Table of Contents

Abstract 1
Introduction 2
Research questions : 2
Research Objective 2
Research Methodology : 3
Literature Review 4
I. Digital Transformation 4
I.1. Digital Framework and enabler 4
I.2. Domains of DT application & Industry 4.0 5
I.3. Roadmap for DT 6
I.4. Factors influencing DT success projects 7
II. Robotic Process Automation 8
II.1. Differences between RPA and automation 8
II.2. Intelligent Automation influences on organizational performance 9
II.3. RPA advantages 9
III. RPA Development and Implementation 11
III.1. RPA market and vendors 11
III.2. Workflow Methodology Development of RPA 12
IV. RPA implementation challenges 14
IV.1. Case studies from literature 15
IV.2. Risk and control environment 16
IV.3. Organizational governance structure 16
IV.4. Robots onboarding 17
IV.5. RPA performance impact: 17
IV.6. An Optimal Task Allocation Approach for Large-Scale Multiple Robotic Systems 18
Conclusion & contribution 20
References V

Figures content

Figure 1: DT Framework 4
Figure 2: DT enabler: Applications & Services 5
Figure 3: DT building blocks 6
Figure 4 : Robotic Process Automation market (Beerbaum,2020) 11
Figure 5 : Automation Quadrant Derivation 14
Figure 6 :RPA processes candidates by frequency, work time and complexity of process 14

Tables content

Table 1:RPA implementations by sectors 15

DEVELOPMENT AND IMPLEMENTATION OF RPA FOR DIGITAL TRANSFORMATION IN MANUFACTURING: MICHELIN R&D CAMPUS AS CASE STUDY

Wafa KACEM

Abstract

In period of the fourth industrial revolution, Digital Transformation (DT) is one of the issues affecting not only the business life, but also the daily life. The effects of digitalization are evident and spread worldwide. Among DT emerged technologies, Robotic Process Automation (RPA) is the most challenging for enterprises. RPA is an application of technology, governed by business logic and structured inputs, aimed at automating business processes. Using RPA tools, a company can configure software, or a "robot," to capture and interpret applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems. While existing literature analyze RPA concepts, tools and framework, we know little about how it is developed and implemented in the manufacturing sector.

This research will provide an in-depth understanding of the current development status of RPA, grasp the future implementation trend of RPA, control the application prospect of this technology in real enterprises, and study the enterprise challenges while implementing it. Furthermore, the development and implementation of RPA in MICHELIN is performed using UiPath platform and applying RPA methodology combined with Business Process Management Systems (BMPS).

Keywords: Digital Transformation, Smart Automation & AI, RPA, Process Optimization, UiPath.

Introduction

Digital transformation (DT) is the process by which entities adapt themselves to modern technology. As digital technology becomes more prevalent (automation, cameras, sensors, touchscreens, artificial intelligence, etc.), there will be increased pressure on companies to leverage it for additional gains and remain relevant to digital customers.

Digital Transformation (DT) is reshaping entire segments and industries: communications, retail, and, increasingly, health care, medicine, agriculture, and manufacturing. While a few companies reach front-runner status, most seem to lag. Among emerged DT technologies ,Robotic Process automation is a top concern of senior leaders worldwide and motivated the development of this study.

Robotic Process Automation (RPA) is the technology that allows the automation of the task in exactly the way how a human does. A robot in robotic process automation does not mean that literally robots are going to replace human beings, but it means a computer program that imitates human actions.

In other words, Robotic Process Automation gives anyone today the ability to configure computer software, or a "robot" to emulate and integrate the actions of a human interacting within digital systems to execute a business process.

Furthermore, advances in AI and its sub-fields have enabled the development of a new form of automation described as Intelligent Automation (Coombs, Hislop, K. Taneva and Barnard,2020) and better known as Cognitive RPA. This promising technology is changing world economy and challenging DT practitioners. RPA implementation projects are tedious DT application. Thus, a roadmap is needed to better understand this technology and get profit.

In this thesis, an exhaustive literature survey is conducted treating the most recent research papers and books. The objective is to define emerging themes surrounding RPA technology, summarize success factors and challenges, suggest application of agile methods, integrated working modes of business & technology and dive deeper into the implementation of Smart automation in companies from different sectors. Practitioners can learn which tools and RPA platforms options exist, in which contexts they are applied, and which consequences can result from them.

Also, in the second part of this thesis, a case study of RPA development and implementation in manufacturing is explained. Within Michelin company, basic concepts of smart automation, DT project management and RPA implementation tools are applied.

Research questions :

Defining the research questions is a very difficult task, therefore, enough time has been given to fulfill this task. This is the main question defined to shape this research based on the found during the literature review. How can RPA enable Digital Transformation for workflow optimization, agile business and Digital workplace?

Research Objective

To meet the specific aim of this study the following objectives are formulated:

1. The first objective is to establish the state of art of DT projects specifically RPA and identify the key characteristics of the RPA concept across various contexts and perspectives. This objective is in this study achieved through literature survey.

2. To understand RPA development and implementation challenges, barriers and opportunities within a manufacturing context. This is very important because the notion of RPA in manufacturing isn't yet well treated by the scientific community. This objective is attained in this master thesis through case study of MICHELIN R&D campus, which implies conducting the whole project lifecycle of RPA initiative within the DORD department: from business analysis and Robots development to RPA implementation.

Research Methodology :

Part 1: Literature review

This part of the master thesis work implies preliminary research phase. In total, many research papers, books and Thesis have been reviewed, mainly on DT Implementation and success factors but also in other related topics. Also researches related to RPA technology, methodology and case studies, were thoroughly analyzed through excel tool, the partial summary of these works is presented in Appendix A. Then an exhaustive research phase is carried. The aim is to explain some of the main concepts which relate to our study. We will start by definitions of DT and RPA from literature. Next, the implementation processes and phases of DT and RPA projects will be discussed, so the challenges and issues that accompany usually the DT implementation projects can be studied deeply. Furthermore, as the research title also denotes, we'll have to learn more about Developing Robots and RPA vendors.

Part 2: RPA development and Implementation in manufacturing -Michelin as Study case

This case study is carried out within the DORD department of MICHELIN R&D campus based in Ladoux, France. An applied new RPA project approach is established by combining BMPS and RPA methodologies, holding the whole project lifecycle and managing its implementation. The most interesting part is the developing experience of two software robots using UiPath platform to achieve operational excellence since few of case studies synthetize the RPA journey of a business and almost none tackling with RPA implementation in manufacturing.

Literature Review

I. Digital Transformation

In this section, we focus on DT concept framework and challenges through literature's survey. Due to pressure from new business entrants, Digital Transformation (DT) drives companies to rethink about their processes and the way they interact with stakeholders, the need to adapt to new consumer behaviors, or the goal of making the most of technological tools in the areas of innovation and productivity (Bala,2018). DT is changing business and reshaping the world economy tremendously, thus an explanation of DT terms such as Digitization and Digitalization is needed.

