NOVA IMS Information Management School

MDSAA

Master Degree Program in

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Intelligent Process Automation: Advancing Efficiency in Business Processes

Sofia Rocha Afonso

Project Work

presented as a partial requirement for obtaining a Master's Degree in Data Science and Advanced Analytics

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
Universidade Nova de Lisboa

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Intelligent Process Automation: Advancing Efficiency in Business Processes

by

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Project Work presented as a partial requirement for obtaining a Master's degree in Data Science and Advanced Analytics, with a specialization in Data Science.

Supervised by

Vítor Duarte dos Santos, PhD, NOVA Information Management School

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Lisbon, 22nd April 2025

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ABSTRACT

Robotic Process Automation (RPA) has significantly transformed how companies handle repetitive tasks by automating routine, rule-based processes. However, traditional RPAs struggle with complex, unstructured tasks requiring decision-making and adaptability. This thesis explores the transition from RPA to Intelligent Process Automation (IPA), which combines RPA with advanced technologies like Artificial Intelligence and Machine Learning to address these limitations. The research focuses on developing and implementing an IPA solution for the Charging Station Operators' invoicing process at EDP Comercial. Through a structured five-phase methodology, including a comprehensive literature review, detailed work plan, design and development, implementation, and evaluation, the study demonstrates the substantial benefits of IPA. The developed IPA system utilizes UiPath's Robotic Enterprise Framework, Azure services, and a GPT-powered API for data extraction and processing. Evaluation results highlighted a 65.2% reduction in processing time, significant cost savings, and a notable increase in accuracy from 90% to 97%. The automation not only streamlined the invoice validation process but also allowed the billing team to focus on higher-value tasks, enhancing overall productivity and job satisfaction. Despite the promising outcomes, the project encountered limitations such as initial investment costs, ethical challenges, and integration with legacy systems. Future work should focus on expanding IPA to other processes, continuous improvement of AI models, enhancing data analytics capabilities, and exploring emerging technologies. This project underscores the transformative potential of IPA in optimizing business processes, aligning with global trends toward digital transformation and intelligent automation, and contributing to the development of smarter and more adaptive business environments.

KEYWORDS

Intelligent Process Automation; Artificial Intelligence; Robotic Process Automation; EDP Comercial.

Sustainable Development Goals (SDG)

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LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial Intelligence
API	Application Programming Interface
BI	Business Intelligence
BPA	Business Process Automation
BPM	Business Process Management
BPO	Business Process Outsourcing
B2C	Business to Customer
DSR	Design Science Research
DT	Digital Transformation
ER	Entity-Relationship
Gen-AI	Generative Artificial Intelligence
HTTP	Hypertext Transfer Protocol
IA	Intelligent Automation
IaaS	Infrastructure as a Service
IPA	Intelligent Process Automation
IoT	Internet of Things
IT	Information Technology
LLM	Large Language Model
ML	Machine Learning
NLP	Natural Language Processing
OPC	Charging Station Operator
OPEX	Operational Expenses
PaaS	Platform as a Service
PRISMA	Preferred Reporting Items for Systematic Reviews and META-Analysis
REFramework	Robotic Enterprise Framework

RPA	Robotic Process Automation
RQ	Research Question
SaaS	Software as a Service

1. INTRODUCTION

1.1. CONTEXT AND PROBLEM IDENTIFICATION

Robotic Process Automation (RPA) has revolutionized the way companies handle repetitive tasks by automating routine, rule-based processes. These systems are designed to mimic human interactions with digital systems, enabling businesses to streamline operations and reduce the need for manual intervention. The implementation of RPA enables companies to relieve their teams of monotonous and time-consuming activities, allowing employees to focus their efforts on more strategic and creative tasks. Key benefits of RPA technology include improved accuracy, productivity, and employee morale, consequently leading to an improvement in employee satisfaction, as workers are relieved from repetitive tasks and can engage in more meaningful work (Asquith & Horsman, 2019).

However, while RPAs excel in handling structured and repetitive tasks, they often fall short when dealing with more complex, unstructured processes that require decision-making and adaptability. This limitation creates a gap in automation capabilities, as many business processes involve variables that RPAs are not equipped to handle. For example, tasks that involve interpreting unstructured data, such as customer emails or documents with varying formats, require a level of understanding and flexibility beyond the reach of traditional RPAs. As a result, companies may find that while some processes are efficiently automated, others remain reliant on human intervention, limiting the overall effectiveness of their automation strategies (Van Der Aalst et al., 2018).

In the context of EDP Comercial, Robotic Process Automation stands as a pivotal strategy, particularly with a focus on innovative implementations integrating Artificial Intelligence (AI). EDP Comercial harnesses RPAs to streamline operations and enhance efficiency across various business processes. These advanced RPAs not only automate routine tasks but also leverage AI capabilities to handle complex decision-making processes. This strategic integration not only optimizes operational workflows but also sets the stage for exploring further advancements. This thesis explores how such technologies can propel businesses towards more intelligent and autonomous operational frameworks.

This is where Intelligent Process Automation (IPA) steps in to bridge the gap left by RPAs. IPAs combine the power of RPAs with advanced technologies such as Artificial Intelligence and Machine Learning (ML). These enhancements allow IPAs to handle unstructured data, make informed decisions, and adapt to real-time changing conditions. Allied with these advantages, the complementary use of AI algorithms and techniques allows for improvement in the accuracy and execution of RPA processes in the extraction of information and the recognition, classification, forecasting, and optimization of processes (Ribeiro, Lima, Eckhardt, et al., 2021). By integrating IPA, companies can achieve a higher level of automation, ensuring that even the most complex processes are managed efficiently and accurately, as human error is nullified in this approach (Kholiya et al., 2021).

Despite the significant advancements offered by IPA, there are still areas that need further improvement. One key challenge is the seamless integration of IPAs with existing systems and workflows. Companies often have a diverse information technology (IT) landscape and ensuring that IPAs can interact smoothly with all components can be complex and resource intensive. Clarifying these aspects and addressing the integration challenges will be crucial for maximizing the benefits of IPAs and ensuring a smooth transition toward more intelligent and autonomous business operations.

This situation led to the formulation of the following Research Question:

RQ: How can Intelligent Process Automation improve the efficiency of business process automation?

1.2. Objectives

The project's goal would be to determine the most effective method for transitioning from RPAs to IPAs for automation, as well as where and how IPAs can be used to improve currently running autonomous business operations or to automate new processes to relieve the team of tedious everyday tasks. This will increase team productivity and efficiency, lower operational risks, and improve customer satisfaction.

To achieve the main goal, the following intermediate objectives were defined:

- Make a comprehensive review of existing literature on RPA and IPA (key findings, theories, and technologies related to RPA and IPA)
- Identify a process at EDP Comercial that could benefit from transitioning to IPA
- Develop a strategy for integrating IPA with existing systems at EDP Comercial (integration plan, technical requirements, timelines, …)
- Implement and deploy the IPA solution
- Assess the performance and impact of the IPA implementation (performance evaluation)
- Provide recommendations for optimizing IPA usage and explore future research directions

1.3. Project Relevance and Importance

The outcomes of this project hold significant potential for EDP Comercial, offering benefits that may improve employee satisfaction and happiness. By exploring the transition from RPA to IPA, EDP Comercial can achieve enhanced operational efficiency by automating complex processes currently beyond the capabilities of traditional RPAs. This advancement can lead to substantial time and cost savings, enabling more efficient resource allocation, optimizing operational workflows, and reducing operational risks (Ribeiro, Lima, Eckhardt, et al., 2021). The increased productivity can lead to better and faster service delivery, contributing to EDP's competitive edge in the market. Furthermore, as more businesses adopt advanced automation technologies, the cumulative effect can drive economic growth by improving speed, accuracy, and efficiency (Kaya, 2019), and reducing operational costs.

Additionally, the adoption of advanced technologies may stimulate job creation in tech-related fields, contributing to societal advancements in technological proficiency and employment. Automating tedious and time-consuming tasks through IPA can significantly enhance employee satisfaction by allowing them to engage in more meaningful and intellectually stimulating work, leading to higher levels of job satisfaction, reduced burnout, and an overall happier and more motivated workforce (Asquith & Horsman, 2019). This shift not only improves individual well-being but also enhances organizational performance through increased innovation and creativity among employees (Kholiya et al., 2021).

From a knowledge and scientific perspective, this project aims to contribute significantly to the fields of automation, artificial intelligence, and business process management. The development of an integration strategy for IPA with existing systems at EDP will offer practical guidelines that are valuable for big companies that deal with a large number of IT tools. The project will provide empirical evidence on the effectiveness of IPA in a real-world setting, culminating in actionable recommendations for optimizing IPA usage and exploring future research directions (Brás et al., 2023).

Thus, the project promises to transform business operations and pave the way for a more efficient, innovative, and satisfied workforce. The project's broader implications underscore its importance, as it aligns with global trends toward digital transformation and intelligent automation, ultimately contributing to the development of smarter and more adaptive business environments.

2. WORK PLAN

As previously stated, this research aims to develop an Intelligent Process Automation solution. In this regard, the Design Science Research (DSR) methodology is the appropriate research methodology to apply. The field of design science studies how to mix multiple elements to produce an artifact (Hevner et al., 2004). A conceptual model is an artifact created to resolve a specific issue or enhance already-existing solutions. (Simon, 2019).

