RPA workflow with BPMN workflow

Previous examples show that both RPA and BPM systems can trigger a process in the other system respectively. BPM systems can replace rule-based User tasks with Robots, while RPA can handle exceptions by exporting tasks to BPM system. Since both ways of interaction are possible, I would like to further explore the idea of combined RPA and BPM process. For this I will use a collaboration diagram to model a process that will use both systems, though, RPA will be seen as main automation system, while BPM will be used only for activities that require human decision-making capabilities. Integrating both systems provides a nice workaround for companies to overcome the limitations of both approaches of automation.

When explaining the notations that BPM and RPA systems use, I mentioned that both notations differ, consequently, the representation of the RPA process shown on Figure 4.11 is not correct. Despite that, I am using the BPMN so that I can present the RPA process in a more visual way, rather than mapping it as "black box". The process shown in the diagram is a typical invoice processing done in Finance sectors. Each step of the work is mapped with appropriate activity representing a separate task. Most of the activities are rule-based and executed in the exact same way, therefore, can be done by RPA Robot. The one that involve working with more sensitive date or making decisions, that cannot be done by Robot, will be managed as User tasks in BPM system.

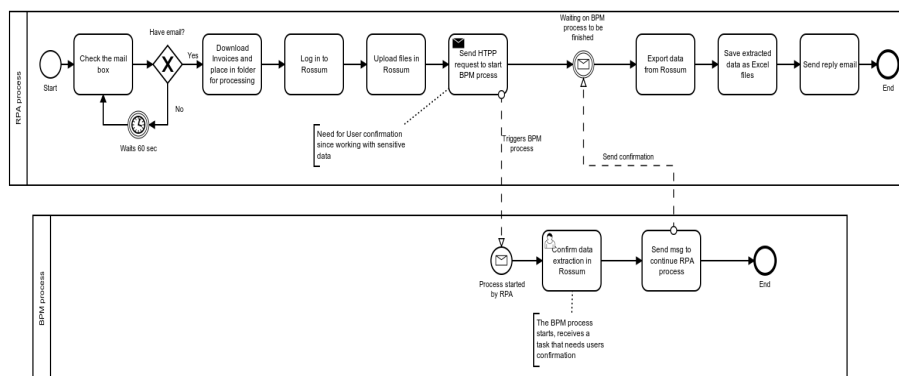


Figure 4.11: Combining RPA and BPMN workflows

The idea of using RPA as main automation system is a bit naive, having in mind that throughout the thesis I stressed out that RPA should not be used for end-to-end business processing, rather focus on single task automation, but it is a perspective that I would like to further investigate. Moreover, in such a combined workflow, this would move the entire user-interaction to a BPM system and may build a basis for mining the end-to-end business processes. As a result, the organisation could step-by-step determine the

technically independent business-process, execute it, and either replace the entire RPA, or still trigger it as described Section 4.4.1 and Section 4.4.2. The implementation of this idea will be presented in Section 5.2.

4.4.5 Summary

In this section, I presented how both RPA and BPM systems are able to interact, due to the functional APIs. Examples presented in Section 4.4.1 and Section 4.4.2 show that RPA Robots can be triggered from BPM Tasks. In this way, BPM systems gain the functionality of automating repetitive, rule-based tasks that need user interaction and the ability to interact with legacy systems without API. Instead of changing the existing system to implement those functionalities, BPM can use RPA as a short term solution. In the end, BPM system will still have the responsibility to manage the end-to-end process, while RPA will present only one step of the process. One of the benefits of using RPA in this context is that users will no longer have to interact with systems with different UIs. On the other side, instead of using pop up windows or messages boxes in RPA processes, when user confirmation is needed, RPA can start a BPM process that will handle these activities. Exporting tasks to BPM systems makes process automation more reliable.

Case study

Chapter 5 is dedicated to the Case study, in which the main goal is implementation of the process shown in Section 4.4.4. The overview of Chapter 2 provide me with enough information to choose RPA tool and explore how to automate typical use-case scenario from the area of Finance. The automation of the use-case will be first implemented using RPA tool and later RPA and BPM combined. In the introduction section, I will explain each step of the process that is executed manually by the worker. Next will be the implementation part, containing process automation implemented in UiPath, Microsoft Power Automate and a prototype of integration of UiPath and Corima BPM. I will end the chapter with a testing section and and a short summary.

5.1 Introduction

Most of the studies suggested that RPA is most helpful for processing invoices and filling in data tables in Excel. Having this in mind I will try to map one end-to-end process involving as many as possible applications in order to explore RPA automation capabilities. The scenario involves receiving invoices, extracting data from files, generating Excel files from it and sending back a confirmation. Broken down into smaller and simpler steps, the process would be done in the following order

The worker:

1. Gets email with attached invoices (in .pdf format), that need to be processed
2. Downloads all invoices
3. Place them in a folder "Invoices for processing", that contains all invoices that are still not processed
4. Signs in to software used for keeping track of all invoices and customers

5. Uploads all .pdf files for processing
6. Starts reviewing and extracts necessary data
7. Confirm extraction of important data fields
8. Writes data in Excel sheets from the the accounting book
9. Moves files that are processed in "Processed invoices" folder
10. Writes reply email (that the invoices were processed)

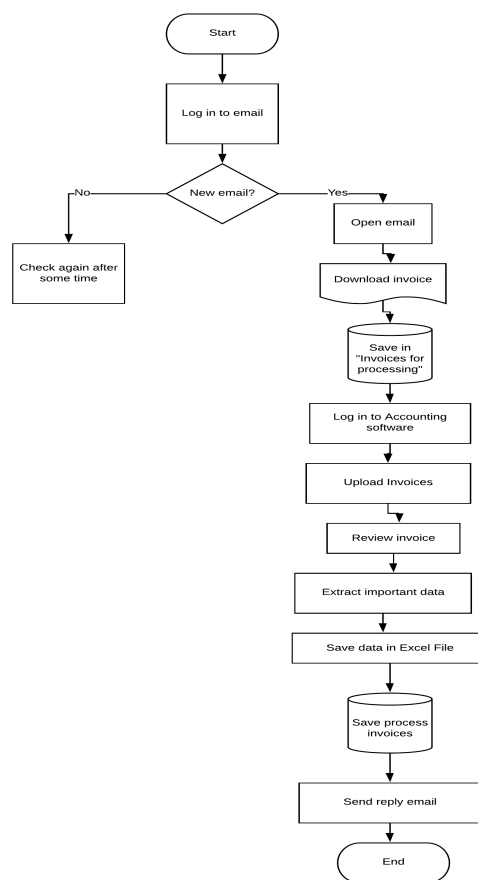


Figure 5.1: Flowchart diagram representation of the Case study

Starting from this point onward, the process described on Figure 5.1 will be referred to as "Invoice processing" process.

To automate the "Invoice processing" using UiPath, or any other RPA tool, some changes need to be applied, such as initial filtering, since RPA processes must be always executed in the exact same way.