There is a big difference between Digitization and Digitalization. According to (Sun ,2018) Digitization is the conversion of information from analogue to digital while Digitalization is the process enabling this conversion and Digital transformation is the effect. Digitization is defined as the conversion of products to digital format including the concomitant inventions that ensue or the automation of processes through information communication technologies. It's noted that Digitization has developed business-IT alignment approaches such as concepts for technology adoption, procedures for software selection, data and information integration using information systems for software selection, or data and information integration using information systems. On the other hand, Digitalization explains the synchronization of business and IT strategy of an organization and the incorporation of information technology into the business strategy to innovate business models and processes that exploit digital opportunities. Furthermore, Digitalization and Digital Transformation DT are used interchangeably by researchers although DT constitutes the systems-level restricting of economies, institutions and society that occurs through digital diffusion. Thus, it can be understood that Digitization had put the first step to an extensive digital transformation process which is fueled by the convergence of social, mobile, cloud, and smart technologies and the growing need for big data applications, automation, and integration (Udovita,2020)

Another advanced levels of DT are summarized by (Marciniak,2019). Automation and robotization constitute the third level and include: macros, scripting, routing, Robotic Process Automation RPA, augmented reality and robotized software testing. The fourth level is the use of cognitive/Intelligent technologies which include: Intelligent Characters recognition, Predictive analytics process & system simulation (digital twin), data mining, natural language processing, machine learning (cognitive RPA/chatbot), etc….

I.1. Digital Framework and enabler

It's evident that understanding DT framework is important to help digital professionals and collaborators performing their transformation projects. Figure 1 represents DT framework according to (Sun ,2018) who adopts a 'Think big, act small and move fast' methodology to ensure a DT approach within four main blocks.

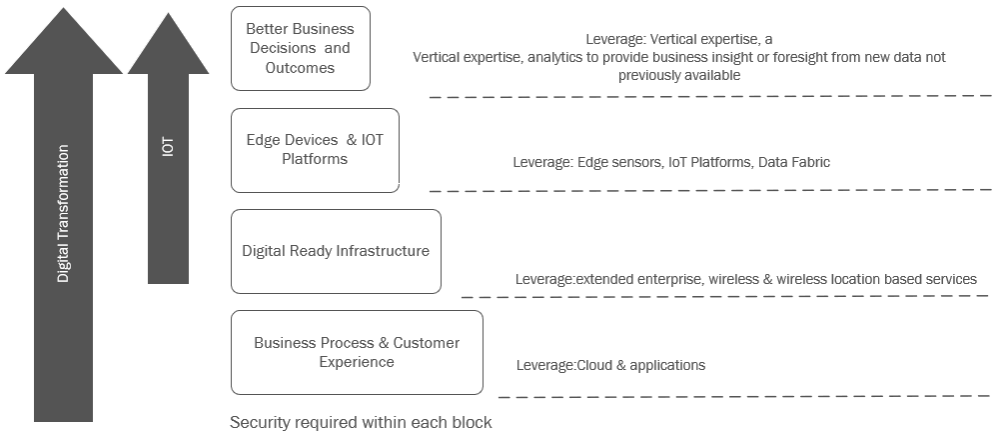


Figure 1: DT Framework

The researcher focuses on key elements such as transformed process & customer experience, infrastructure driven differentiation, instrumenting the physical world, data collection and analysis, new business problem solutions, decrease human costs, and increased accuracy.

The underpinning technologies of the digital transformation are multiple and diverse. Researchers have been interested in DT enabler to better understand this phenomenon and its components. Starting from technology advances that supports the digitization such as machine to machine communication (MMC or M2M), Block-chain, Cryptocurrencies, Artificial Intelligence (AI), and Big data and Analytics. The integration of these elements plays a fundamental role in digital transformation (Bala,2018). These also include Industrial Internet of Things (IoT) and Internet of Services, advanced application of CPS, Simulations enabling modelling and virtualization, Cybersecurity, Cloud computing, Augmented reality, Horizontal and Vertical System Integration, Autonomous Robots and Integrated agile industry. (Schallmo,2018) represents a digital radar with enablers and applications as shown in Figure 2.

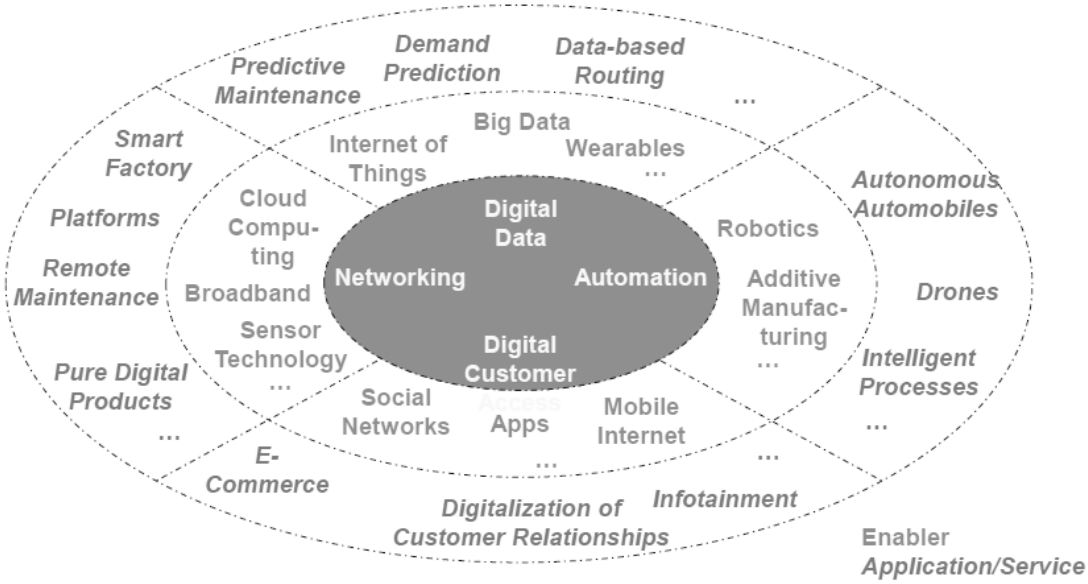


Figure 2: DT enabler: Applications & Services

This figure highlights both the massive expansion of Information Technology (IT) in value creation and the digital acceleration that leads to instantaneous exchanges of business holders within customers. From industrial point of view, it reminds the Industry 4.0 concept, which consists on vertical networking of smart production systems (Bala,2018).

I.2. Domains of DT application & Industry 4.0

The most vulnerable industries to digital disruption are media & entertainment, technology products & services, telecommunications, retail, and financial services. However, manufacturers haven't changed yet their relative positions in the market (Udovita,2020)

An overview of DT revolutionaries reveals that Information Technologies companies are in the lead. (Sun ,2018) lists ten DT leaders that change the world economy and technologies among them: Apple with $ 961.3 billion market Cap and growing, Microsoft: $ 946.5 billion market Cap and growing, Amazon with $ 916.1 billion market Cap and growing, Alphabet $863.2 billion market Cap, Alibaba with $545.4 Billion market Cap, etc…

The telecommunication industry is very vulnerable industry which continues to face challenges with outmoded IT systems, corporate cultures, and organizational structures. Moving forward towards the core in DT vortex, the industry needs to be well equipped to compete with strong digital capabilities such as Apple and Google. Most of the top players have now started to capture new revenue opportunities through IoT, digital services, and new business models and experiment with cross industry service creation and delivering. Moreover, the hospitality and tourism industry is another very digital

disruptive industry which laid the platform to many new trends and pushes the organizations towards digital transformation (Udovita,2020). Whilst the manufacturing sector profitability from DT is limited. From 2015 to 2017, this sector diverged from DT vortex center.

It should be noted that Digital Transformation is commonly associated to Industry 4.0 which is defined as the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing, and cognitive computing (Sun ,2018). In fact, in the period of the fourth industrial revolution, DT is one of the issues affecting the business life and changing traditional processes and approaches in the business ecosystem. The world is confronting a new digital economy platform where a series of conditions must be placed in a business model in sequential to approach a Digital transformation (Türkmen,2019). Moreover, several case studies and surveys in industry indicate that companies feel a need to invest in DT due to customer demand and market pressure, but at the same time it's challenging their abilities in planning and implementing digital transformation processes. (Udovita,2020) mentions the study among 12000 German companies where 41% of all enterprises see a "strong push" towards digitization and concludes based on empirical material that there is a clear need for better support of enterprises in digital transformation.