Research on DSR has produced several publications, many of which offer comparable models for creating artifacts that address certain issues. However, in the context of this study, it will be used as an adaptation of the model put forth by (Peffers et al., 2007). This model has multiple iteration steps that are utilized in the application of the methodology.

2.1. PROJECT PHASES

This project will have five phases, and each phase is designed to build on the previous one, ensuring a systematic and comprehensive approach. The first two phases will focus on defining the main objectives and building the theoretical pillars. Then, in the third and fourth phases, an IPA solution will be designed, developed, tested, and deployed at EDP Comercial, following the business requirements, and ensuring its quality control. In the last phase of the project, the results obtained will be evaluated and discussed.

Figure 2.2.1 - Project Management Stages

(Source: prepared by the author)

2.1.1. Phase 1: Problem Definition

In this initial phase, the focus is on laying the groundwork for the research. It begins with conducting a comprehensive literature review on Robotic Process Automation and Intelligent Process Automation and culminates in the development of a theoretical framework that will guide the research.

The activities in this phase ensure a clear understanding of the current state of automation technologies and set the stage for the subsequent research steps.

2.1.2. Phase 2: Methodology

During the second phase, the objectives and methodologies for the project are clearly defined. This includes developing a detailed work plan and the methodology for integrating IPA into existing systems at EDP Comercial. The aim is to create a structured approach that aligns with the goals of the research. A chronogram with milestones and timings is also included in this phase. By the end of this phase, a robust framework will be in place to guide the design and development of the IPA solution.

2.1.3. Phase 3: Design & Development

Once a Theoretical Framework and the work plan are established, it is necessary to define the specific process at EDP Comercial that will benefit from IPA.

In this critical phase, the actual design and development of the IPA solution take place. It starts with aligning objectives and requirements and designing the solution architecture. This is followed by the development and iterative testing of the IPA solution, ensuring it meets quality standards and performs as expected. This phase is crucial for translating theoretical insights into practical, workable solutions.

It is important to note that this phase will be carried out following the agile methodology for software development.

2.1.4. Phase 4: Evaluation

Once the IPA solution has been deployed, evaluating its performance and impact is essential. This phase includes analyzing the financial impact, and performing a detailed results analysis. The conclusions drawn from this evaluation will provide insights into the effectiveness of the IPA solution and its implications for EDP Comercial. This phase is essential for validating the implementation's success and identifying improvement areas.

2.1.5. Phase 5: Communication

The final phase focuses on communicating the research findings and recommendations. It involves writing conclusions, outlining limitations, and suggesting future work and development directions, ensuring continuous improvement and innovation in business process automation at EDP Comercial. The thesis will undergo revision and improvements, followed by a final review by the supervisor before delivery. This phase ensures that the research is thoroughly documented and reviewed, ready for submission.

2.2. CALENDAR

Based on the DSR methodology, the figure below describes the planned chronogram associated with the project phases described before.

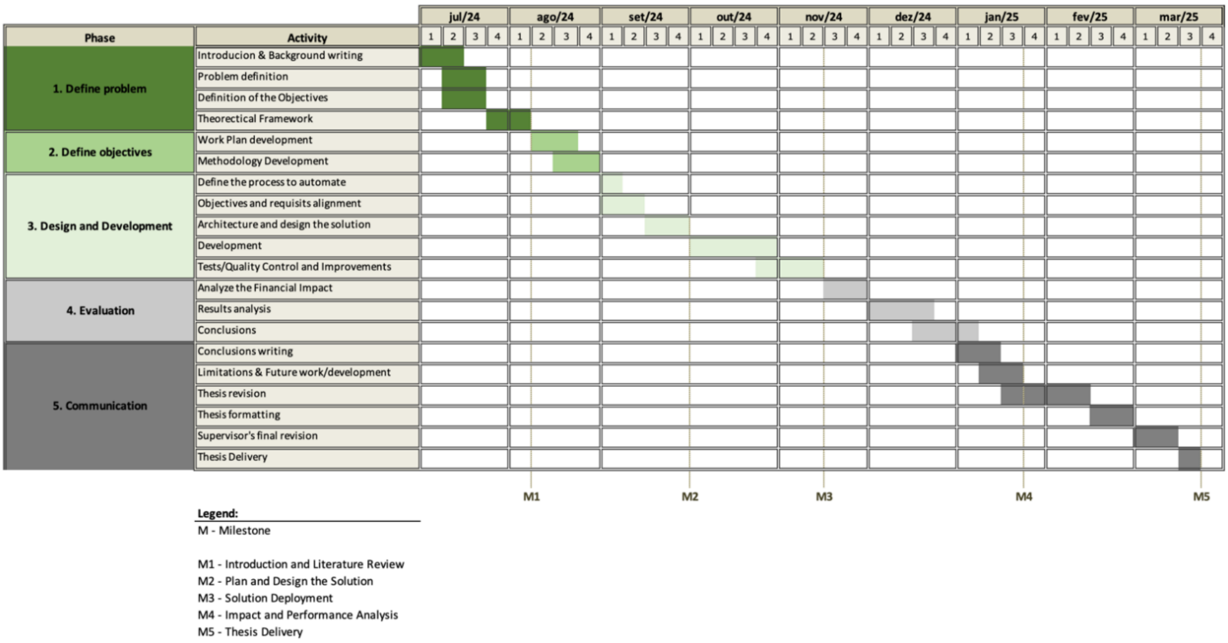

Figure 2.2 - Project Chronogram

(Source: prepared by the author)

Figure 2.2 is available in Appendix A for better readability.

2.3. Tools & Technologies

2.3.1. Microsoft Azure

Azure is a comprehensive cloud computing platform offered by Microsoft, providing a wide range of services to help individuals and organizations build, deploy, and manage applications and services through Microsoft-managed data centers. It encompasses infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) offering, enabling users to leverage computing power, storage, and networking resources without needing to invest in physical hardware. Azure's broad service offerings support a variety of use cases, including machine learning, data analytics, and Internet of Things (IoT) applications (Microsoft, 2024).

One fundamental concept in Azure is the idea of resource groups. A resource group is a logical container that holds related Azure resources such as virtual machines, databases, web apps, and storage accounts. It serves several key purposes: first, it provides a way to manage and organize resources that share a lifecycle, such as those belonging to a specific application or project. Second, it allows for easier management of access control and permissions, as permissions can be assigned to the resource group as a whole rather than to individual resources. Third, it enables efficient deployment and tracking of costs and usage, as resources within the same group can be managed collectively. Resource groups also facilitate the application of policies and compliance standards across all resources, contributing to more consistent and secure cloud environments (Microsoft, 2024).

2.3.2. UiPath (Studio and Orchestrator)

UiPath is a leading Robotic Process Automation platform that enables organizations to automate repetitive and rule-based tasks, significantly improving efficiency and reducing operational errors. It has been widely adopted across various industries for automating processes such as data entry, invoice processing, and customer service tasks. The platform leverages software robots, or "bots", to mimic human actions within digital systems, freeing up human resources for more strategic and creative tasks. The ease of use and flexibility of UiPath have contributed to its widespread adoption, particularly in business environments where automation is crucial for enhancing productivity (Van Der Aalst et al., 2018).

Two essential components of the UiPath ecosystem are UiPath Studio and UiPath Orchestrator. UiPath Studio is a development environment where users can design and build automation workflows using a visual, drag-and-drop interface, which makes it accessible even to non-technical users. This tool supports the creation of workflows that can interact with various applications, such as web browsers, desktop applications, and databases, thereby offering a versatile solution for automating a wide range of tasks. UiPath Orchestrator, on the other hand, is the centralized platform that manages these automated workflows. It provides functionalities for scheduling, deploying, and monitoring bots, as well as logging and auditing. This management layer is critical for scaling automation efforts across an organization, ensuring that processes run smoothly and efficiently (Aguirre & Rodriguez, 2017). Together, these components form a comprehensive automation solution that enables businesses to enhance operational efficiency and drive digital transformation.

2.3.3. Python

Python is a high-level, interpreted programming language widely recognized for its simplicity, readability, and versatility. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming, making it suitable for various applications, from web development and data analysis to artificial intelligence and scientific computing. The language’s design philosophy emphasizes code readability and simplicity, allowing developers to write clear and concise code. According to research, Python's popularity has surged due to its extensive libraries, community support, and applicability in emerging fields like data science and machine learning (Lutz, 2013). Python’s ability to integrate with other languages and tools, alongside its vast ecosystem of packages, further enhances its utility in both academic and industrial settings (Oliphant, 2007).

2.3.4. SAS Enterprise Guide

SAS Enterprise Guide is a widely used data analysis and reporting tool developed by the SAS Institute, designed to provide a user-friendly graphical interface to access the extensive analytical capabilities of SAS software. It is employed in various industries such as finance, healthcare, and research for tasks like data manipulation, statistical analysis, and the generation of reports. The tool's graphical user interface allows users to design and automate data analysis workflows without needing to write complex code, making it accessible to both technical and non-technical users. The drag-and-drop interface facilitates tasks such as data querying, filtering, and summarization while also allowing the integration of custom SAS code for advanced analysis (SAS Institute Inc., 2024).