As a replacement for software used professionally in Finance and Accounting, I will be using a few web-based application, in order to be able to simulate the process from beginning to end. For generating invoices I am using a free online web application "Invoice Simple" that allows me to register some clients, set parameters, generate invoices and email them to "customers"[50]. I will not go into too many details regarding this invoice generator since it does not play an important part in the process automation.

Another third-party software that will be used in the scope of this case-study is Rossum.ai, cloud-based application that uses Artificial Intelligence (AI) to extract data from the invoices [51]. Rossum provides many options for importing invoices. It can be done either directly from email, or with simple upload by the user, invoices can be even scanned or photographed. I will use Rossum API in order to upload the invoices from UiPath. The pricing for the product is dependent on the number of invoices being processed and the data fields that need to be extracted. Based on these two parameters, they offer Start, Standard and Pro edition. Again, since the use of this software is not my main interest, I use the Start edition, in which automated learning is not available and can be used only predefined data fields.

5.2 Implementation

As mentioned at the beginning of the chapter, in the implementation section will be explained the process automation achieved by using RPA tools and combination of RPA with BPM system. First, I will present UiPath automation, then Microsoft Power Automate and last will be the integration of UiPath with Corima BPM.

5.2.1 Automation of the case study in UiPath

After defining clearly the steps of the "Invoice processing" process, the automation in UiPath can be done easier. On Figure 5.2 is presented the whole process that will be executed by UiPath Robot. The process is mapped by using Flowchart layout diagram and represents a loop where every 60 seconds the Robot checks if a new email has arrived. There is a Start activity, that is followed by collapsed Sequence, in which the checking for new, unread email is done. More details regarding UiPath Activities can be found in Chapter 4.

Then, the result is passed in the Flow decision which branches the process in two different activities. If there is no new email, then the process waits for 60 seconds and returns to the first activity. Otherwise, checks whether or not the new email has an attachment and if the attachment is in the right format. Again, the result of this activity is passed to the next Flow decision. If the unread email contained attachment in a .pdf format then it is sent for processing, otherwise continues to wait for new email.

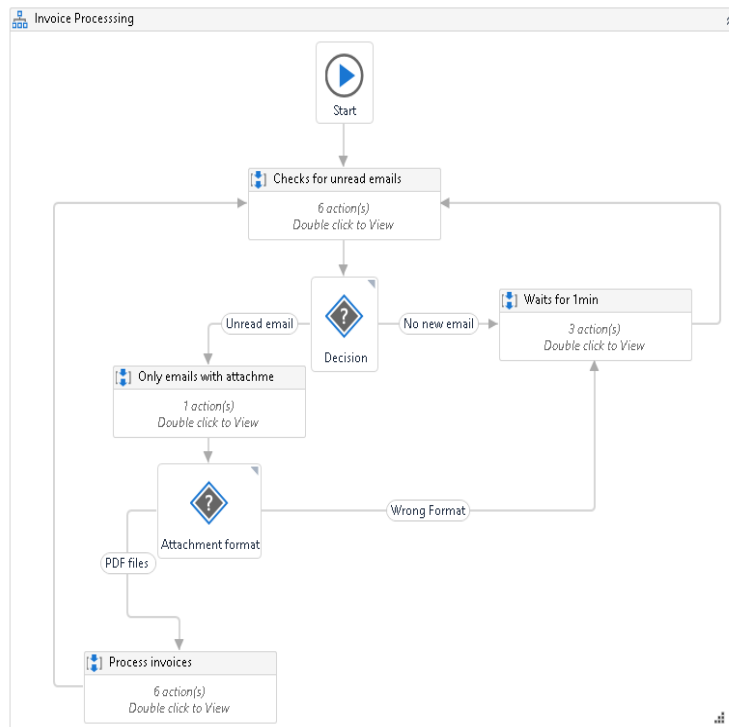


Figure 5.2: Case study implementation in UiPath studio

The sequences in UiPath can be collapsed, to see the big picture of the mapping, and extended, to show more details. On Figure 5.3 is presented the Sequence in the Flowchart that is executed after the process starts. At the beginning, I place a Comment in which I shortly explain what is done in the "Check for unread email sequence". First the email account is saved in Variable by using the Assign activity. UiPath also provides Password activity, instead of saving it as string. Both the emails and password are used in the Get Message activity.

It can be seen on Figure 5.4 that UiPath provides an activity to connect to an email, in my case I use Outlook account. In the properties panel, the user can set parameters as email account, password, which emails to be open, whether they should be deleted afterwards and other settings. For this process, I created "Invoices" folder in Outlook, and set from which email account I expect to get invoices. In general practise this is very useful, because not all emails need to be processed from the "Inbox" folder. The last activity is If-condition, which checks the number of unread email, obtained as output from the Get Message activity.

After the execution of the sequence, presented on Figure 5.3, finishes, the next step is the Flow Decision. In case the output form the Get Message

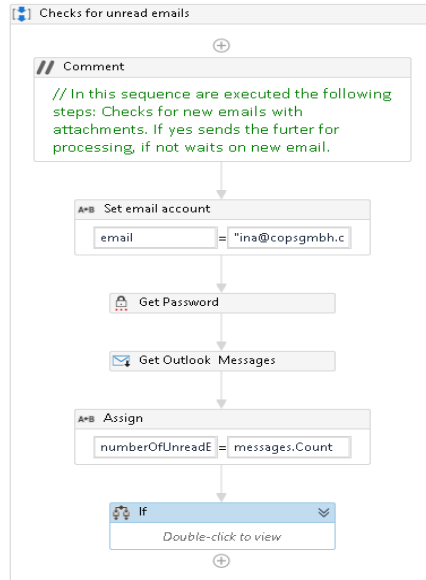


Figure 5.3: Checking outlook for new emails

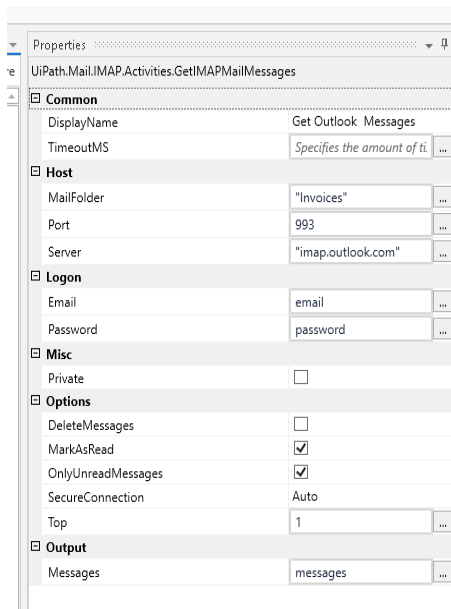


Figure 5.4: Settings in Mail Activity

activity was empty, it continues to the "Waiting sequence". Beside the short comment and the Log Message activity, used for debugging, I use a Delay activity to set a waiting time of one minute.