I.3. Roadmap for DT

A study conducted by MIT Center for Digital Business and Capgemini Consulting Team members reveals that executives are digitally transforming three areas of their enterprises: customer experience, operational processes, and business models (Bala,2018). Also, it defines nine elements form of building blocks for DT and an essential enabler element (digital capabilities) as shown in Figure 3.

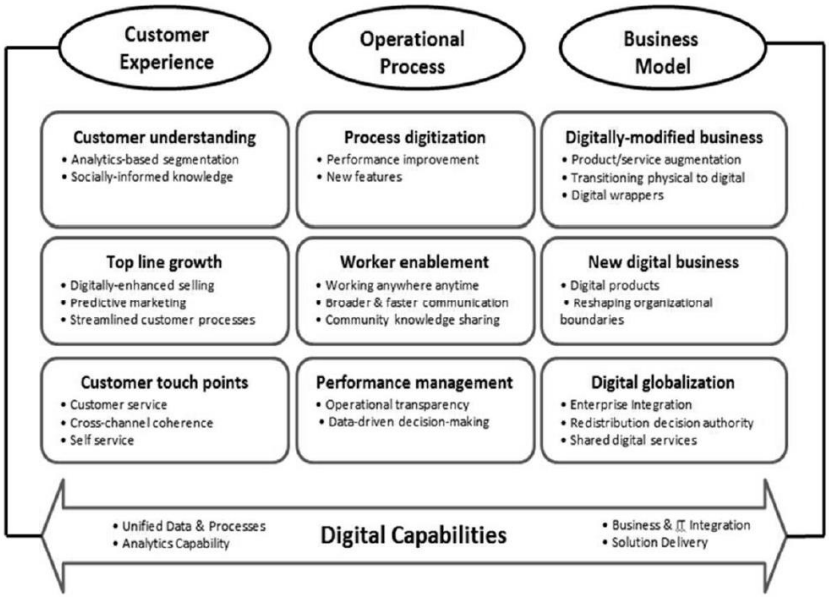


Figure 3: DT building blocks

According to (Bala,2018), no company has fully transformed all nine elements. Rather, executives are selecting among these building blocks to move forward in the manner that suits their organizations. In addition, (Schallmo,2018) proposes a Roadmap for DT serving as a reference for companies seeking techno change. It includes five phases from business analysis to the implementation of the digital business mode which are:

1.Digital Reality: In this phase, the company's existing business model is sketched along with an analysis of value chain related to stakeholders and a survey of customer requirements.

2. Digital Ambition : Based on the Digital Reality, objectives with regards to DT are defined. These objectives relate to time, space, finances, and quality. Digital Ambition postulates which objectives

should be considered for the business model and its elements. Subsequently, objectives and business model dimensions are prioritised .

3. Digital Potential : It's a starting point in terms of Digital Potential and the design of a future digital business model. Within this phase, best practices and enablers for the DT are established.

4. Digital Fit: This phase looks at options for the design of the digital business model which are evaluated to determine Digital Fit with the actual business model. This ensures that one fulfils customer requirements and that business objectives are achieved.

5. Digital Implementation which includes the finalisation and implementation of the digital business model. The various combinations of options are further pursued within a digital implementation framework. Resources and capabilities are also identified in this phase. The DT also includes the design of a digital customer experience and digital value creation network that describe integration with partners.

I.4. Factors influencing DT success projects

The digital transformation of industry is a complex task including many different facets and aspects. It is creating tremendous opportunities and confronting business holders with huge challenges. The possibilities opened by connected, more efficient production and new business models are highly promising but the risks are equally dramatic (Bala,2018).

(Sandkuhl,2019) defines eight success factors to help digital actors realize their vision which are:

- **Strategy**: Expressing a precise target picture is needed. The objective of the strategy can be interpreted in different directions, mainly to create awareness of the DT. This strategy must be integrated and communicated in all parts of an enterprise.
- **Products**: Communication with customers is essential; in addition, non-customer-oriented areas such as IT must seek dialogue with customers.
- **People**: Mandatory task and role models should exist for the digital competencies of employees in all areas of the company. In addition, further training opportunities should be provided.
- **Establish an innovation culture**: In a major change process, the company's culture must always be considered. The DT is a strategic project and must be a shared goal.
- Communication: Communication and cooperation within the company, but also with external stakeholders and customers, must be promoted. Accordingly, the organizational structure must be designed for digital processes, which can ensure transparency and dynamism.
- **Operations**: Due to the new digital orientation, further elements of the business must be adapted. The digital enterprises should leverage their knowledge of the business model to determine its digital potential.
- **Governance**: The digital transformation activities must be visible and controllable for the company. Digital governance structures should help with several tasks: mobilizing resources, acquiring digital skills, and reducing system redundancies. Frameworks and guidelines are often used to this end. Furthermore, the process of digitalization should be assessable, which explains why the digital strategy must be measurable through economic targets.
- **Technology**: In the field of technology usage, an essential task linked to digitalization is cross-channel interaction. The provider of the services should have an overview of all transactions and services for the customer considering different communication channels.

In addition to these factors, it's crucial to test ideas on a small scale first to reduce risks and foster acceptance as adviced by (Schallmo,2018) to get started today (or tomorrow at the latest).

During our research, we observed different levels of digital transformation that builds on each other. The digitization of process contents is the first step transforming physical extant (i.e., hand-written or printed) documents to digital materials. This step leads on to digitalization of processes that is the application of various technologies such as workflow systems to gain from electronic management and

operation of processes. Once processes are modeled and operated digitally, they can be automated or robotized. Automation permits decreasing the level of human interaction required for process completion. Robotization explicitly refers to the application of technologies that can substitute for the human workforce. These technologies are primarily either physical or software robots that specialize in specific tasks and functions (Marciniak,2019). Our study focuses on RPA (Robotic Process Automation) as DT enabler. Thus, the next section provides researchers definitions and summarizes RPA benefits & challenges for the industry. Also, an implementation methodology is treated.

II. Robotic Process Automation

Robotic Process Automation (RPA) is as an emerging form of business process automation based on the notion of software robots or artificial intelligence (AI) workers (Asquith and Horsman,2019) in which a new business language is revealed through this powerful technology since it enables the automation of rules-based business process and tasks using software bots (Kokina &Blanchette,2019). Also, RPA has superior advantages versus human execution:24x7 execution scalability and eternal lifetime (Beerbaum,2020).

RPA is defined as the automation of processes mimicking human interaction and using technology to reduce manual intervention and low value human touches in auditable and controlled manner. It can be thought as "digital workers" each using its own computer station. The "robot" allows for repetitive tasks to be performed accurately by interpreting the application, this is when the RPA program performs the instructions set by the developer by communicating with the systems using on screen recording and variables, then it triggers the response to produce results. These actions include logging into applications, copying and pasting data, opening emails, filling out forms, and many other actions performed on a computer.

RPA has evolved from desktop automation (DA) centered around macros focused on performing a single task using structured data. Unlike macros, RPA bots can interact with multiple systems, work autonomously, and perform routine tasks consisting of binary decisions that do not require intelligence. More sophisticated RPA evolves into cognitive or intelligent automation (IA) that can perform non-routine tasks involving judgment based on unstructured data bots (Kokina &Blanchette,2019).

According to (Kokina &Blanchette,2019), the RPA software product landscape is dominated by three companies: UiPath Inc., Blue Prism Group PLC, and Automation Anywhere Inc. A growth in the RPA market from $250 million in 2016 to $2.9 billion by 2021 is estimated. Thus, this technology is considered more powerful among the 21st century technologies.