One of the strengths of the SAS Enterprise Guide is its integration capabilities with other SAS products and various data sources, including databases, spreadsheets, and flat files. This integration supports comprehensive data management and advanced analytical procedures. Additionally, the tool enhances collaboration by allowing project sharing, where multiple users can work on the same project by adding tasks, notes, and results. The automation of repetitive tasks and support for scheduling in the SAS Enterprise Guide increases productivity and ensures consistency in reporting. These features are particularly valuable in data-driven environments where timely and accurate decision-making is critical (Slaughter & Delwiche, 2017).

3. LITERATURE REVIEW

The Literature Review chapter is strategically organized to explore both Process Automation in a more general perspective and IPA. The section on Process Automation introduces essential concepts, different types, and the challenges and opportunities in the field. The second section, however, takes a more rigorous approach by conducting a Systematic Literature Review on IPA using the PRISMA protocol. PRISMA, which stands for "Preferred Reporting Items for Systematic Reviews and Meta-Analyses", is a widely recognized methodology that ensures a transparent and replicable process in reviewing existing literature. By following PRISMA, this section systematically identifies, selects, and critically appraises relevant studies, providing a comprehensive and unbiased analysis of the current state of research in IPA.

3.1. PROCESS AUTOMATION

3.1.1. Concepts

Process automation refers to the use of technology to perform tasks with minimal human intervention, leveraging various tools and systems to execute repetitive, rule-based processes. This approach increases efficiency and reduces human error by integrating software applications that can replicate human actions in interacting with digital systems. Early automation efforts focused primarily on simple tasks, but advancements have led to systems capable of managing complex operations (Van Der Aalst et al., 2018).

A key concept within process automation is the use of "bots" or software robots that execute predefined tasks. These bots can perform a wide range of activities, from data entry and extraction to complex decision-making processes. The objective is to streamline workflows, enhance productivity, and allow human workers to focus on more strategic activities (Lacity & Willcocks, 2016). Automation technologies vary widely in their capabilities, with some systems relying on basic scripting and others incorporating advanced algorithms and artificial intelligence to handle dynamic tasks.

3.1.2. Types

Process automation can be categorized into several types, each with distinct characteristics and applications:

Workflow Automation: Defined as the technology-driven automation of a series of tasks or processes to streamline and improve the efficiency of workflows. According to (Van Der Aalst et al., 2016), workflow automation involves the use of software to perform tasks that were previously done manually, ensuring that business processes are executed consistently and efficiently.

Business Process Automation (BPA): BPA extends workflow automation by automating end-to-end business processes, focusing on optimizing and automating entire processes rather than individual tasks. BPA solutions typically involve complex integrations and can span multiple departments and functions within an organization (Moreira et al., 2024).

Robotic Process Automation (RPA): RPA utilizes software robots to mimic human actions in interacting with digital systems. These robots can perform tasks such as data entry, transaction processing, and report generation. RPA is particularly effective for automating repetitive, rule-based tasks and is widely used in industries such as finance, healthcare, and customer service (The Institute of Electrical and Electronics Engineers, Inc., 2017).

Business Intelligence (BI): BI involves the use of data analysis tools to help organizations make informed decisions. While not a form of automation in the traditional sense, BI tools automate the collection, analysis, and presentation of business data, supporting decision-making processes (Chen et al., 2012).

Intelligent Process Automation (IPA): IPA combines AI, machine learning, and RPA technologies to automate and streamline business processes. IPA goes beyond traditional automation by incorporating cognitive capabilities, such as natural language processing and predictive analytics, to mimic human decision-making and perform complex tasks. IPAs can interpret unstructured data, learn from it, and make informed decisions, allowing businesses to automate processes requiring a level of understanding and adaptability beyond the capabilities of traditional RPAs (Asadov, 2023).

Agentic Artificial Intelligence: Agentic AI refers to autonomous AI systems capable of making decisions and executing tasks with minimal human intervention. Unlike traditional AI, which operates within predefined rules, agentic AI actively pursues objectives, adapts to changing conditions, and optimizes workflows to achieve goals efficiently. These systems analyze real-time data, learn from past experiences, and refine their decision-making processes dynamically. This kind of AI is widely applied in business automation, supply chain management, and customer service, where its ability to operate independently enhances efficiency and responsiveness. For example, in supply chains, agentic AI can autonomously adjust logistics in response to unexpected disruptions, ensuring optimal resource allocation. In customer service, it can handle inquiries, refine interactions based on user feedback, and improve customer satisfaction without human oversight. Ensuring transparency, accountability, and compliance with ethical guidelines is crucial to managing the risks associated with autonomous decision-making. As adoption grows, organizations must implement robust frameworks to align agentic AI with business objectives and societal values (*AI Agents in 2025*, 2025; Viswanathan, 2025).

3.1.3. Challenges and Opportunities

While the benefits of process automation are significant, several challenges must be addressed to maximize its potential. In the research "A systematic literature review on intelligent automation: Aligning concepts from theory, practice, and future perspectives", the authors noted that companies are dealing with the following challenges regarding IPA (Ng et al., 2021):

Expert Trust and Dependency Problems: It is critical to ensure that experts trust automation systems while avoiding overreliance on them. As reliance on automated systems grows, there is a potential risk of diminishing human expertise, which may result in the erosion of critical skills and knowledge within the organization.

Cultural Readiness and Staff Reskilling: Successful implementation of process automation requires a cultural shift within the organization. Employees must be willing to embrace new technologies and adapt to changes in their roles. This often necessitates significant investment in staff training and reskilling to equip employees with the necessary skills to work alongside automated systems.

Integration with Legacy Systems: Integrating automation technologies with existing legacy systems can be complex and resource intensive. Many organizations have diverse IT landscapes, and ensuring seamless interoperability between new automation tools and legacy systems is crucial for successful implementation.

Despite these challenges, the opportunities presented by process automation are substantial. Organizations that successfully navigate these hurdles can achieve significant improvements in efficiency, accuracy, and overall operational performance, positioning themselves for greater competitiveness in the digital age (Davenport & Ronanki, 2018).

"It seems that robots – although still bearing the burden of deep-seated human stigmas – have entered the mainstream. The challenge is no longer how will we accept intelligent automation in the workplace, but how can we apply it wisely and to the greatest benefit." (Horton et al., 2020).

3.2. Systematic Literature Review on Intelligent Process Automation

One has carried out the systematic literature review using the PRISMA methodology. "Preferred Reporting Items for Systematic Reviews and META-Analysis" is what PRISMA stands for, and it consists of a series of recommendations that help perform critical literature analyses, meta-analyses, and systematic literature reviews (Moher et al., 2009).

3.2.1. PRISMA Protocol

To conduct review-based investigations, the PRISMA approach employs a set of techniques for conducting a systematic search of scientific articles and other scientific literature. It is founded on the inclusion and exclusion standards for every study that is evaluated methodically. The study either includes or eliminates publications based on their quality (Liberati et al., 2009).

Created in 2005 by a group of 29 individuals comprising scientists, writers, and other experts from various fields, they reached a long-lasting agreement on a four-phase flow diagram and a 27-item checklist, which produced a potent template that researchers could utilize (Liberati et al., 2009).

The four phases that make up the overall procedure follow a straightforward methodology. The stages are:

1. Identification - Use the most popular databases to find pertinent articles, papers, and other scientific documentation based on a specific search strategy.

2. Screening – Make sure to include relevant publications and weed out those that don't add anything to the research by using some specific exclusion criteria.

3. Eligibility - Determine the eligibility of the included articles and remove any that don't make sense for well-justified reasons.

4. Included - List of results for articles that will serve as the research's complete source.

3.2.2. PRISMA Execution

The introduction of the theoretical framework for the subjects under research was the aim of section 3.1 of this work. Using the keywords extracted from this theoretical foundation, a custom search string will be created to locate relevant scientific publications for the investigation. The aim is to attain a thorough comprehension of the current state of the art about the application of artificial intelligence in process automation, with a special focus on intelligent process automation.

The research one has proposed to perform shall answer the following questions:

Table 1 - Systematic Review's Research Questions

RQ1	What is the current status of research in this area?
RQ2	What are the major issues of IPA for businesses and governments?
RQ3	What kind of AI techniques are currently useful in this area?
RQ4	What are the advantages and disadvantages of applying AI techniques in process automation?

(Source: prepared by the author)

To respond to these inquiries, one has chosen the most pertinent research in this area following the PRISMA definition. In order to perform the search, a selection of keywords that were deemed more pertinent from the various concepts examined in the theoretical backdrop was made. Since one has chosen to limit their search to English terms, the majority of the articles that came up were authored in that language. As per the PRISMA execution criteria, the documents written in non-English languages were not included in the selection process.