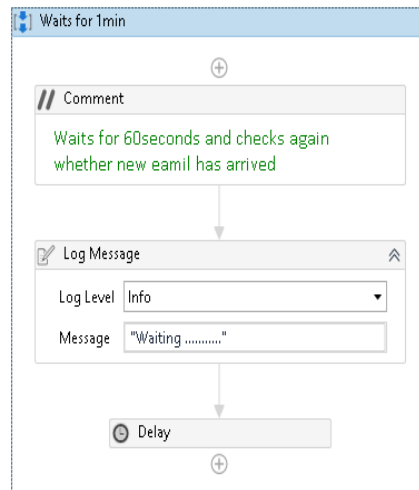


Figure 5.5: Delay Activity

In case of new email, next activity in the Flowchart is to check if the email contains attachment and the format of the attachment. This is done in the "Only emails with attachment" Sequence. If no attachment was provided or the invoice is in a wrong format, as show on fig. 5.6, reply email will be send to the sender. In this activity, I also set Boolean *processEmail* variable to determine the further steps in the process.

Mapping these small sub-processes was easy, since it was pretty much straight forward. The more interesting part is the other branch of the Flow Decision which leads to the "Process invoices" Sequence. On Figure 5.7 are presented the sub-sequences, each defining a different step in the RPA process. I represent this part of the process with collapsed sequences for better visibility and understanding of the Sequence flow.

Further, I will present deeper insight of each of the steps in "Process invoices". The downloading of attached invoices as well as saving of the sender's data is presented on Figure 5.8.

I will use this information in order to send reply emails. The most important activity is the ForEach that loops through the saved messages, saves important information regarding the sender of the email and the .pdf files, as shown on Figure 5.9.

UiPath provides Save Mail Attachment activity which I used to set the path of the folder where I want the files to be saved and it is even possible to filter which type of files to be saved. The sender's data is saved in a previously

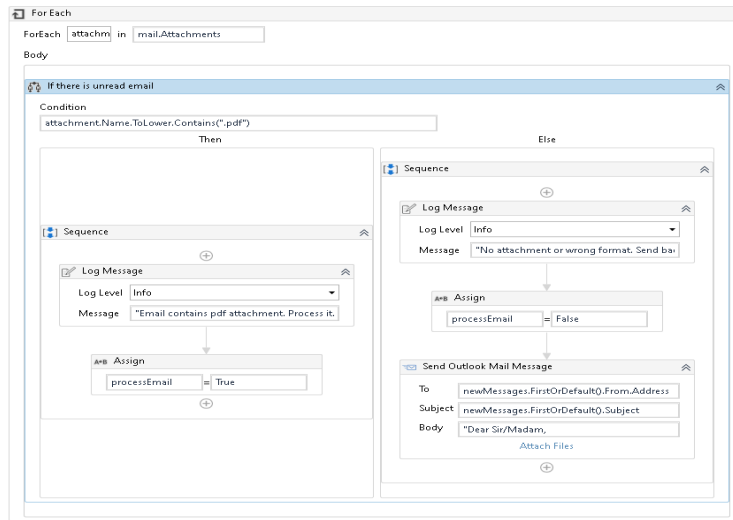


Figure 5.6: Checking attachment format

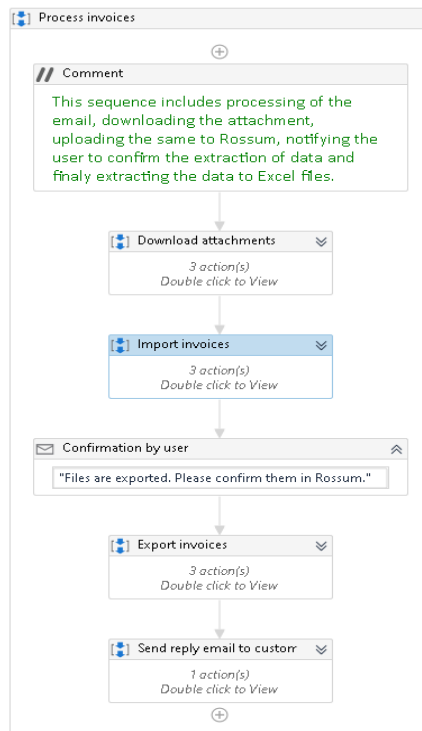


Figure 5.7: Processing emails

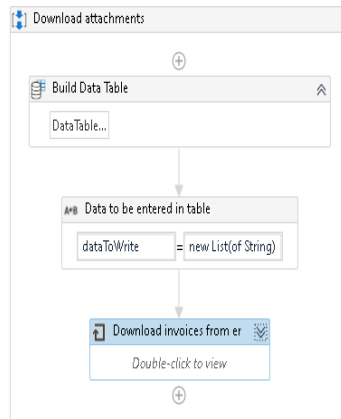


Figure 5.8: Downloading attachments

created Data table by using Add row activity.

The next step is to upload the files to Rossum.ai. I mentioned previously that I will use this application as a third-party system in order to see how UiPath interacts with systems for which it does not provide predefined connectors. On Figure 5.10 are shown the Sequences that are part of the "Import invoices" Sequence.

For the files to be uploaded, login and authenticate is required. The logging is done by using HTTP POST request activity and the API provided by Rossum. The email account and the password must be provided in the body of the request as JSON data.

In the HTTP reply, Rossum returns a JSON objects that contains "key" parameter, which is the authentication token that will be needed for further communication. In the HTTP request can be set a variable in which the output can be stored. The "key" can be extracted from the reply by using the JSON Deserialize activity and stored it in Variable by using Assign activity. The Logging out is done in the same way, by sending HTTP POST request.

After successful login, the process continues to execute the next Sequence, uploading of the files. On Figure 5.12 are shown the used activities. First, I used HTTP GET request to get the queue from Rossum. From the HTTP reply, I extracted the queue ID and the URL link to the queue.

In a For Each activity the files are uploaded by using "multipart/form-data" parameter in the HTTP request. After each file is upload, from the reply HTTP output, I used the Annotation ID in order to track if later the same files that have been uploaded for processing, have been processed in Rossum. The files are also moved in "processing invoices" folder, so that the user can keep track at every moment if invoices are processed or still pending to be processed.