II.1. Differences between RPA and automation

There are so many big differences between RPA and Automation. To start with, the approach of BPA (the traditional process automation which is considered as an aspect of Business Process Management) is focusing on removing inefficiencies and creating or evolving systems and processes to increase efficiency. While, RPA is focused on making a faster process, using software robots for performing process operations instead of human operators by not aiming necessarily to optimize it. Therefore, RPA is a tactical move to be used in the short term, until a traditional automation project can be planned and implemented.

Besides, the traditional automation of business processes (BPA) can be considered as an information system transformation move because it highlights the places where an existing process can be automated. Enterprise resource planning (ERP) system, Application Programming Interfaces (APIs), and Service-Oriented Architecture (SOA) are some of the traditional business process automation's solutions. On the other side, the implementation of RPA can be deployed on server or on user's desktop and it automates actions at the User Interface level without the need of sophisticated programming skills (Sibalija and Jovanović ,2019).

Finally, the BPA relies on Application Programming Interfaces or APIs and other integration methods, which mean that a developer should appear a high-level understanding of how the system/application works before integration takes place. However, RPA interacts at a human level (clicking buttons, typing

into text fields etc.) so it can only work as fast as the application works as it sits on the presentation layer (Asquith and Horsman,2019).

II.2. Intelligent Automation influences on organizational performance

In this section, a brief description is provided for to describe how have Intelligent Automation investments influenced business process performance or organizational performance.

The researches in the literature suggest that the application of Intelligent Automation would improve the business process performance. Researchers reported that the utilization of robots in science labs can increase labor, present so much precision, reduce risks to human operators, remove the contamination risks, and accomplish tasks so faster than human. As much as physical robots, Software robots are facilitating daily life. Considering that some of highly structured, routine, and manual tasks could be carried by a robot, the skilled workers have more time taking complex decisions. This is the promise of Robotic Process Automation (RPA) that emerges in the last seven years as a set of software tools and automation platforms that can automate tasks on rules-based business process. When we talk about Robots in the Robotic Process Automation processes or systems or tools, it doesn't exactly mean that robots (physical) but instead it means that there would exist software applications or blocks that can take over these responsibilities or tasks from humans and these can be performed more quickly and efficiently. (Kumar,2018).

(Ye ,2015) claims that pathologists can save time via automating routine secretarial work using an AI system. Similar thoughts for the Intelligent Automation efficiency in the sales work and in analyzing social media, and public affairs reporting are discussed.

Many studies show the positive influence of Intelligent Automation on business process performance. The business process performance can be improved through a full automation of processes or augmenting human capabilities. Mainly, by calling for Robotic Process Automation (RPA), routine administrative tasks will be executed automatically which will increase the need for people to undertake routine data entry work. This kind of AI will widespread business relevance, validating the sale of insurance premiums, generating utility bills, paying healthcare insurance claims, and keeping employee records up to date (Lacity and Willcocks, 2016). AI is the broad suite of technologies that can match or surpass human capabilities, particularly those involving cognition such as learning and problem solving (Coombs, Hislop, K. Taneva and Barnard,2020). (Lacity and Willcocks ,2016) report a case study of the RPA implementation experiences of Telefónica O2. By automating 15 processes using 160 RPA robots, they have provided a 600–800% return on investment in only three years and reported reductions or re-deployments of full-time employees (FTE) in the hundreds.

In another case study of Xchanging, a London-based business process and technology services provider that called RPA to validate the sale of 500 insurance policies reduced the process from days to about 30 min. By 2016, Xchanging had automated 14 processes using 27 RPA robots, saving 30% on each process. In both cases, it was shown that using business process performance improvements, the overall organizational performance will increase but it didn't explain the direct link. The combination of technical capabilities of Intelligent Automation with the social skills of human workers in hybrid worker teams will for sure improve the business process performance as reported in so many cases. (Coombs, Hislop, K. Taneva and Barnard,2020)

II.3. RPA advantages

While existing capabilities of screen-scraping and macros software technology may come to mind, RPA is an evolution beyond these solutions (Kumar,2018).

In contrast to other traditional IT solutions RPA allows for businesses and organization to automate at a lower cost with less time to market. RPA also doesn't disrupt underlying systems as it performs tasks as a human would meaning no downtime. It' s a real potential of cost-effect solution which theoretically can be implemented on top of any existing software solutions. The main Benefits of RPA technology outlined by researchers are accuracy, reliability, improved employee work experience, productivity,

non-invasive technology, consistency, compliance, and a low technical barrier. Thus, RPA is an important automation tool driving the future of work and DT.

II.3.1. Extreme Accuracy

Bots are extremely accurate, consistent, and arguably, it is less prone to procedural errors (mistaken implementations of a procedure) which may occur from a human performing the same set of tasks. Once a robot has been correctly programmed with its functionality tested and verified, it will perform the task with consistent provision. Any variable changes that leads to an failure in the process will return a notable errors to the user indicating that a process has not been completed as expected for some reason.

(Beerbaum,2020) affirms that it is an important factor to allow any results to be checked and help to instill trust in any process. So, a high level of reliability can be reached upon the procedures undertaken via RPA as there is limited margin for a robot to deviate from its allocated tasks.

II.3.2. Boosting efficiency and productivity with non-invasive Technology:

RPA offers an alternative to the typical approaches to bring about business change, including building or buying a new system, optimizing systems using a BPMS (Business Process Management Software), or outsourcing or shared services. Rather than requiring fundamental process redesign and associated expensive IT-driven transformation, RPA sits on top of the application and interacts with it. Providing that any underlying forensic software is compatible with any RPA platform, interaction can occur without any disruption to existing processes.

However, scheduled assignments can target processing times where resources are free or processing power is available such as overnight, allowing results to be available for practitioners at the start of a shift. It means, procedural tasks need to be confined to standard working day patterns where robot's commencement processing can be scheduled across all routine hours to obtain maximum processing benefits from existing infrastructure and resources (Asquith and Horsman,2019).

II.3.3. Relative Ease of Building Robots:

Despite requiring some level of upskilling (have to learn on new technological platforms of vendors), RPA offers a relatively low entry point. RPA vendors claim that no programming knowledge is necessary to configure a software robot. RPA tools generally offer a desktop process modelling tool which enables even business users to build complex desktop automation processes in the form of visual workflows. For example, UiPath platform uses flowchart actions to create a process by recording on screen actions (Asquith and Horsman,2019) while other studies reveal that it's not that easy to develop modules using RPA platforms.

II.3.4. Easily Calculated Savings:

Once a software robot is built, it is easy to understand savings and evaluate ROI (Return on Investment) because there is a direct relationship between a robot and an employee's tasks. Moreover, the orchestrator tool provided by many RPA vendors monitors Bots executions and calculates KPI's (Key Performance Indicators) instantly. However, the ability to realize any efficiency gains will depend upon management's willingness to change current business practices.

II.3.5. Improved Moral :

By implementing RPA bots, employees will have more time to invest their talents in more engaging and interesting tasks. RPA can handle some of the most routine tasks a business completes each day. Bots enable workers to offload manual tasks like filling out forms, data entry and looking up information from websites. This will improve morale in the HR (Kumar,2018) which will be a key factor in the business growth.