The keywords that were utilized are:

Table 2 - Systematic Review's Keywords

	Core Topic	**Technology**
Keywords	Robotic Process Automation (RPA)	Artificial Intelligence (AI)
	Intelligent Process Automation (IPA)	Natural Language Processing (NLP)
	Business Process Automation (BPA)	Machine Learning (ML)
	Digital Transformation (DT)	Generative Artificial Intelligence (Gen-AI)

(Source: prepared by the author)

In an attempt to locate the aforementioned terms and/or words in abstracts, titles, or keywords of articles and other scientific papers, a customized search string was created. This string choice made sure that the search would only turn up information that was pertinent to the subjects under investigation. Recent scientific publications were the only ones that piqued one's interest because technology is always evolving and only the most recent studies can guarantee accurate and timely information. In order to get precise information about the state of the art regarding the application of AI in process automation, a filter has been created only to display articles published between 2020 and 2024.

The search string used was:

"Intelligent Process Automation" OR ("Robotic Process Automation" AND ("Artificial Intelligence" OR "Machine Learning" OR "Natural Language Processing" OR "Generative Artificial Intelligence")) AND ("State of Art" OR" Issues" OR "Challenges" OR "Techniques" OR "Current Status") OR ("Business Process Automation" OR "Digital Transformation")

In addition to searching for keywords directly associated with IPA and Artificial Intelligence, a Boolean query was added to include terms found in research questions, since the goal of this process is to locate papers that tackle the issues under investigation.

The search was conducted in September 2024 on the following scientific information resource databases:

Table 3 - Systematic Review's Resource Databases

Resource Database	Resource URL
Scopus	https://www.scopus.com/home.uri
Science Direct	https://www.sciencedirect.com/
Research Gate	https://www.researchgate.net/

(Source: prepared by the author)

Following the PRISMA methodology, the next step was to define the inclusion and exclusion criteria for the articles resulting from the mentioned search.

Table 4 - Systematic Review's Inclusion and Exclusion Criteria

<table>
<tr><th>Inclusion Criteria</th><th>Exclusion Criteria</th></tr>
<tr><td rowspan="2">Any scientific article showing evidence of AI utilization in Robotic Process Automation</td><td>Papers focusing on Robotic Process Automation but without focusing on AI techniques utilization</td></tr>
<tr><td>Papers with titles and abstracts that do not align with the focus of AI utilization in process automation.</td></tr>
<tr><td>Papers in English.</td><td>Articles not in English and duplicate papers</td></tr>
<tr><td rowspan="3">Paper published between 2020 and 2024</td><td>Articles published before 2020</td></tr>
<tr><td>Non-academic or non-scientific papers (e.g., websites, magazines reports, newspapers, consulting articles, books, citations)</td></tr>
<tr><td>Papers with titles outside the scope of this work</td></tr>
</table>

(Source: prepared by the author)

The identification phase of the PRISMA workflow yielded a total of (n=203) articles after the search string was inserted into the sources' websites. This is the output that was obtained through the database search. Eliminating duplicates is the first step before proceeding to the screening stage. Here, (n=13) items have been eliminated, advancing a total of (n=190) records to the second stage of the screening process. The inclusion and exclusion criteria were applied in this second screening step, leading to the exclusion of (n=91) articles, with a total of (n=99) articles proceeding to the eligibility phase.

Article abstracts were further examined at the first stage of the eligibility process, and those that had no direct bearing on the study were eliminated. Since one is looking for wider applicability of IPA and not examining its usefulness in a specific industry, publications that focused on specific areas, such as IoT, or 5G networks or in specific industries like health, education, insurance, etc., were regarded very specific and non-relevant for this study. As a result, (n=67) articles have been deleted. A final list of papers included in the study of (n=32) has been produced by excluding the ones that did not contribute to answering the research questions. The workflow image that follows depicts this process:

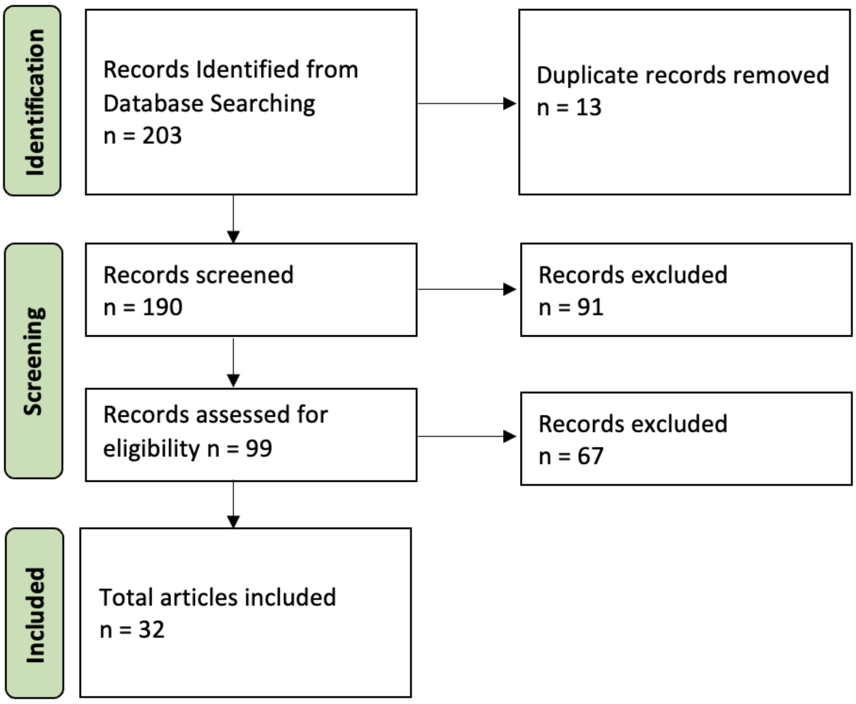

Figure 3.1 - PRISMA Execution

(Source: adapted from Page et al., 2021)

The following table lists the 16 journal articles, and 16 conference papers produced as a result of this research, which includes a synopsis of the findings, recommendations for future work, and any gaps that need to be filled.

Table 5 – PRISMA Results Analysis

#	Authors	Article	Contribution	Publication Type
1	(Thakur & Scholar II, 2024)	Automation 2.0: The impact of artificial intelligence	Discusses Automation 2.0, combining traditional automation with AI and machine learning, addressing the benefits and challenges of intelligent automation systems.	Journal Article
2	(Palaniappan, 2024)	An Overview on Robot Process Automation: Advancements, Design Standards, its application, and Limitations	Reviews advancements and limitations of RPA, highlighting efficiency gains but noting ethical challenges like job displacement.	Journal Article
3	(Kitsantas et al., 2024)	Integrating Robotic Process Automation with Artificial Intelligence for Business Process Automation: Analysis, Applications, and Limitations	The paper reviews RPA-AI integration in business automation, identifying key benefits (efficiency, cost reduction) and challenges (implementation costs, security issues) from 89 analyzed studies.	Journal Article
4	(Haase et al., 2024)	Interdisciplinary Directions for Researching the Effects of Robotic Process Automation and Large Language Models on Business Processes	This paper discusses the impact of RPA and large language models on business processes, calling for further interdisciplinary research on human-automation interactions and long-term effects on organizational routines.	Journal Article
5	(Gupta, 2024)	A Study Toward Combined Approaches Using AI-Based RPA and SOA-Based BPM: A Future Perspective	Explores the integration of RPA with BPM, offering a roadmap for future research in optimizing business process automation and enhancing operational efficiency.	Conference Paper
6	(Ghulaxe, 2024)	Robotic Process Automation with ML and Artificial Intelligence: Revolutionizing Business Processes	Examines the impact of integrating RPA with machine learning and AI to manage complex unstructured data and enhance business process accuracy and scalability.	Journal Article
7	(Fani Sani et al., 2024)	LLMs and Process Mining: Challenges in RPA	Explores how large language models (LLMs) can improve process mining and RPA, enhancing automation efficiency.	Conference Paper
8	(Zhang, 2023)	Study on the curriculum learning of robotics process automation in the era of artificial intelligence	Explores the development of RPA curricula in alignment with industry needs, emphasizing its growing importance in AI-driven business operations.	Journal Article
9	(Visalli et al., 2023)	Building a Platform for Intelligent Document Processing: Opportunities and Challenges	Discusses hybrid AI platforms for intelligent document processing, integrating natural language processing and context-free grammars to automate business processes.	Conference Paper