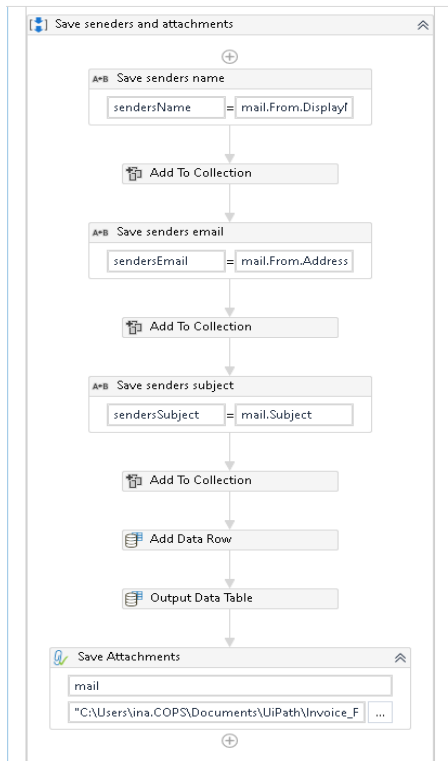


Figure 5.9: Saving .pdf files and sender's information

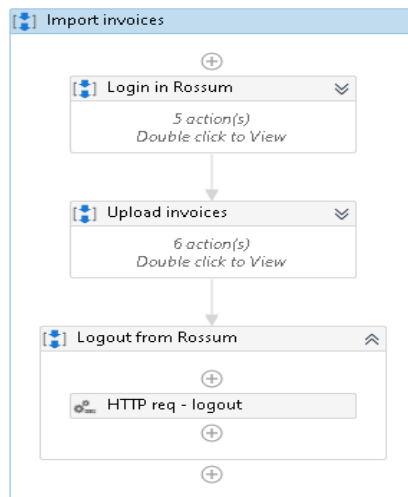


Figure 5.10: Importing files to Rossum.ai

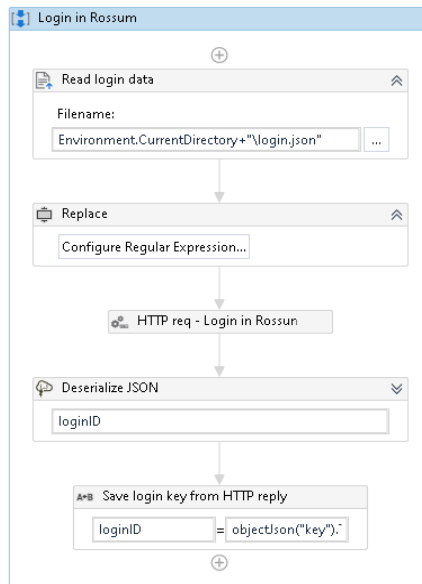


Figure 5.11: Logging in to Rossum.ai

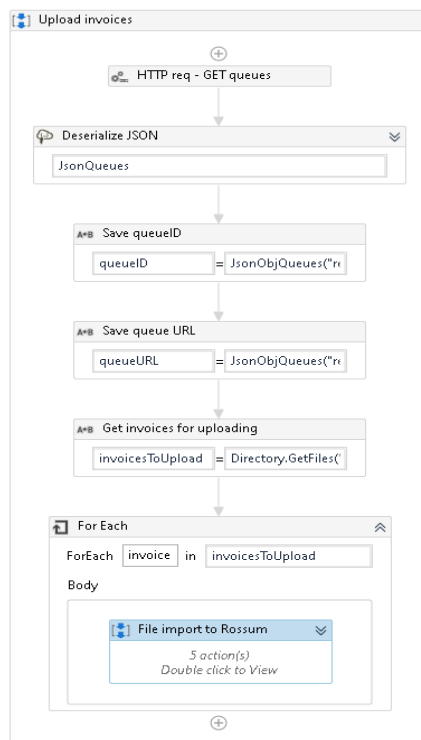


Figure 5.12: Uploading files to Rossum.ai

The next step requires human interaction. I must point out that this is actually solvable in UiPath by using either the Recording option or using UI activities, as clicks, typing and capturing elements from the UI design. With the Recording option, after capturing the user interaction, UiPath automatically maps each step with suitable activity.

In my case, I used only Message Box activity that will display a message in order to remind the user that the files are already uploaded and the extraction of the data, which is done automatically by Rossum, needs to be confirmed. In this way, I wanted to present that there can be tasks that need user's approval.

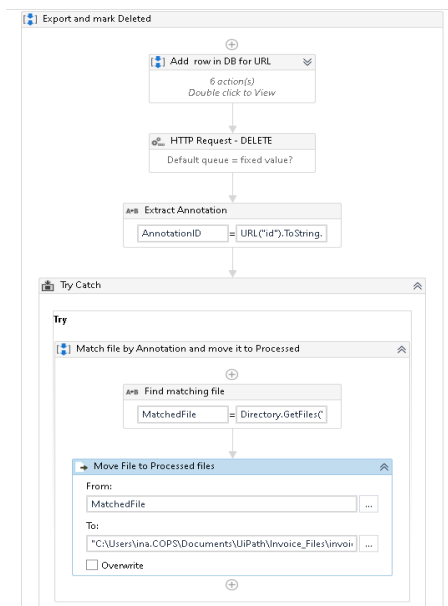


Figure 5.13: Matching processed invoices and moving them to another folder

After successful data extraction, by using the Rossum's API, the data can be downloaded and stored in Excel file. Again, by using HTTP requests I will get the queue that contains the exported Annotations. Match the Annotation ID from the exported files and the Annotation ID from the files that are stored in the folder with invoices for processing, if the same invoice was processed (important data was extracted), then they will be moved in the folder with processed invoices. Then, they are deleted from the queue in Rossum. The exported data is saved in Excel file stored in another folder.

The last step is to send reply email to the sender. On Figure 5.14 it is shown For Each activity, that loops through the data base of senders and fills the Send Mail activity that requires email address, subject and body. It also allows attachments, but in this case that was not needed. This is the final step of the "Processing unread emails" Sequence and then the process goes back to checking whether new email was received in the meantime.

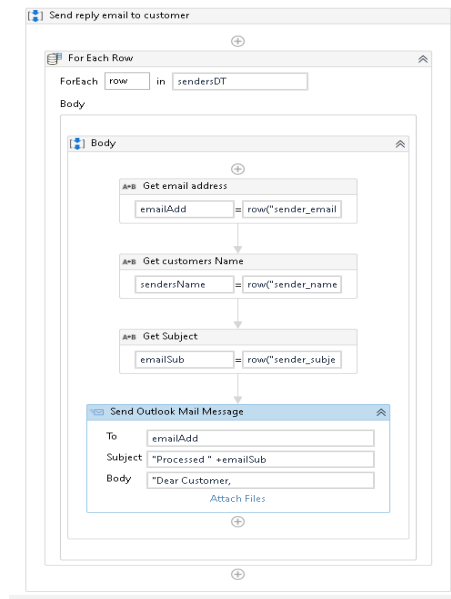


Figure 5.14: Sending reply email

The process can be executed within UiPath Studio, or it can be deployed on UiPath Orchestrator and run by using UiPath Robot. The deployment can be done from the Studio or the user can manually upload the packages in Orchestrator. The process diagram is saved in .xaml file and for every .xaml file that is marked as Main is automatically created project.json file, that contains information about the project, dependencies, the expression language, etc.