III. RPA Development and Implementation

We can describe the implementation process as one consisting of five stages: process selection, process automation, process running, process monitoring, and exception management. Initial RPA implementation typically starts with an organization selecting their preferred software vendor and a partner consulting organization for the technical aspects of RPA. In addition, a dedicated organizational structure for RPA is needed for governance and oversight such as the Center of Excellence (CoE). Then, the partner organization prepares a proof-of-concept (PoC) to demonstrate RPA software capabilities by automating a process that is simple yet important to an organization, one that, if automated, will generate meaningful savings, one that doesn't require prior standardization and one that interacts with several systems. This is done before software licenses are purchased. Before automating a process, it is important to examine if it can be improved or standardized in some way. If you automate a bad process, you'll just be automating errors. So, it's important to make sure that you clean up the processes first and not rely on RPA to fix a bad process for you (Kokina and Blanchette, 2019). In the following sections , we dive deeper in RPA implementation phases and challenges.

III.1. RPA market and vendors

In this section, an analysis of RPA vendors in the current market is conducted. In terms of RPA vendors, the research indicates how each vendor governs the market and emphasizes which vendor might correspond to Michelin's need. (Beerbaum,2020) recommends a rigorous capability-based assessment to identify the offering which is best suited to specific use cases. There are currently over 50 RPA product vendors in the market which is predicted to produce up to 4 million robots re-placing human work in 2021(Duc and Minh Thu ,2018).

In this context, it is important to distinguish between AI technology that supplements conventional RPA tools and that which modifies such tools. There has been an explosion of marketing buzzwords in the RPA space. "Smart process automation", "cognitive RPA" and "intelligent automation" all generally refer to the same thing, which includes anything that enhances basic RPA(Beerbaum,2020). Figure 4 is a survey of RPA market in terms of vendors and technologies.

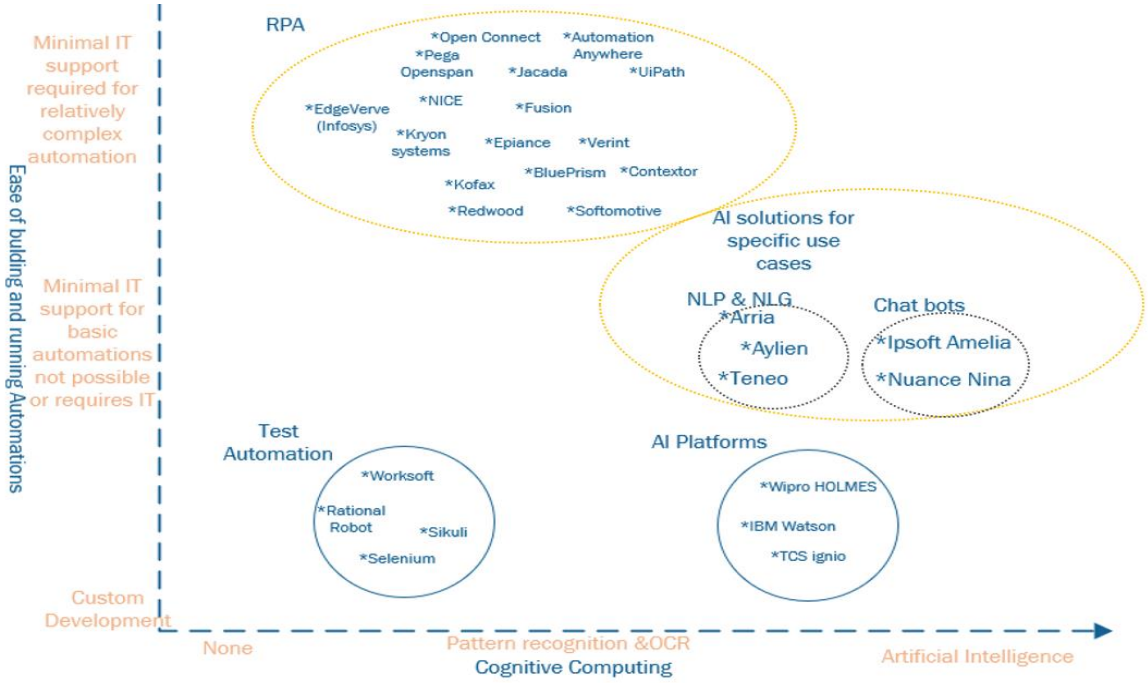


Figure 4 : Robotic Process Automation market (Beerbaum,2020)

Generally, RPA ensures that Intelligent Automation will take one of two forms. Either RPA vendors will develop their own AI algorithms and incorporate them into their products, or they will link to AI platforms such as IBM Watson via APIs. For better understanding. A match between a requested need of automation and the capabilities of a pre-ferried RPA tool will be investigated. These available intelligent automation tools are explained according to (Beerbaum,2020) and (Duc and Minh Thu ,2018) as the following:

- **OCR: Optical Character Recognition** which enables the extraction of a text from an image. These capabilities are useful in virtual desktops & Citrix where the screen appears as an image and the APIs can't connect to the software's backend.

- **IDR: Intelligent Document Recognition,** which is an extension to OCR that allows the image text to be converted into structured data, more precisely it is a sub-type of NLP.

- **NLP: Natural Language Processing** is useful as current RPA tools don't interpret the content of the textual data that arises in the workflow. This enables robots to use cognitive capabilities such as understanding context and using judgement where required. This can be shown in a simple use case in the form of a customer support desk ticket resolution system. An NLP engine would enable the robot to understand a submitted message and intelligently categorize it. However, some provide the ability to be integrated with an NLP offering. For example, UiPath offers the NLP integration through packages.
- **NLG: Natural Language Generation** involves the collation of data from a number of sources and then the production of a natural language report from this data. For example, Wealth Management firms review and analyze portfolio data, determine meaningful metrics and generate natural language reports for their customers on the investment performance of each of their funds generating natural language
- **Automatic identification of candidate business processes** for RPA identify candidate business processes which are suitable for RPA. Users can run a client in the background which gathers data on user activity, and machine learning techniques are used to suggest automation opportunities to the user.
- **Knowledge Bases and Advanced Exception Management** can enhance RPA agents with smart knowledge bases that find new and less-used patterns, memorize those patterns and support agents in the handling of complex exceptions. This allows RPA agents to work out the correct way to deal with situations that might not match pre-compiled rules.
- **Machine Learning techniques** enable RPA software to learn from previous activities and to become increasingly efficient and accurate.

RPA market leaders are UiPath, Blue Prism and Automation Anywhere (Asquith and Horsman,2019).In the last « Forrester Wave: Robotic Process Automation, 4th trimester 2019 » report UiPath is recognized as market leader, having best marks in actual offer , Strategy and market presence category

III.2. Workflow Methodology Development of RPA

It should be noted that RPA is a specific Digital Transformation project that express a Digital Business Strategy (DBS). RPA is the best illustration of business and IT strategy fusion. This emerged technology leverages on digital technology to improve several aspects of an organization, by studying the customers' interaction, the derivation of the value proposition, and/or how the monetization happens. (Udovita,2020).

III.2.1. Business Process Management Systems (BPMSs) vs RPA

Although RPA and BPMS present similarities as both play a significant role in digital transformation of enterprise, there are slight differences between them. The major aim of RPA is to automate repetitive

tasks, while BPMS focus not only on automation, but also on process improvement and decision support. Therefore, RPA acts at GUI level of an existing application, while BPMS development require programming skills. That is the reason why RPA can be implemented faster than a BPMS(Osman,2019). Also, from costs point of view, RPA is low-priced than implementing a BPMS because it requires less resource and time to market. Thus, RPA is considered lightweight IT, while BPMS as a heavyweight IT. RPA should be a complement of BPMSs or other type of system or IT technology, not as its rival as automating existing processes requires a structured approach to process analysis which is a critical aspect for RPA. In the second part of this master thesis, we'll try to apply BMPS concepts while developing and implementing RPA project.