#	Authors	Article	Contribution	Publication Type
10	(Tang & Hwang, 2023)	Bibliometric Analysis of Robotic Process Automation Domain: Key Topics, Challenges and Solutions	Conducts a bibliometric analysis of the RPA domain, identifying key challenges and future trends in the evolution of RPA technology.	Conference Paper
11	(Stoykova & Shakev, 2023)	Artificial Intelligence for Management Information Systems: Opportunities, Challenges, and Future Directions	Presents a systematic literature review on AI for management information systems, identifying trends like cloud computing, federated learning, and the need for data privacy and security guidelines.	Journal Article
12	(Siderska et al., 2023)	Towards Intelligent Automation (IA): Literature Review on the Evolution of Robotic Process Automation (RPA), its Challenges, and Future Trends	Discusses the organizational and technological challenges in transitioning from RPA to IPA, emphasizing AI techniques like NLP and ML.	Journal Article
13	(Kumar Tyagi et al., 2023)	The Role of Artificial Intelligence in Promoting Sustainable Business Operations and Autonomy	Examines AI's role in revolutionizing sustainable business operations, focusing on environmental, social, and economic impacts, highlighting benefits like resource optimization and operational autonomy.	Conference Paper
14	(Dandale et al., 2023)	Business Process Automation using Robotic Process Automation (RPA) and AI Algorithm's on Various Tasks	Proposes using the Random Forest algorithm to improve RPA performance in tasks like email and invoice processing, offering more accurate classification.	Conference Paper
15	(Al-Slais & Ali, 2023)	Robotic Process Automation and Intelligent Automation Security Challenges: A Review	Reviews security challenges in RPA and Intelligent Automation, identifying blockchain as a potential solution for mitigating security risks like data leakage and auditing.	Conference Paper
16	(Wang & Siau, 2022)	Artificial Intelligence, Machine Learning, Automation, Robotics, Future of Work and Future of Humanity: A Review and Research Agenda	Reviews the impact of AI, automation, and robotics on society, proposing a research agenda to manage both the promises and challenges of these technologies.	Journal Article
17	(Sharma et al., 2022)	Robotic Advancements in Business Process Automation using Artificial Intelligence: An Investigative Study	Investigates Robotic Process Automation (RPA) and its distinction from Business Process Management (BPM), analyzing adoption across industries and providing a systematic review.	Conference Paper
18	(Rizk et al., 2022)	Can You Teach Robotic Process Automation Bots New Tricks?	Explores how RPA bots can be trained to generalize tasks through user interaction, identifying research challenges in AI-driven task learning.	Conference Paper

#	Authors	Article	Contribution	Publication Type
19	(Pramod, 2022)	Robotic process automation for industry: adoption status, benefits, challenges, and research agenda	Analyzes RPA adoption across industries, identifying its wide use in banking and proposing a research agenda for further applications.	Journal Article
20	(Neifer et al., 2022)	The Role of Marketplaces for the Transformation from Robotic Process Automation to Intelligent Process Automation	Explores how RPA marketplaces can facilitate the transition to Intelligent Process Automation (IPA), addressing challenges like connector scarcity.	Conference Paper
21	(Helm et al., 2022)	Application of Cognitive Automation to Structuring Data, Driving Existing Business Models, and Creating Value between Legacy Industries	Demonstrates how cognitive automation extracts information from unstructured data, particularly in legacy industries like insurance and healthcare, enhancing business model transformation.	Journal Article
22	(Chugh et al., 2022)	Robotic Process Automation: a review of organizational grey literature	Reviews organizational grey literature on RPA, identifying its benefits, challenges, and providing guidelines for future implementation.	Journal Article
23	(Chakraborti et al., 2022)	From Natural Language to Workflows: Towards Emergent Intelligence in Robotic Process Automation	Highlights the convergence of machine learning and RPA in IPA, identifying research opportunities to improve business process outcomes.	Conference Paper
24	(Ribeiro, Lima, Eckhardt, et al., 2021)	Robotic Process Automation and Artificial Intelligence in Industry 4.0 - A Literature review	This paper reviews RPA tools integrated with AI in Industry 4.0, demonstrating how AI techniques like Neural Networks and NLP enhance information extraction, process optimization, and organizational efficiency.	Journal Article
25	(Ribeiro, Lima, & Paiva, 2021)	Document Classification in Robotic Process Automation Using Artificial Intelligence - A Preliminary Literature Review	This paper reviews RPA tools integrated with AI in Industry 4.0, demonstrating how AI techniques like Neural Networks and NLP enhance information extraction, process optimization, and organizational efficiency.	Conference Paper
26	(Ng et al., 2021)	A systematic literature review on intelligent automation: Aligning concepts from theory, practice, and future perspectives	Conducts a systematic review of intelligent automation, highlighting the integration of RPA, AI, and soft computing for improved decision-making in business processes.	Journal Article
27	(Martínez-Rojas et al., 2021)	AIRPA: An Architecture to Support the Execution and Maintenance of AI-Powered RPA Robots	This study introduces the AIRPA architecture to separate AI and RPA development processes, ensuring AI-powered RPA systems are maintainable and high-performing over time.	Conference Paper

#	Authors	Article	Contribution	Publication Type
28	(Herm et al., 2021)	From Symbolic RPA to Intelligent RPA: Challenges for Developing and Operating Intelligent Software Robots	Discusses the challenges in transitioning from symbolic RPA to intelligent RPA, identifying issues such as data bias and lack of explain ability.	Conference Paper
29	(Baviskar et al., 2021)	Efficient Automated Processing of the Unstructured Documents Using Artificial Intelligence: A Systematic Literature Review and Future Directions	Conducts a systematic review on AI-based information extraction from unstructured documents, identifying challenges with complex layouts and real-time processing.	Journal Article
30	(Baidya, 2021)	Document analysis and classification: A robotic process automation (RPA) and machine learning approach	Proposes AI-based document analysis solutions to address challenges in unstructured data processing, using machine learning and deep learning models.	Conference Paper
31	(Chakraborti et al., 2020)	From Robotic Process Automation to Intelligent Process Automation: Emerging Trends	Surveys trends in IPA, exploring how AI and machine learning are improving business processes and identifying research challenges.	Conference Paper
32	(Ali & Frimpong, 2020)	Artificial intelligence, machine learning and process automation: existing knowledge frontier and way forward for mining sector	Reviews AI and ML applications in the mining sector, discussing how these technologies improve operational autonomy and safety in traditionally slow-to-adopt industries.	Journal Article

(Source: prepared by the author)

3.2.3. PRISMA Result Analysis

After gathering the necessary data for the study and applying the PRISMA methodology, which was fully covered in the previous section, the next step is to analyze the research's findings. To do this, one must examine each of the included articles to determine each one's primary contribution and identify the answers to the research questions.

RQ1 - What is the current status of research in this area?

The current status of research in Intelligent Process Automation and Robotic Process Automation shows a rapidly growing interest in the integration of AI to enhance traditional automation. Many studies, such as Kumar Tyagi et al. (2023), emphasize the role of AI in promoting sustainable and autonomous business operations. The combination of RPA and AI, often referred to as IPA, is seen as essential for improving process efficiency and decision-making across industries. Stoykova & Shakev (2023) highlight that intelligent process automation, NLP, and predictive analytics are key research trends, with cloud-based solutions being preferred over on-premises platforms due to scalability advantages.

There is also increasing attention to the integration of edge computing and federated learning to enhance automation (Stoykova & Shakev, 2023). However, despite the advancements, there are significant challenges. Al-Slais & Ali (2023) point out that security vulnerabilities, particularly in RPA, present significant risks to businesses and governments. Moreover, Pramod (2022) discusses the uneven adoption of RPA across industries, with sectors such as banking leading in adoption while healthcare and manufacturing lag behind. Research has also identified a gap in comprehensive literature reviews on the topic, prompting studies like Tang & Hwang (2023) to perform bibliometric analyses to map out future trends and challenges in the RPA domain. Overall, research shows that while significant progress has been made, there remain challenges related to security, integration, and the need for more comprehensive frameworks.

RQ2 - What are the major issues of IPA for businesses and governments?

IPA adoption faces several major issues for businesses and governments, particularly related to security, integration, and cost. One of the most significant challenges is the vulnerability of automation systems to cyberattacks. Al-Slais & Ali (2023) emphasize that RPA and Intelligent Automation (IA) introduce security challenges, especially around data leakage and access control, which are critical concerns for governments handling sensitive information. They suggest that blockchain technology may help mitigate these risks by improving logging and auditing processes. Another issue is the difficulty in integrating IPA with legacy systems, which increases implementation costs and complexity (Gupta, 2024). For many organizations, integrating AI-driven IPA into existing infrastructure requires not only technical expertise but also a significant financial investment, which may be a barrier for small and medium enterprises (Kitsantas et al., 2024).

Moreover, there are organizational and ethical challenges. As noted by Palaniappan (2024) and Pramod (2022), IPA can lead to job displacement, raising concerns about the social and economic impact of automation. Businesses and governments must address these concerns through workforce reskilling and ethical governance. Additionally, data privacy is another critical issue, as the extensive use of AI requires access to large datasets, some of which may contain sensitive or personal information. Ensuring compliance with data protection regulations, such as GDPR, is essential but challenging (Neifer et al., 2022). Lastly, there is a need for regulatory frameworks and standards to govern the widespread use of IPA, as its adoption becomes more prevalent across industries and public sectors.

RQ3 - What kind of AI techniques are currently useful in this area?

Various AI techniques are being effectively applied in IPA, particularly Machine Learning, Natural Language Processing, and predictive analytics. Machine learning is essential for improving automation by enabling systems to learn from data and make better predictions and decisions. Fani Sani et al. (2024) highlights the use of large language models (LLMs) to assist in process mining, event log generation, and automation improvements, demonstrating the practical application of ML in enhancing RPA capabilities. Additionally, NLP is a growing focus in IPA research, with Stoykova & Shakev (2023) noting its use in intelligent process automation and customer service automation, where AI systems understand and process human language to interact with users.