Listing 5.1: project.json file

```
{
  "name": "Invoice Processing",
  "description": "Blank Process",
  "main": "Flowchart.xaml",
  "dependencies": {
    "UiPath.Excel.Activities": "[2.8.0 - preview]",
    "UiPath.Mail.Activities": "[1.8.0 - preview]",
    "UiPath.System.Activities": "[19.12.0 - preview]",
    "UiPath.UIAutomation.Activities": "[19.12.0 - preview]",
    "UiPath.WebAPI.Activities": "[1.4.4]"
  },
  "webServices": [],
  "schemaVersion": "4.0",
  "studioVersion": "19.12.0.61",
  "projectVersion": "1.0.8",
}
```

```

"runtimeOptions": {
  "autoDispose": false ,
  "isPausable": true ,
  "requiresUserInteraction": true ,
  "supportsPersistence": false ,
  "excludedLoggedData": [
    "Private:*",
    "*password*"
  ],
  "executionType": "Workflow"
},
"designOptions": {
  "projectProfile": "Developement",
  "outputType": "Process",
  "libraryOptions": {
    "includeOriginalXaml": false ,
    "privateWorkflows": []
  },
  "fileInfoCollection": [
    {
      "editingStatus": "InProgress",
      "testCaseId": "a3fe865b-071d-4a22-9cb9-b20d66382994",
      "fileName": "TestCase1.xaml"
    }
  ]
},
"arguments": {
  "input": [],
  "output": []
},
"expressionLanguage": "VisualBasic"
}

```

The generated .xaml file for the "Invoice processing" project will be not include, since is pretty long, but it can be found in the src folder on the enclosed CD.

5.2.2 Automation of the case study in MS Power Automate

The initial idea was to have a overview of the RPA leaders and then narrow it down to only one of them, which will be analysed and used for implementation of process automation. While doing my research Microsoft Power Automate got my attention, since only recently Microsoft introduced the RPA capabilities in the Power Automate service through the UI Flows. For that reason,

I decided to also automate the case study with this tool and see what are its automation abilities.

On Figure 5.15 are presented the initial steps of the automation process. The nice thing about Power Automate is the smoothness it provides when using applications for which they offer build-in connectors. For example, the initial step which is actually the trigger of the flow, every time an email arrives the flow starts to process it. Then the attachment is saved and uploaded on SharePoint. The next step is to log in to Rossum and get the authentication token. All of these needed only one activity, unlike in UiPath where I had to use so many filters and sequences in order to do few simple steps.

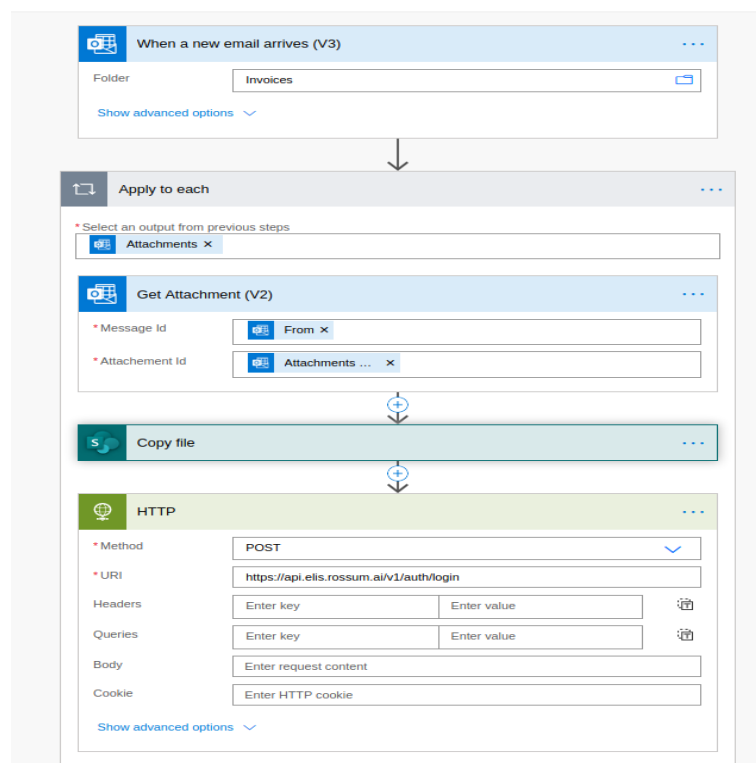


Figure 5.15: Automation with Microsoft Power Automate

Most of these activities can be found under Automation Flows and are used for creating flows that are mostly triggered by some event, such as getting email, or being tagged on Twitter. In order to have the RPA experience the user needs to use the UI flow form Power Automate. The problem is that they have a lot of limitation. UI Flow can either be used for Desktop or Web application, only Windows 10, 64-bit machines or latest version of Microsoft Edge and Google Chrome. They do not support interactions on Windows such as File explorer, startup menu, task bar, etc. Nor Java applications, Microsoft Office 2016 and earlier, Microsoft Office online and many more.

UI Flows are generated by recording the interaction of the user with the desktop or web application, which is handy on one side, but then again many actions are not supported.

Overall, I find Microsoft Power Automate only handy and useful for automation of task that rather use Microsoft applications or applications for which this service provides connectors, otherwise shows a lot of limitations. I believe that in future they will overcome these obstacles and come closer to the rest of the RPA vendors.

In my experience Power Automate cannot provide the automation, as other RPA tools. RPA is more of an enterprise process automation, that depends on bots or AI workers, and I think that for now Power Automate cannot provide that. Therefore, Microsoft Power Automate will not be further explored in the scope of this thesis.

5.2.3 Combining UiPath and Corima BPM

In this section, I will practically explore the idea presented in Section 4.4.4, by presenting a prototype that integrates both RPA and BPM systems, to be more specific, UiPath and Corima.BPM.

UiPath has API based on OData protocol⁴ and allows GET, POST, PUT and DELETE request.

As for Corima.BPM for the purpose of the prototype implementation, I was provided with APIs enabling me to start a process, and to complete User and Service Task without any need for authentication.

My initial idea was to automate the RPA process presented in section 5.2.1 and to modify it so that it can be combined with BPM system. Instead of having a Message Log activity that pops up to notify the user to confirm the sensitive data in Rossum, I wanted to activate BPM process, in which will be created a User Task, to confirm the data. After the user completes the task, the BPM process notifies the RPA to continue. However, this cannot be done in such a way. The tendency of RPA is to automate a process from beginning to end without any interruption, or if any activity requires user interaction, then those are handled by Message log activities.

Because of these reasons, I had to divide the initial process mapped in UiPath to two different fully automated workflows. One workflow will be executed by unattended Robot, running constantly and checking for new emails to be processed, shown on Figure 5.16. While the other process is exporting data from Rossum and will be started by completing a User Task.

After going over the emails, sorting them in files and uploading them for processing, UiPath starts BPM process in Corima BPM. The starting of the

⁴OData (Open Data Protocol) is an ISO/IEC approved, OASIS standard that defines a set of best practices for building and consuming RESTful APIs, which allow resources, identified using URLs and defined in a data model, to be published and edited by Web clients using simple HTTP messages.[52]

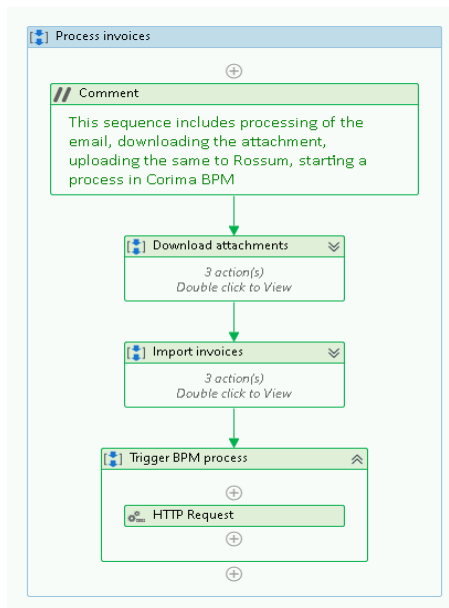


Figure 5.16: Uploading invoices to Rossum

process is done by using HTTP GET request Activity in UiPath and passing BPM process ID. UiPath executes this sequence "Trigger BPM process" and continues to check for new emails. By exporting the user activity to Corima, UiPath can execute the process uninterruptedly, while still having handled data-sensitive activities with more attention. This increases the flexibility of the solution.