Also, RPA projects are special IT transformation, so the Software Development Life Cycle (SDLC) methodology is applied . In general, it provides steps to design, develop and test a software. SDLC aims to increase the quality of both software and development process. According to (Duc and Minh Thu ,2018), there are six steps which formed a life cycle in that software development method which are:

Planning and requirement analysis: This is the most essential and fundamental stage in SDLC. A step is delivered by getting inputs from people who have both direct and indirect effects in the whole process, also called "product owner". Those inputs are utilized to plan project descriptions, product feasibility development and possible process risk identification.

Defining requirements: After delivering a requirement analysis, it is documented and get approved by customers. A document is done by following a Software Requirement Specification template (SRS). An SRS includes all requirements of a quality software product from designing to developing a life cycle.

Designing a product architecture: Based on SRS, a product designer will then develop a DDS which is design document specification. A DDS provides all definition of product's architect models and data flows of any external and third-party modules.

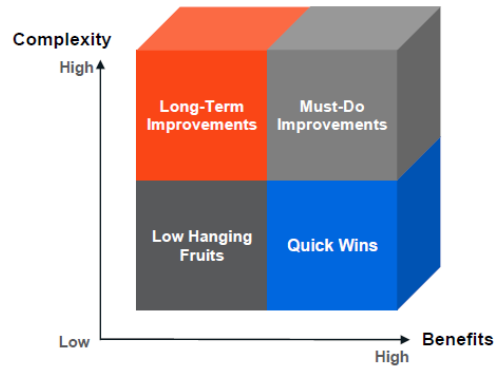
Developing a product: The product is built in this phase. Therefore, a programing language or any developing tool should be chosen based on a DDS which has been written in a previous step.

Testing a product: An activity of product testing has been done in each stage of SDLC model. However, a final testing will be done in a more comprehensive way that requires all testing indicators be qualified before deployment.

Deployment in a market and maintenance: There are two steps for production deployment. First, a product is deployed in a limited market to test its functions and level of impacts in the business environment. Second, based on that testing, a product is suggested to expand its scope in more market segments. Maintenance and supporting service are always ready to be delivered based on the customer's need.

III.2.2. Task suitability for RPA:

Although RPA is a promising technology, it has limits related to work processes and the IT environment. According to (Kokina and Blanchette, 2019), the nature of the process determines its suitability for RPA, not where the process is occurring. The tasks that are labor intensive, repetitive, high volume, and rules based on digital form using multiple systems and structured data are strong candidates for automation with RPA. Furthermore, tasks that doesn't require much human interaction to make judgment or decisions tend to be easier to automate. Processes that interact with several systems are particularly suitable for RPA and processes that are repeated by several people, if automated, result in greater ROI (Return on investment). Processes with tangible paper inputs and processes that interface with external applications that tend to change are less suitable for RPA. In this context, the RPA project manager is asked to prioritize actions depending on automation complexity and the estimated benefits. The following figure highlights four possible cases of automation.



Complexity	Benefits	Automation Quadrant
Low	High	Quick Win
Low	Medium	Quick Win
Medium	High	Quick Win
Low	Low	Low Hanging Fruit
Medium	Medium	Low Hanging Fruit
High	High	Must-Do Improvement
High	Medium	Must-Do Improvement
Medium	Low	Long-Term Improvement
High	Low	Long-Term Improvement

Figure 5 : Automation Quadrant Derivation

(Source: UiPath Academy,2020)

According to (Beerbaum,2020), the processes that are most suited for RPA are:

- **High volume of structured digital data**: Processes with unstructured data are not generally suitable for most RPA tools without IA support.
- **Relatively fixed processes or user interfaces, which do not change frequently**: It's a big mistake to spend time automating unfixed processes.
- **Rule-based activities that require little or no cognitive decision making**: this factor enhance automation with less time to market product.
- **Tedious, repetitive and low complexity tasks**

Furthermore, work duration or full-time equivalent (FTE) is considered as well as processes frequency. A survey of processes selection in RPA projects realized by (Sibalija and Jovanović,2019), is shown in Figure 6.

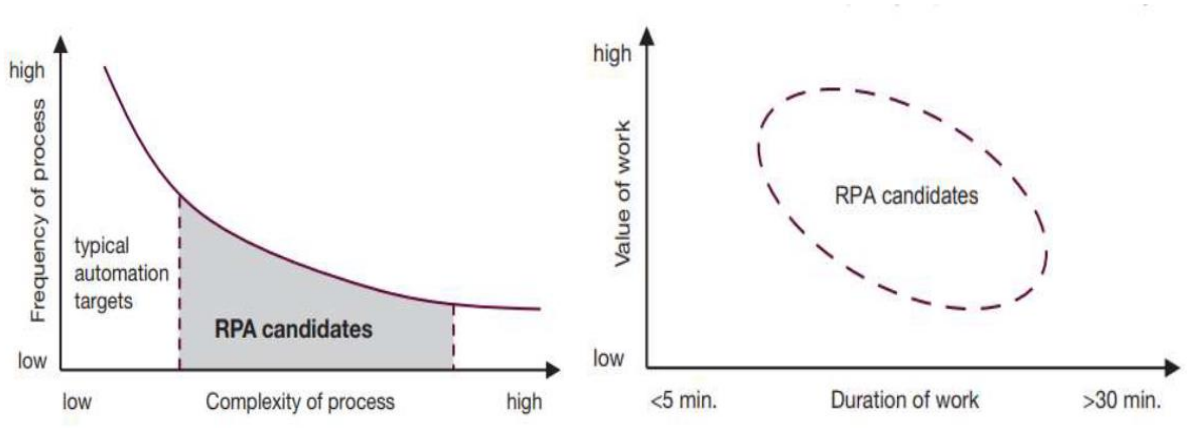


Figure 6 :RPA processes candidates by frequency, work time and complexity of process

IV. RPA implementation challenges

The focus of this section is to find answers for RPA most common proposed question: How this RPA needs to be executed? How to control risks & the new IT environment? what are the results expected

from smart automation and how to measure them? Why robots task allocation is a huge concern for RPA professionals?

IV.1. Case studies from literature

We searched for case studies of RPA and DT projects implementation, to investigate the actual state and implementation challenges in practical. Depending on industries sector, different types of processes are automated. Among the various applications of process automation, we find administrative tasks, financial transactions, HR operations … The next table illustrates activities automation by industry type, (Ivančić, Vugec and Vuksic,2019).

Table 1:RPA implementations by sectors

Industry type	***Process Type***	***Country***
Services	Recruitment (HRM services)	India
	Payroll process (outsourcing services)	Finland
	Financial and Insurance	Finland
	Payment receipt (outsourcing services)	Colombia
	Process of promotion in HRM (outsourcing services)	N/A
	HRM, IT management, Public relations, Knowledge management (consulting services)	N/A, global company
	HRM (audit, tax, and consulting services)	N/A, global company
Telecommunications	Purchasing	N/A, global company
	Sales (capacity check for bid processing) Subscription-based online service	Finland
	Back-office processes	UK
Financial & Insurance	Healthcare claims adjudication process	USA
	Administrative back-office process; Premiums processing; E-policies offshore process	N/A,global company
Healthcare management	Administrative, back-office processes	Finland
Sales	Vendor information processing	N/A, global company
Oil & Gas	Finance and accounting: the process of reconciliation the bank with the cash from the stations in the previous day	N/A

Generally, companies are facing same difficulties and challenges. One of the greatest challenges companies encountered when implementing RPA was the level of complexity associated with the need to document a process at a granular level of detail (Kokina and Blanchette, 2019).