Predictive analytics is another valuable AI technique, widely used to analyze data and make informed decisions. Helm et al. (2022) demonstrates the use of cognitive automation, which relies on AI to extract insights from unstructured data. Predictive models help organizations optimize processes by identifying patterns and making real-time decisions. In financial sectors, for example, AI-driven predictive analytics aids in risk assessment and fraud detection. Additionally, Gupta (2024) and Kitsantas et al. (2024) point out the role of AI in optimizing business processes by combining RPA and business process management (BPM) to improve automation efficiency. Deep learning, another subset of machine learning, is also gaining attention for its ability to process large and complex datasets, such as in image recognition and document processing (Baidya, 2021).

RQ4 - What are the advantages and disadvantages of applying AI techniques in process automation?

The application of AI techniques in process automation brings several advantages but also presents notable disadvantages. One of the primary benefits is the increased efficiency and scalability that AI can provide. According to Pramod (2022) and Kumar Tyagi et al. (2023), AI-driven IPA enables organizations to automate complex, repetitive tasks at a faster rate and with greater accuracy than traditional RPA, leading to cost reductions and improved productivity. Additionally, AI can process large datasets in real time, enabling organizations to make data-driven decisions and optimize their processes (Helm et al., 2022). Cognitive automation, for example, enhances traditional automation by allowing systems to learn and adapt to new data, making them more flexible in handling complex tasks (Gupta, 2024). Furthermore, AI can help identify patterns in data, providing valuable insights for predictive maintenance and fraud detection (Stoykova & Shakev, 2023).

However, there are also disadvantages to applying AI in process automation. One of the main challenges is the high initial investment required for AI implementation. Kitsantas et al. (2024) note that integrating AI into existing business systems can be costly, especially for smaller organizations. Additionally, AI models require significant amounts of high-quality data to function optimally, and obtaining and managing this data can be difficult (Palaniappan, 2024). Another issue is the complexity of maintaining AI systems over time, as models can degrade without proper monitoring and updates (Al-Slais & Ali, 2023). Ethical concerns, such as job displacement and data privacy, are also significant disadvantages. As AI systems become more autonomous, there is a growing fear of job losses in roles that were previously performed by humans (Haase et al., 2024). Moreover, the extensive use of AI in data processing raises concerns about privacy, as these systems often handle sensitive personal information (Neifer et al., 2022). Balancing the benefits of AI with these challenges is essential for businesses and governments looking to adopt IPA technologies.

4. PROJECT

This project is composed of six major phases that are described in depth in this chapter.

4.1. Phase 1: Problem Definition

The Transformation & Automation team within the Operations Business to Costumer (B2C) department of EDP Comercial is at the heart of driving operational efficiency, and this project is aligned with that mission. The initiative began with the objective of automating a specific operational process that may be time-consuming for employees and contribute to costs associated with the Business Process Outsourcing (BPO) contract. Additionally, automating processes will free up resources and ensure more scalable and error-free operations.

Given the need to optimize resources and reduce manual workload, this automation effort is being carried out using an IPA. Since IPA, unlike RPA, incorporates AI, it enables more advanced and intelligent automation, especially for tasks that require decision-making and adaptability.

As the project progresses, the benefits of this approach will be gaining recognition from other teams within the department, leading to increased internal demand for similar automation solutions and positioning it as a key driver of transformation within the organization.

The process that was considered the most suitable for automation in the areas where the project will be developed is going to be introduced in Phase 3 of the Project Lifecycle.

4.2. Phase 2: Methodology

This phase, which is ongoing throughout the project lifecycle, comprises a collection of several scientific publications created about intelligent process automation and business process management to create a framework that supports the choices made during the project.

In the Literature Review (3rd Chapter), the Literature Framework gathered during this stage was presented and examined.

4.3. Phase 3: Design & Development

In this phase, the first step was to determine which process would benefit most from an IPA solution. After careful deliberation with the Digital Transformation & Automation Team Manager of the Department of Operations B2C, it was decided that the Charging Station Operators' (OPCs) invoicing process would be automated using IPA.

Automating this process using traditional RPA posed significant challenges, as each OPC sends a unique invoice to the company every month, with varying formats and details. Given that there are more than 80 OPCs, managing and processing these invoices manually is extremely time-consuming, especially since the billing must occur monthly. The variability and sheer volume of the task make it inefficient to handle manually or even with basic automation tools, which is why IPA was chosen to streamline and optimize the process. The business case for introducing IPA into this process, including expected efficiencies and cost savings, will be explored in more detail later in this project.

This phase indicates the beginning of the project's core objective by initiating the process of as-is modeling to allow for further analysis and improvement.

4.3.1. Process As-Is

The OPC billing process is currently performed entirely manually, involving multiple stakeholders, and requiring extensive human intervention at every stage. This manual workflow introduces inefficiencies, increases the risk of human error, and limits scalability. The process follows a biweekly schedule and consists of several steps, from receiving invoice emails to validation and final forwarding for payment processing.

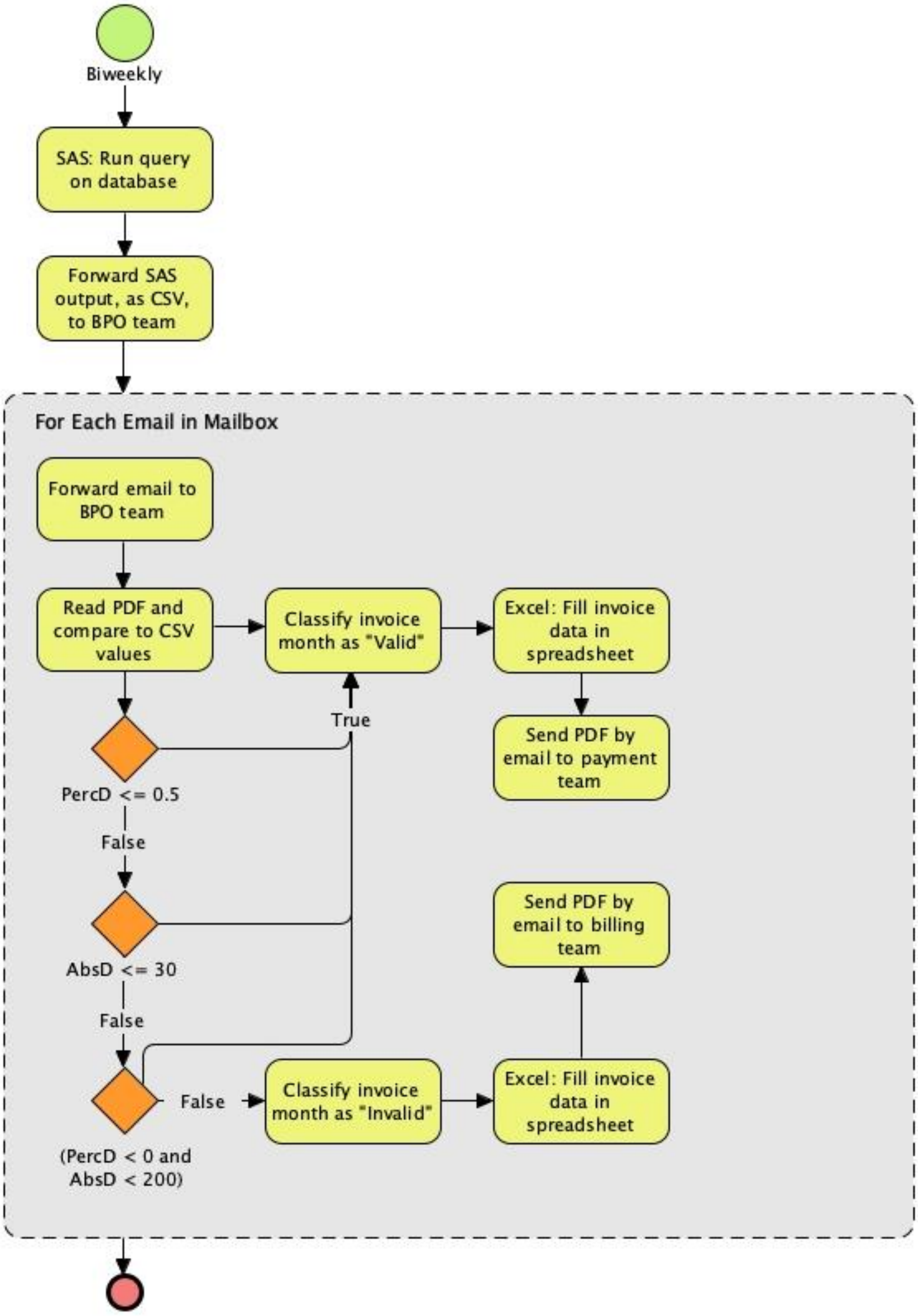

Figure 4.1 - OPCs Billing Process (As-Is)

(Source: prepared by the author)

The process begins with manually executing a SAS query on the company's database to extract consumption data. Once the query is run, the retrieved data is manually exported as a CSV file and forwarded via email to the BPO team for further analysis.

Incoming invoices are received in a dedicated mailbox, and the billing team manually forwards each email to the BPO team. This step is not automated, so every invoice must be manually identified, retrieved, and sent forward.

Once the invoices are received, the BPO team manually extracts invoice details from the PDF documents and compares them with the data in the CSV file retrieved from the SAS query. This comparison involves checking several key data points, including:

- OPC company name and acronym
- Invoice date
- Invoice number
- Total amounts (with and without taxes)

This step is prone to human error, as discrepancies must be identified manually, increasing the likelihood of oversight.