On Figure 5.17, is shown only the part of the process that was previously mapped with Collaboration diagram on Figure 4.11.

Process on Figure 5.17 is designed using BPM modeling tool in Corima and then is deployed to be executed. Corima BPM uses the BPMN 2.0 standard for modeling diagrams. When the BPM process is started by UiPath, in the Worklist is created a User task, that needs to be completed by the user.

This lets the user know that there are files uploaded, which need to be reviewed and approved. I still use Rossum for processing data from .pdf files. Confirming the data extraction and completing the User task in Corima will start the next activity, a Service Task. This task should be used when an external service is called to perform some action, as in this case, running a job in UiPath Orchestrator.

On Figure 5.19 can be seen the task panel from the Corima modeler. In this section can be declared that the service task will be performed by external worker. It is done by setting the implementation type to External and for the Topic option I defined a topic "activateRPA". The implementation of the Service task is done in C# programming language and uses the RestSharp API

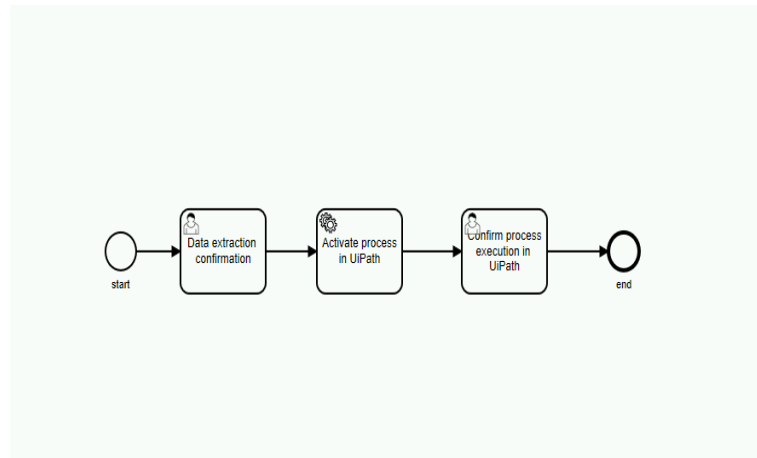


Figure 5.17: BPM process in Corima

The screenshot displays the Corima BPM user interface. The top navigation bar includes 'HOME', 'APPLICATIONS', 'INBOX', and 'SETTINGS'. The main content area is divided into a 'WORKLIST' section on the left and a 'TASK DETAILS' section on the right. The 'TASK DETAILS' section shows the following information:

- TASK DETAILS:** process_bpm, 50, 5/21/20, 9:30 PM, admin
- RELEASE TASK:** Enter date, 5/25/2020, Groups
- TAB NAVIGATION:** DESCRIPTION, FORM, HISTORY, COMMENTS, DIAGRAM
- DIAGRAM:** A BPM diagram showing the process flow from start to end through three tasks: Data extraction confirmation, Activate process in UiPath, and Confirm process execution in UiPath.

Figure 5.18: User Task in Corima BPM

client library for .NET framework in order to trigger the process in UiPath Orchestrator.

When BPM engine executes the Service task, by using the topic, it will call functions defined externally. First, the authentication with an Orchestrator needs to be done. For authentication is used Bearer token and the same credentials as when logging via the User Interface. By using RestSharp client, it is created POST method request that sends Client ID and User Key, both parameters generated by UiPath Orchestrator. The User Key is used in order to generate unique login keys that can be used with APIs and other third-party services.

If the provided data is correct and the request is successful, in the response is provided access token for API calls, which is active only for 24 hours, after

The screenshot shows a configuration window for a 'service_task'. At the top, there are four tabs: 'General', 'Listeners', 'Input/Output', and 'Field Inject'. The 'General' tab is selected. Below the tabs, the configuration is organized into sections: 'General', 'Details', and 'Implementation'. Under 'General', there are two text input fields: 'Id' with the value 'service_task' and 'Name' with the value 'Activate process in UiPath'. Under 'Details', there is a dropdown menu for 'Implementation' set to 'External' and another text input field for 'Topic' with the value 'activateRPA'.

Figure 5.19: Service Task in Corima BPM

that needs to be regenerated. To start the process in Orchestrator, after successful authentication, next is to find folder's ID, Robot's ID and Release key from the process.

For all three, are used GET requests, providing access token, proper headers and filters. Both Robot ID and process Release key can be obtained by using process and Robot's name in the filter. To start a Job in Orchestrator are required more parameters, that can be sent in the body of POST request. (Job represents a process that is has been run or is running.) Besides selecting which process to be executed and which Robots to do the job, user needs to be specified the Source, Strategy, Jobs Count and Input Arguments (if any input arguments are expected).

Listing 5.2: "Body for "Start Job" request"

```
{ "startInfo ":
  { "ReleaseKey": "process_key",
    "Strategy": "Specific",
    "RobotIds": [ 1234 ],
    "JobsCount": 0,
    "Source": "Manual",
    "InputArguments": "{}"
  }
}
```

After, calling the function that creates the POST request, the Service Task is completed and goes to the next task in the BPM diagram, and at the same time in UiPath Orchestrator Job is started.

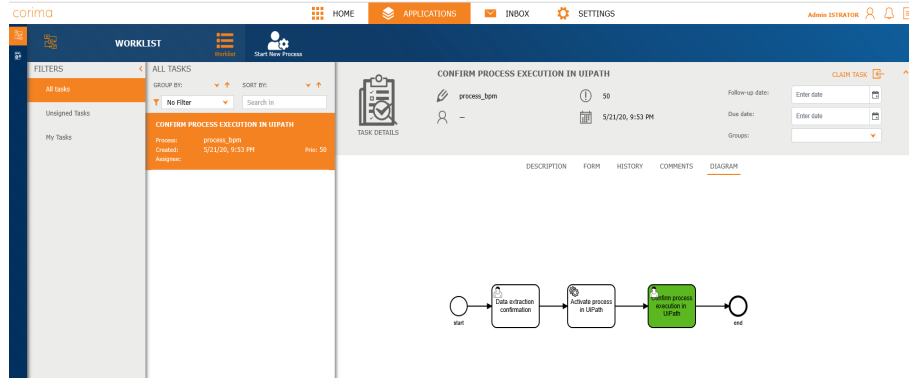


Figure 5.20: Service Task completed

PROCESS	ROBOT	USER	MACHINE	ENVIRONMENT	TYPE	STATE	PRIORL.	STARTED	ENDED	SOURCE
Invoice_data_export_...	iRobot	COPS\ina	CZWSINA1	en1	Unatten...	Successful	Normal	2 minutes ago	2 minutes ago	Manual
Invoice_data_export_...	iRobot	COPS\ina	CZWSINA1	en1	Unatten...	Successful	Normal	33 minutes ago	33 minutes ago	Manual
Invoice_data_export_...	iRobot	COPS\ina	CZWSINA1	en1	Unatten...	Successful	Normal	34 minutes ago	34 minutes ago	Manual

Figure 5.21: Job finished in UiPath

Jobs in Orchestrator can be executed only by unattended UiPath Robot. After the Job is finished, user can check the results and finish the other User Task in the Worklist in Corima BPM. With this, both RPA and BPM processes will be done.