Another difficulty with RPA that stems from the level of complexity encountered in RPA implementation is the realization that process owners who become bot managers need to possess technology-related skills to a much greater extent than the RPA software providers advertise.

(Kokina and Blanchette, 2019), a company D reports: «It's advertised like you don't need IT, you can just you know [how to] go build bots and run them, but it's not been like that at all.We've had a lot of IT help and support needed, more than we thought we would, and dropping an innovative new tool into the legacy environment and ecosystem of IT […] it's been challenging".

A notable difference in RPA implementation is that it is not typically driven by an organization's IT department. Instead, it is usually driven by business department employees, those who are directly involved in the process being automated, we call them process owners. Therefore, the technical complexity of RPA challenges organizations to think about the level of self-service to strive for while minimizing process owner dependence on IT who has limited capacity to move every RPA project forward. The benefit of automation begins to diminish with the amount of maintenance it requires. Organizations are struggling since they need to be prepared for more complexity and should expect a need of assistance from IT as part of an RPA implementation. In addition, incorporating bot resiliency (ability to deal with failure and errors) into the initial design phase can significantly improve RPA performance

IV.2. Risk and control environment

At the bot development stage there are other concerns that emerge. For example, understanding how to appropriately achieve collaboration between worker and the bot and determining how information should be reported are areas that are important yet frustrating and not clear-cut for organizations. Specifically, RPA implementation presents a need to reexamine and question existing internal controls and reconsider their need. To establish a strong RPA control environment especially as organizations, scale the number of bots in operation. (Kokina and Blanchette, 2019) collect and analyze interview data from adopters of RPA and document implementation issues and other aspects. The study summarizes implementation experience within sixteen companies from the Finance business.

RPA requires a new understanding of risk and internal controls by internal and external parties. It's evident that RPA does not increase overall risk within an organization if appropriate internal controls are put in place. (Kokina and Blanchette, 2019) relate the case of company D, focused on developing RPA-specific preventive controls and thorough documentation including coding best practices. To design the controls as part of RPA implementation. This company D continuously engages its SOX team and internal audit team who focus on software development controls and process controls. As organizations establish RPA-related internal controls, it is important to anticipate the needs of external auditors as they audit the work of both human and digital workers. Internal controls refer to ability to implement mechanisms that ensure reliable reporting, compliance with relevant regulations, and risk mitigation in RPA environment. If appropriate internal controls are not in place, users will not be able to rely on RPA output which in turn can negatively influence RPA-related performance.

IV.3. Organizational governance structure

None can deny the need for newly created elements of robotic governance in order to implement the digital worker. Many companies dealt with those elements as a part of their daily governance strategy and considered it as a part of their continuous improvement strategies. On the other hand, many companies have developed a Robotic Operating Model (ROM) which was, at first, instituted through a centralized governance body such as the Center of Excellence (CoE) (Kokina and Blanchette, 2019). Eventually, while RPA implementation expands, the level or model of governance within companies has become less centralized. In this model, certain aspect of governance central has been kept untouched like knowledge repository, coding standards and sharing of best practices when it keeps distributing control to various teams by using RPA. Governance can be considered as a new aspect of TTF which leads to RPA success. Governance refers to RPA tool's ability to meet its users' needs for accountability. Therefore, so the companies achieve RPA program success, RPA governance policies must be established, and the governance models will mainly depend on structure of an organization and the stage of RPA implementation maturity.

IV.4. Robots onboarding

To onboard a bot or a human employee, similar steps are involved. Some companies assign to each bot a bot ID, register it in the application inventory system, document each bot's purpose, and estimate its life span. Besides, every single bot presents an appropriate access for the function a bot performs for the organization. However, some other companies claim that ID and service account assignment for each bot will confuse IT as there is no existing IT policy with such path. Furthermore, to give each bot access to systems, the broad organizational structure needs to consider each digital worker, its specific roles and responsibilities. Some companies call for a dashboard, which serves as a central mechanism to assign operational bots across the entire organization as an anticipated step of having thousands of bots within the next few years. There is no doubt that Bot onboarding is more complex than anticipated as it is so difficult to determine what organizational IT and HR policies. Therefore, organizations need to improve documentation (organizational charts, job descriptions and responsibilities) for bots and for those humans managing them. As bot onboarding includes developing structures for bot management, assigning it to the governance component of TTF seems appropriate. It is an important part of successful RPA implementation even though governance is not a part of the original TTF construct.

IV.5. RPA performance impact:

IV.5.1. Quantitative performance measurement

Researchers conceptualize performance as the completion of tasks where better performance consists of improvements in efficiency, effectiveness, and quality. In RPA implementations, each of those categories of performance will be documented. There is an important RPA performance indicator used by many companies is Return on Investment (ROI) to evaluate the quality of the investment (Kokina and Blanchette, 2019). Companies attempt to identify early indicators of RPA performance by quantifying some of the different benefits. The major goal is to transform their employees' tasks from manual to higher value tasks. So many elements are usually considered; labor hours saved, the headcount of the temporary staff it currently employs reduce, the quality process improvement and the efficiency a bot runs without any intervention.

Some organizations target using RPA-related metrics in the long-term because otherwise, they prefer to focus on proper understanding of issues and provide time for adjustment.

Some companies claim that the measurement of time saved can be so imprecise because it is hard to really measure how long it takes someone to perform a task or a process. People have difficulty in estimating and, if they do, they often underestimate their actual time spent. This can make the bot appear to be performing worse than a human can. Therefore, those companies developed sensitivity around using the term “non-value-added” work considered as demeaning and cause robot-anxiety.

As organizations go ahead along their RPA implementation project, they realize that the impact of RPA is multi-faceted and not easily measurable. Some companies limit ROI in terms of hours saved, the use of those newly-found hours, and the risks that RPA helps mitigate. Organizations are successful in achieving quantifiable returns; however, a single traditional quantitative measure of ROI is less relevant in RPA implementation. Eventually, almost all of the companies use a broad range of quantitative success measures associated with RPA including hours saved, cost reduction, revenue generated, hours given back to customers, reduced error rates and bot efficiency. Companies are really facing challenges to measure ROI due to imperfect tracking mechanisms for hours and costs and motivation for human estimation error. Companies will need to continue to refine tracking methods and may consider process mining software to assist.

IV.5.2. Qualitative performance impact

Companies admit that even if they decide not to pursue RPA, a process still benefits as pre-RPA work. It forces teams to question why this process is performed in a certain way and if it can be a candidate for continuous improvement. Besides, it eliminates or decommissions of unnecessary processes, more precisely, those that do not add any value. For processes that are automated, RPA offers improved visibility and measurement as every step a bot performs is recorded when it comes to automated

processes. Therefore, RPA offers improved evidence, documentation, and support for audit and compliance and risk minimization. RPA appears to offer a better management of peak times at period ends because bots can be scheduled to work around the clock (Kokina and Blanchette, 2019). While implementing RPA, personal had forced them to understand their processes in detail and explain them to others. RPA helps to transform work from task performance to review which is considered an important success for employees. Lastly, RPA leads to a more agile by relying less on IT and implementing changes faster.

All we dealt with in this part proves that implementation of RPA has provided a wide range of qualitative success to organizations. Overall, if the appropriate tasks are automated and TTF components are considered and addressed, companies included in this study experienced at least some performance improvements.