The BPO team manually classifies invoices based on predefined discrepancy thresholds:

- If the percentage deviation (PercD) is ≤ 0.5, the invoice is considered valid.
- If PercD > 0.5, the team checks if the absolute deviation (AbsD) is under 30€, AbsD ≤ 30, the invoice is still valid.
- If AbsD > 30, the team checks whether PercD <0 and AbsD < 200, meaning that the deviation is negative, but the absolute value is under 200€. If none of these steps is true, the invoice is classified as invalid and requires further review.

There is no automated flagging or validation mechanism, meaning every invoice must be checked manually against these thresholds.

When an invoice is deemed valid, the BPO team manually inserts the details into an Excel spreadsheet and emails them to the billing team, who then forwards the information to the payment team for additional processing. In cases where an invoice does not meet the validation criteria, it is manually sent to the billing team for further investigation, following the same process of entering details into a spreadsheet before forwarding them via email.

However, due to the high rate of errors in the BPO team's validation process, the billing team almost always needs to double-check their classifications before any invoice can proceed. This additional manual verification step further increases processing time and workload.

Before invoices are processed for payment, the billing team performs a final manual review, checking for errors or inconsistencies in the validated invoices. If discrepancies are found, the process requires additional manual adjustments, further extending processing time.

4.3.2. Challenges and Limitations of the As-Is Process

The current process is highly inefficient due to its reliance on human intervention at every step, leading to several critical issues:

1. **High Risk of Human Error** – Since every step requires manual data extraction, comparison, and entry, the probability of mistakes (e.g., misclassification, incorrect values) is significant.
2. **Lack of Process Scalability** – As invoice volume increases, the manual workload grows proportionally, making it difficult to scale operations efficiently.
3. **Time-Consuming Workflow** – The necessity for multiple manual checks and double checks, email forwarding, and spreadsheet updates significantly slows down invoice processing times.
4. **Inconsistencies in Validation** – The absence of automated validation mechanisms leads to subjective decision-making and inconsistencies in how discrepancies are identified and classified.
5. **Frequent Rework Due to Validation Errors** – The BPO team frequently **misclassified invoices**, leading to **additional manual verification by the billing team**, which extends processing time and increases the risk of delays in the payment timings.
6. **Dependency on Individual Operators** – The process relies heavily on the availability and accuracy of individual team members, making it vulnerable to delays in case of absences or workload fluctuations.

This As-Is process serves as the foundation for the automation strategy, highlighting the inefficiencies that an Intelligent Process Automation solution aims to address. The next phase of this study will focus on defining an optimized To-Be process that leverages automation to reduce manual effort, improve accuracy, and enhance overall operational efficiency.

4.3.3. Process To-Be Modelling

The implementation of Intelligent Process Automation in the OPC billing process represents a fundamental shift from inefficient, error-prone manual operations to a structured, automated, and optimized workflow. By leveraging UiPath's Robotic Enterprise Framework (REFramework) and integrating artificial intelligence, database queries, and automated decision-making, the process becomes significantly more efficient, reducing manual intervention to only exceptional cases. This automation drastically improves accuracy, compliance, and operational efficiency while allowing human workers to focus on value-added tasks.

The new automated OPC billing process follows a structured, event-driven workflow that eliminates redundant manual tasks and streamlines invoice validation. The automation is triggered three times per week to ensure that invoices do not accumulate, increasing payment timings and time for complaints and clarifications with the OPC companies, if necessary. The system interacts with email servers, databases, cloud storage, and Gen-AI models to classify, extract, and validate invoice data before routing them accordingly.

4.3.3.1. Step 1: Automated Email Retrieval and Preprocessing

The process begins with an automation trigger that executes at predefined intervals. The bot connects to the dedicated OPC billing email inbox and retrieves all unread emails that contain PDF attachments. By automatically filtering relevant emails, the automation eliminates the need for human intervention in sorting and categorizing incoming invoices.

Once an email is retrieved, each attachment is uploaded to a blob storage container to ensure centralized and structured handling of documents. The system then marks the processed emails as "Dispatched" to prevent duplicate processing. If any unread emails remain unprocessed after this operation, an alert is sent to the billing team to ensure human oversight when necessary.

4.3.3.2. Step 2: Invoice Classification and Data Extraction

Once attachments are stored, the automation initiates the classification process by calling an API that processes the PDF documents. The system determines whether the document is an invoice, a credit note, a receipt, or an unknown-type document. This classification is crucial as it dictates how the document will be processed further. Documents that do not fit the expected invoice or credit note criteria are immediately forwarded to the billing team for manual review, also if the document is a receipt the automation ends, since the document is already archived in the blob storage container.

For invoices and credit notes, the system retrieves relevant details from the documents using an AI-powered extraction model. This model accurately identifies essential information, including invoice number, emission date, due date, total amounts (inclusive and exclusive of tax), and the associated OPC company. The extracted data is then stored in a structured JSON format, reducing the risk of human error in data transcription.

4.3.3.3. Step 3: Database Validation and Rule-Based Decision Making

The extracted data is validated against company records by running a query in the SAS database. The goal is to compare invoice-reported consumption against recorded values of the client’s electric car charge times and kWh and determine the accuracy of the billing data.

- The deviation between invoice data and database values is checked following the same rules as in the “As-Is” Process. If the invoice month is classified as "Valid", then the information is recorded in an Excel spreadsheet for historical purposes and further processing.
- If the criteria are not met, an additional check is performed:
    - The process proceeds with a secondary database query to check for "status-8" conditions, this status is for the charges in excessive time. If adding charges in

“status-8” to the invoice values makes the absolute deviation go to 0, then the invoice month is marked as “Valid” but with a "status-8" observation.

- If no “status-8” match is found, and there is still a deviation in the invoice values, the invoice month is classified as "Invalid".

4.3.3.4. Step 4: Final Invoice Routing and Exception Handling

After validation, invoices are routed based on classification:

- **Valid invoices** are automatically forwarded to the payment team via email, ensuring seamless and efficient transaction processing.
- **Invalid invoices** are escalated to the billing team for further investigation, along with a detailed report highlighting discrepancies, since this may involve reaching out to vendors.
- **Credit notes** undergo an additional lookup process to verify their corresponding records before being processed or escalated.

By ensuring that only problematic invoices and credit notes require manual intervention, this automation significantly reduces the workload of the billing team and ensures that human oversight is reserved for critical decision-making. In cases where no discrepancies are found, either through automation or after manual investigation, the invoice is sent to the payment team. This step marks the culmination of a streamlined and optimized process, significantly reducing delays and ensuring that payments are handled promptly and accurately.

The benefits of this revamped process are manifold. By automating repetitive and time-consuming tasks such as email monitoring, data extraction, and routine validations, the process not only saves time and BPO costs but also ensures unparalleled accuracy. The use of GPT-based AI minimizes errors in data handling. Moreover, automation allows the billing team to shift their focus to higher-value tasks, such as resolving complex discrepancies and driving strategic improvements.

This automated workflow also scales easily with increasing business demands. As the volume of invoices grows, the system can handle additional workload without requiring more personnel, offering both efficiency and cost savings. Additionally, by incorporating detailed reporting and escalation mechanisms, the process ensures compliance with audit requirements and creates a transparent trail of all actions taken.

The "To-Be" process represents a transformative step forward for OPC billing. By replacing repeating manual operations with state-of-the-art automation technology, it provides a quicker, and more economical invoicing solution. By doing this, the billing team can concentrate on important tasks while maintaining the integrity and accuracy of the invoicing process.

4.3.4. Development and Implementation of IPA

4.3.4.1. The API

This chapter details the API, which serves as the "brain" of the IPA. The API is deployed on an Azure Function App, using Python as the main language, and leverages GPT-based AI to extract data from invoices and credit notes. The extracted data is then processed and stored in a PostgreSQL database for future use. This chapter will elucidate the components, workflow, and functionalities of the API, showcasing how it integrates various Azure services to achieve seamless and efficient data extraction and storage.

The API is composed of several key components, each playing a crucial role in the overall data extraction process. These components include the Azure Function App, which acts as the core of the API, handling incoming Hypertext Transfer Protocol (HTTP) requests and orchestrating the data extraction workflow. Azure Blob Storage is utilized as a scalable storage solution for storing PDF files of invoices, credit notes, and other documents that may appear to be processed by the API. Azure Key Vault is employed to securely manage sensitive information such as API keys and database connection strings. A PostgreSQL database serves as the repository for the extracted data, and the GPT-based AI, powered by Azure OpenAI service, is the core component responsible for extracting data from the PDF images.

The API workflow begins with the receipt of an HTTP request containing the filename of a PDF stored in Azure Blob Storage. The request is handled by the Azure Function App, which serves as the entry point for the API. Once the request is received, the API fetches the PDF file from Azure Blob Storage. This is achieved by utilizing the Azure Blob Storage client to download the specified file and store it temporarily for further processing.

The next step in the workflow involves converting the retrieved PDF into images. Each page of the PDF is transformed into a high-resolution image, which will be processed by the GPT-based AI for data extraction. The images are then sent to the Azure OpenAI API. The GPT model, trained to recognize and extract data from invoices and credit notes, processes the images and returns the extracted data in JSON format. The AI model uses predefined prompts tailored for different document types to ensure accurate data extraction. If the file detected type is neither an invoice, receipt, or credit note, the API will return “unknown” as the file type, and then it may be analyzed by a human.