5.3 Testing

Testing is important part of software development. Even though, in the scope of this thesis was not done a full application development, testing should be done to detect errors, as well as to see whether the application is behaving in the expected way.

5.3.1 Testing in UiPath

When it comes to testing RPA processes, fortunately UiPath offers Test Suite for its user to be able to design and create test cases. Beside for RPA testing, UiPath Test Suite aims to provide automation of application testing, since it covers testing of mobile, web and desktop applications, SAP, Citri, etc [53]. In this way they are able to provide to their customers resilient and high performing automation deployments. Key component of the Test Suite is StudioPro, which was released in April 2020. By registering for free trial period, I was able to use Test Suite features to test my implementations of the RPA processes.

In StudioPro, by creating test cases I was able to ensure that my automated workflows cover all cases and that they perform in the desired way.

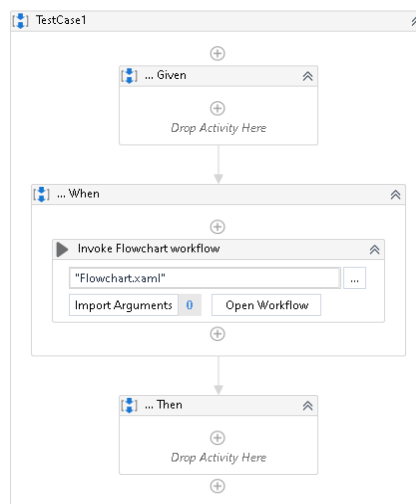


Figure 5.22: Test Case in UiPath for "Invoice processing" process

The testing is done by creating a Test Case from the existing workflow. Test Case is also UiPath workflow, that has three containers: *Given*, *When* and *Then*, shown on Figure 5.22. "When" sequence has Invoke Workflow Activity, that requires the path to the project and import arguments. To see whether test cases cover all the activities, they must be run in debug mode. As the workflow is executed, it is shown how much coverage provide the created test case.

In order to avoid creating too many test cases to cover all the activities, I generated different emails (with no attachment, with wrong format of attachment, etc) in order to test whether the project workflow can handle all the cases. The result is presented on Figure 5.23. The tests created for the UiPath automation of the case study, covered 97% of the activities, without any error.

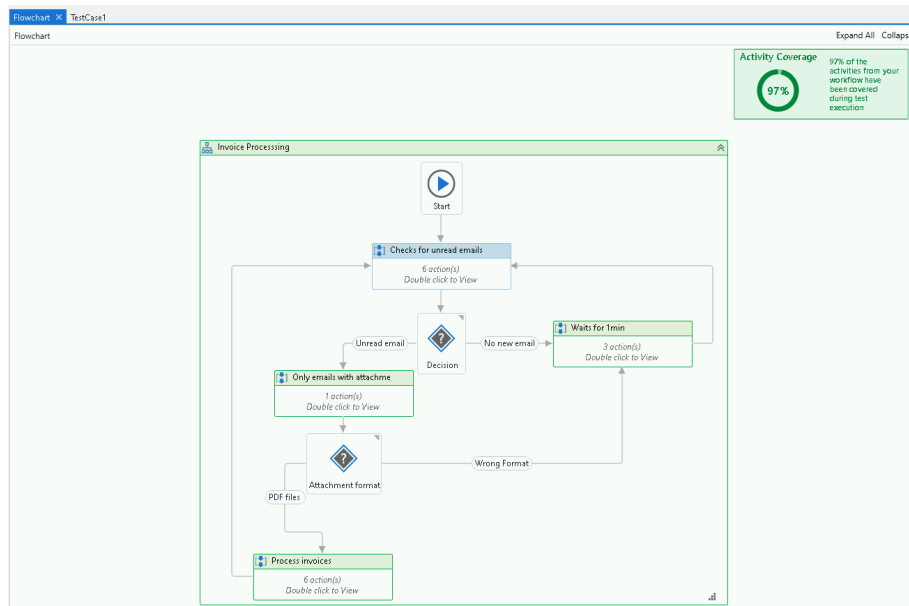


Figure 5.23: Activity coverage from the Test case

5.3.2 Testing implementation of UiPath with Corima BPM

When implementing solution that integrates different units, in reality, should be done integration testing [54], to discover faults in the interaction between the integrated components. First, each component is tested separately, and after they are assembled together, integration testing needs to be performed. In such case of testing the focus in on data communication between the units.

Since the focus in my thesis is on implementing a prototype to test the concept of RPA and BPM integration, I will not be providing a full integration testing, as for real world solution. When it comes to testing modules separately, I used the Test cases in StudioPro for the RPA part of the prototype. Also, in order to ensure that each step is executed as expected, I am tracing the execution of activities as logs.

5.4 Summary

In this chapter, I presented one typical use case scenario in the area of Finance and tried to automate the same process by using UiPath as well as Microsoft Power Automate. UiPath offers many possibilities for automating tasks, even when working with third-party software for which they do not have connectors, as in the case with Rossum. The mapping of the process with UiPath workflows sometimes can be overwhelming, since it happens that for a rather simple task many activities are needed. On the other side, Microsoft Power

Automate is more user friendly and offers smooth task automation for the applications they support, but it is rather limited and should not be put in the same category with RPA vendors such as UiPath, Blue Prism and others.

The third part of the implementation section was dedicated to prototyping an integrated solution of UiPath and Corima BPM. The goal was to export the tasks that require user attention to a BPM system, rather than to use Message windows in UiPath. Since, both UiPath and Corima, provide APIs for communication with third-party software, the implementation of such prototype was not impossible. UiPath, or better said RPA seems to be a nice complement to BPM systems, but should not be seen as the main system for managing business processes. By combining RPA with BPM systems, the business processes can be improved. BPM can handle exceptions that might come along in RPA process, as well as activities that require human approval, especially when working with sensitive data. In this way, RPA processes will not be interrupted, while all the exceptions will be nicely dealt with. On the other hand, RPA can be used to cover all the rule-based, boring User tasks and can serve as API for legacy systems without APIs or Web services. So instead of changing the existing system to implement those functionalities, BPM can use RPA as a solution.

Related and Future Work

One way of putting this thesis in context of other work, is considering existing solution that offer integration between RPA and BPM in one way or another. This includes all the examples of existing BPM systems integrating RPA tools, as explained in Section 4.4. Within the mentioned section, I exhibited how systems, such as Bizagi and Camunda, implement RPA tools and their point of view of why these two concepts should be collaborating.