IV.6. An Optimal Task Allocation Approach for Large-Scale Multiple Robotic Systems

Multiple robotic systems are of great interest in recent decades. As a typical yet challenging problem, multirobot task allocation (MRTA) has received much attention (Ren, Yu, Cao , Wu, Yu , Zhou, and Tan,2018). The objective of MRTA is to establish the relationship between robots and tasks with an effective resources deployment. Reviewing MRTA methods is essential when it comes to RPA solution deployment since it requires licenses allocation from the RPA vendor. These licenses are generating extra costs for the DT. If we optimize the number of licenses used, an important gain is realized especially for enterprises having a large scale multiple robotic system.

(Séguina and Benkalaïa,2019) develop an algorithm for MRTA of Robotic process automation (RPA) using an integer linear method. This two-phase approach is presented in this paragraph.

The first phase is used to compute the minimal number of robots required to complete the transactions. A linear integer program is proposed. Whilst, the second phase is about operations assignment to the robots.

The sets are defined as follows:

- P: types of transactions
- K: periods
- The parameters are:
- tp = time required to execute a transaction of type $p \in P$
- d = start-up cost of a robot
- c = reconfiguration cost of a robot
- vp = volume of transactions for type $p \in P$
- Wkp = 1, if process p ∈ P can be executed at period $k \in K$,
  - 0, otherwise.
- lk = length of period $k \in K$
- M = big-M value
- Variables are the following:
- $x\ pk$ = number of transactions of type $p \in P$ executed at period $k \in K$
- $n\ k$ = number of robots required at period $k \in K$
- $y\ k$ = number of robot start-ups at period $k \in K$
- $z\ kp$ = 1, if the transaction type $p \in$ P is executed at period k ∈ K,
  - 0, otherwise.

The objective function aims at minimizing the total number of robots and penalizing the total number of robot start-ups and reconfigurations:

$$\min \sum_{p \in P} \sum_{k \in K} n_k + y_k \times d + z_{kp} \times c \quad (1)$$

s.t.

$$\sum_{k \in K} x_{kp} w_{kp} = v_p \,, \forall\, p \in P, \quad (2)$$

$$\sum_{p \in P} \left(x_{kp} t_p + z_{kp} c + y_k d \right) \leq l_k n_k, \forall k \in K, \quad (3)$$

$$n_k - n_{k-1} \leq y_k, \forall k \in K \setminus \{1\}, \quad (4)$$

$$n_1 = y_1, \quad (5)$$

$$x_{kp} - M z_{kp} \leq 0, \forall k \in K, \forall p \in P, \quad (6)$$

$$n_k \in N, y_k \in N, \forall k \in \mathrm{K}, \quad (7)$$

$$x_{kp}, z_{kp} \in N, \forall k \in K, \forall p \in P. \quad (8)$$

This method is tested on practical case from a financial institution along with a bigger synthetic case to calculate the number of robots required to carry out a set of transactions for a financial institution in an RPA setting. The results are promising leading to a viable solution in the industry.

In the second part of the master thesis, UiPath platform is used to develop two robots having different rules and capabilities. This algorithm could be useful to optimize licenses allocation for developed robots.

Conclusion & contribution

In the age of the 21.st century, the economic world is under tremendous pressure to change. In the so called VUCA world (Volatility, Uncertainty, Complexity and Ambiguity) a high capacity for transformation and innovation is necessary (Burchardt, Maisch,2019). In this context, Smart automation represents an opportunity for business holders to get the DT profit.

RPA is a Digital Transformation solution that increments productivity, enhance operational excellence and reduce human's errors by using a software robot for automation in any knowledge work that requires employees to perform routinely and repeatedly.

In this thesis, an exhaustive literature survey is conducted treating the most recent research papers and books. The objective is to define emerging themes surrounding RPA technology, summarize success factors and challenges, suggest application of agile methods, integrated working modes of business & technology and dive deeper into the implementation of Smart automation in companies from different sectors. Practitioners can learn which tools and RPA platforms options exist, in which contexts they are applied, and which consequences can result from them.

This thesis R&D is considered as a first initiative in literature to treat RPA implementation challenges in manufacturing applying a BMPS approach. It includes all RPA project phases: Analysis, design & development, test, implementation and monitoring.

Appendix

Article	YEAR	DT								RPA													Technochange			
		Digitization	Digitalization	digital transformation	Enablers/Success factors	effects , challenges of DT	digital revolution	10 Digital revolutionaries	industry 4.0	RPA	Automation	AI	RPA Tools	RPA lifecycle	Roadmap	RPA benefits	RPA Vendors	UiPath	Structured Analysis	Robot development	Implementation	MULTIPLE robotic systems	Technochange management	Agile	BMPS	Case studies
The digital transformation of the banking industry	2015		1	1	1						1												1			1
An Optimal Task Allocation Approach for Large-Scale Multiple Robotic Systems With Hierarchical Framework and Resource Constraints	2018																					1				
Delineated Analysis of Robotic Process Automation tools	2018									1							1	1	1		1					
Digital Transformation in a Nutshell	2018			1	1										1				1		1					
From Digital Transformation to Digital Revolution	2018	1	1	1			1	1			1															
Workflow Methodology Development of RPA Solution for A Vietnamese Bank: A Case Study of Korkia Oy	2018			1						1					1		1		1	1	1				1	1
Digital Transformation: Review of Concept, Digital Framework, and Challenges	2018		1	1		1																			1	
RPA (Robotic Process Automation) – Case Study	2018									1	1			1		1										
Robotic process automation (RPA) using an integer linear programming formulation	2019									1												1				
Are Digital Transformation Projects Special?	2019			1																				1	1	1
Development Prospect and Application Feasibility Analysis of Robotic Process Automation	2019									1									1						1	1
Digital transformation: conceptual framework	2019		1	1															1							
Digitalization needs a cultural change – examples of applying Agility and Open Innovation to drive the digital transformation	2019		1	1																			1	1		
Early evidence of digital labor in accounting: Innovation with Robotic Process Automation	2019			1						1																1
Facilitating Digital Transformation by Multi-Aspect Ontologies:Approach and Application Steps	2019		1	1	1										1											
Let the robots do it! – Taking a look at Robotic Process Automation and its potential application in digital forensics	2019			1	1					1							1	1		1			1			1
Research on Cost Management Optimization of Financial Sharing Center Based on RPA	2019				1					1													1			1
Robotic Process Automation: Lessons Learned from Case Studies	2019									1															1	1
ROBOTIC PROCESS AUTOMATION: OVERVIEW AND OPPORTUNITIES	2019				1					1	1						1		1				1			
Robotic Process Automation: Systematic Literature Review	2019									1															1	
The Effects of Digital Transformation on Organizations	2019			1		1			1																	1
Process Selection in RPA Projects – Towards a Quantifiable Method of Decision Making	2019									1				1					1						1	1
An economy under the digital transformation	2019				1		1		1														1			
A Review of Digital Transformation in Mining	2019			1							1															1
Intelligent Business Services Operation	2019	1	1	1	1	1					1												1			
Artificial Intelligence Ethics Taxonomy-Robotic Process Automation (RPA) as business case	2020									1		1					1	1						1		
Conceptual Review on Dimensions of Digital Transformation in Modern Era	2020	1	1	1																				1	1	
Digital Transformation in Business	2020		1	1																					1	
Robotic Process Automation: A Scientific and Industrial Systematic Mapping Study	2020				1					1			1	1					1	1	1		1			1
The 2020 Pivot of RPA to Accelerate Business Transformation	2020				1					1		1											1		1	
The strategic impacts of Intelligent Automation for knowledge and service work: An interdisciplinary review	2020										1	1													1	
Patterns of Digitization A Practical Guide to Digital Transformation	2020			1																			1		1	
Our work : DEVELOPMENT AND IMPLEMENTATION OF RPA FOR DIGITAL TRANSFORMATION IN MANUFACTURING: MICHELIN	2020	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

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