Others examples of related work, can be found in the scope of research papers and case studies that explore the usage of RPA. Most of the papers focus on the benefits RPA brings to organisation, as well as the challenges they face in the process of implementation. There are also number of research papers that explore the idea of combining RPA with BPM solution.

In the book "Applied Computer Science in Engineering", can be found paper on topic "Automation of Business Process Using RPA" published in 2017 [55]. The main goal of this paper is to verify the benefits that are generally reported by consulting companies in annual reports. Researches conduct a case study by applying RPA within business processes. The obtained results showed that RPA improves the productivity, but they did not manage to achieve time reduction.

White paper published by Ovum Consulting, explores the use of RPA alongside BPMS solutions, where RPA is used to create APIs for legacy systems used by BPMS [56]. They see RPA as a complement to BPMS rather than replacement.

Another area is the use of RPA in digitalization of organisations. Recently published paper on topic "Value-Driven Robotic Process Automation" [57], discusses opportunities and challenges of applying RPA as process improvement approach. As mentioned

"Value-driven RPA is a part of a discipline of process-led digital transformation management, leveraging the capabilities of business

process management (BPM) to realize the full value of digital initiatives, fast and at minimal risk [57].”

Most of the papers focus on the use of Robotic Process Automation for accelerating digitalization of businesses.

6.0.1 Future Work

When it comes to future work, some of the possibilities that this topic offers are a further development of the prototyped integration of RPA and BPM, in a sense of more user-friendly interface. In-depth analysis of the benefits that this integration brings to companies is another way to explore this topic. In the focus of this thesis was the development of a prototype tool, without making a real evaluation of the benefits from the solution. I think that it would be interesting to see whether companies will achieve improvement in automation, cost reduction as well as increased productivity.

Evaluation

In this chapter, I will evaluate the goals set in Chapter 3, Goals revisited.

G1 Select Robotic Process Automation and Business Process Management notations for future work and inspect them

This goal was met and presented in Chapter 4, Section 4.1 and Section 4.2. I analysed UiPath notation as RPA vendor and the BPMN 2.0 standard, notation used by most of the BPM systems. Both notations were explained in great details, stating their differences and similarities, in Section 4.3. It should be mentioned that not every RPA vendor uses the same notation.

G2 Analyse how to combine Robotic Process Automation with already existing Business Process Management Systems

This goal is explained in Section 4.4, "How to combine RPA with BPMS". In this section, I describe the two main approaches of integration, either by starting RPA process from BPM system or the other way around, triggering BPM process from RPA activity. In this section, I presented some examples of how existing BPM systems, such as Bizagi BPM and Camunda BPM, offer this type of integration.

G3 Introduce Case study example in the area of Finance, suitable to be automated with Robotic Process Automation tools

In Chapter 5, in Section 5.1, I introduced a typical example of manually executed process in the area of Finance. The process was broken in more concrete steps in order to be simplified for automation. I also tried to use as many as possible applications in order to explore the automation abilities of RPA tools.

G4 Demonstrate how the Case study can be automated by using one of the already reviewed RPA tools, such as UIPath or Microsoft Power Automate

This goal was met in Case study chapter, in Section 5.2.1 and Section 5.2.2. I presented how the example from the introduction part of the same chapter, can be automated by using RPA tools, in this case UiPath and Microsoft Power Automate. I limited the implementation to only using these two RPA tools, since most of them work more or less in the same way and it was not in the focus of the thesis to evaluate all of them.

G5 Implement a prototype tool that helps integrate UiPath and Corima BPM

Combining RPA and BPMS, was my last goal in the scope of the thesis and I explain the implementation of such prototype tool in Chapter 5, in Section 5.2.3. The goal was to see how these two different tools can collaborate in order to provide full automation of processes. The implementation was done by using UiPath as RPA vendor and Corima BPM, both products are reviewed in Chapter 2.

G6 Evaluate the work and summarise the gained knowledge

This goal is achieved through the whole thesis. Starting from the general overview of both concepts Robotic Process Automation and Business Process Management, similarities and differences, to the analysis part where I went over the notations they use and whether or not can be combined. After every chapter, I provided a short summary in which I pointed out the most relevant and needed knowledge. The work done itself was evaluated through the previous stated goals.

Conclusion

The scope of my thesis was to explore the concepts of Robotic Process Automation and Business Process Management, and the idea of RPA helping existing systems to evolve faster. First, I started my work with an overview of the currently most trending RPA vendors on the market. Providing information on the products each vendor offers, exploring the limitations and the benefits organisations get from using RPA. The conclusion was that RPA finds use in many different areas, as long as the processes that need to be automated are well defined and rule-based. Both small and big organisation can benefit from using RPA, if they manage to properly identify the challenges they have, find suitable RPA vendor and implement the automation in the right way.

Second, I investigated the concept of Business Process Management and existing BPM systems. I researched this topic similarly to RPA. I chose a few BPM systems, overview their products and benefits that they claim to provide. Unlike, RPA, BPM is not a new trending topic. It has been present for a long time and many companies use BPM systems, enjoying the benefits they bring.

After the brief overview of both RPA and BPM, further was explored how similar or different are these concepts – whether they trying to solve the same problems and when is it better to use one or the other. The gathered knowledge implied that, although both RPA and BPM try to automate business processes, their area of influence is not the same. While RPA mainly focuses on automating rule-based, repetitive user tasks, BPM influences an organisation on all levels, providing end-to-end process management.

Having in mind these finding, next was explored the idea of whether these two concepts can work together, and in which way this can be implemented and what are the benefits from it. These questions were answered throughout the last two chapters. By finding a suitable case study example, I managed to explore practically how UiPath as RPA representative, can automate processes in the area of Finance. The last part was to implement a prototype, simulating the collaboration of RPA and BPM system. This helps see the benefits of using

RPA with existing legacy systems, and at the same time shows that it is not intended to replace them.

Overall, can be concluded that both concepts have a different area of influence and neither can independently maximise the business process automation. When combined together they tend to deliver better results. RPA cannot replace BPM systems but can help them evolve.

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Acronyms

AI	Artificial Intelligence
API	Application Programming Interface
BPM	Business Process Management
BPM	Business Process Modeling
BPMN	Business Process Modeling and Notation
BPMS	Business Process Management Systems
CMMI	Capability Maturity Model Integration
CMMN	Case Management Model and Notation
CRM	Customer Relationship Management
DMN	Decision Model and Notation
ERP	Enterprise Resource Planning
OMG	Object Management Group
REST	Representational State Transfer
RPA	Robotic Process Automation
SOA	Service Oriented Architecture
TMS	Treasury Management System
XML	Extensible markup language

Contents of enclosed CD

	readme.txt	the file with CD contents description
	videos	screen recordings of executions
	src	the directory of source codes
	impl.....	implementation sources
	thesis.....	source codes of the thesis \LaTeX
	text	the thesis text directory
	thesis.pdf.....	the thesis text in PDF format