Once the data is extracted, it is validated to ensure completeness and accuracy. The validated data is then stored in a PostgreSQL database. The database schema includes tables for storing information about files, invoices, and credit notes. The data is inserted into the appropriate tables based on the document type. After the data is successfully stored in the database, the API returns the extracted data in a structured JSON format as the response to the initial HTTP request.

The Azure Function App acts as the execution environment for the API. It handles incoming HTTP requests, orchestrates the workflow, and coordinates the interactions between different components. The Function App ensures scalability and reliability, allowing the API to handle multiple requests simultaneously.

Azure Blob Storage is used to store the PDF files of invoices and credit notes. The storage service provides high availability, scalability, and security for the stored files. The API retrieves the PDF files from Blob Storage based on the filenames provided in the HTTP requests.

Azure Key Vault is employed to securely manage sensitive information such as API keys and database connection strings. By storing these credentials in Key Vault, the API ensures that sensitive information is protected and can be accessed securely during runtime.

The PostgreSQL database serves as the repository for the extracted data, for the purpose of control, logging or even auditing. The database schema includes tables for files, invoices, and credit notes. The data is inserted into the appropriate tables based on the document type. The database handler component of the API manages the database connections and performs the necessary operations to store the extracted data. The database Entity-Relationship (ER) diagram is shown in Figure 4.3.

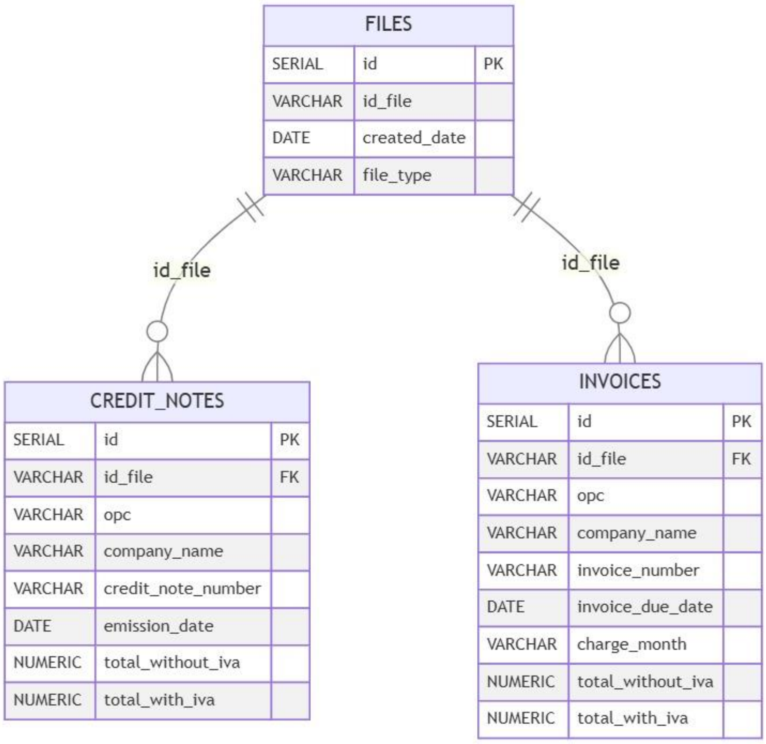

Figure 4.2 – Database ER Diagram

(Source: prepared by the author)

The GPT-based AI, powered by Azure OpenAI service, is the core component responsible for extracting data from the PDF images. The AI model is trained to recognize and extract relevant information from invoices and credit notes based on predefined prompts. The model processes the images and returns the extracted data in JSON format.

The API returns the extracted data in JSON format. The figures below are examples of the JSON output for an invoice and a credit note.

Figure 4.3 - API Response JSON examples

(Source: prepared by the author)

The API described in this chapter serves as the "brain" of Intelligent Process Automation, utilizing various Azure services and GPT-based AI to extract and process data from invoices and credit notes. By leveraging Azure Function App, Blob Storage, Key Vault, and PostgreSQL database, the API provides a scalable, secure, and efficient solution for document data extraction. The extracted data, returned in structured JSON format, is stored in the database, making it available for further analysis and processing. This API exemplifies the seamless integration of cloud services and AI to automate complex data extraction tasks, contributing significantly to the overall efficiency and effectiveness of the OPC invoice validation process.

4.3.4.2. The Automation

The automation of the OPC billing process is built using UiPath's REFramework, a robust framework designed for enterprise-grade deployments. This ensures that the solution is reliable, modular, and resilient against failures while providing scalability to accommodate varying invoice volumes. The primary objective of this automation is to enhance operational efficiency, improve accuracy, and reduce manual intervention in the invoice validation workflow.

The solution is divided into two major components:

1. **Dispatcher (Email Retrieval & Preprocessing)**
2. **Transaction Processor (Invoice Classification, Validation, and Routing)**

The automation interacts with multiple external systems, including:

- Email servers for invoice retrieval.
- Azure Blob Storage for centralized document management.
- The SAS database for validation and reconciliation.
- An Azure Function App for GPT-powered PDF data extraction and classification.
- UiPath Orchestrator for scheduling, monitoring, and execution control.

Dispatcher: Email Retrieval & Preprocessing

The Dispatcher (illustrated in Figure 4.4) is responsible for retrieving invoice-related emails, extracting relevant attachments, and uploading them to a structured processing queue for downstream processing. This component ensures that all incoming invoices are systematically captured, preventing potential processing delays or errors due to manual handling.

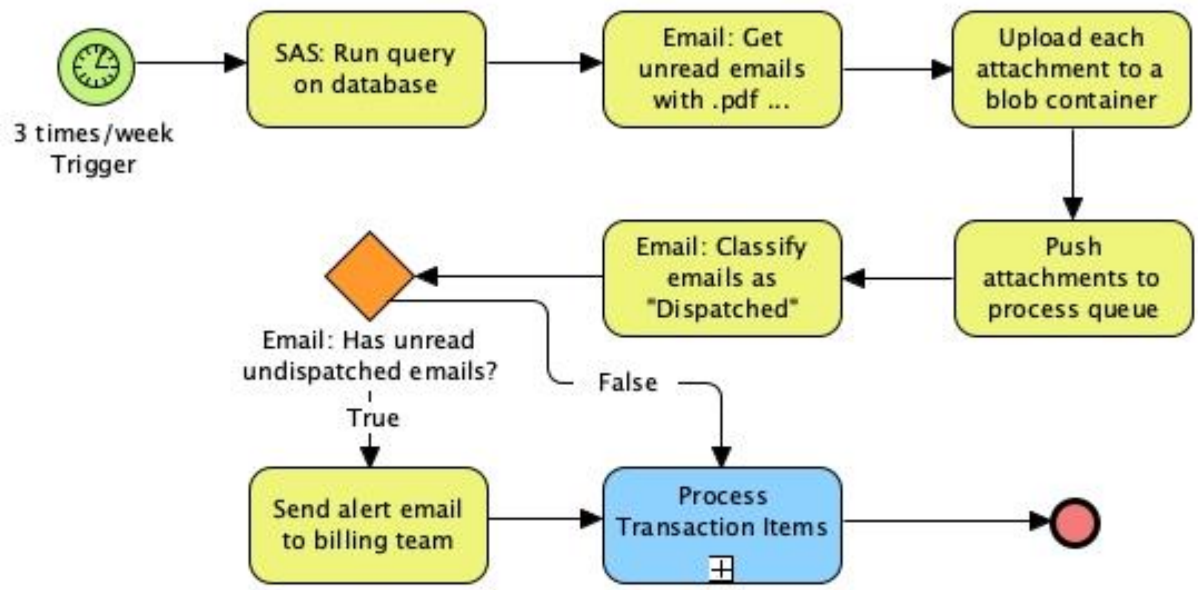

Figure 4.4 – Initialization (Dispatcher) Workflow

(Source: prepared by the author)

Workflow Breakdown

1. **Trigger Mechanism:**
   - The bot executes three times per week via UiPath Orchestrator, ensuring timely processing of invoices and credit notes received via email.
2. **SAS Database Query:**
   - Before processing the emails, the bot runs a SAS project with queries to retrieve client charge data from OPC charging stations.

3. **Email Processing:**
   - Fetches unread emails that contain PDF attachments.
   - Extracts and uploads each attachment to Azure Blob Storage, ensuring centralized access.
   - Marks processed emails as "Dispatched," preventing redundant processing.
   - If any emails remain unprocessed, for example, emails without attachments from the suppliers asking for additional information, the bot triggers an alert notification to the billing team for manual intervention.
4. **Queue Management:**
   - Successfully extracted attachments are pushed to the Transaction Processing Queue, where the next phase of automation handles validation and classification.

Transaction Processor: Invoice Classification, Validation, and Routing

The Transaction Processor (illustrated in Figure 4.5) is the core component responsible for analyzing and validating each invoice and credit note based on predefined business rules. By leveraging intelligent data extraction and rule-based decision-making, this phase ensures that only accurate and complete invoices are forwarded for payment processing.

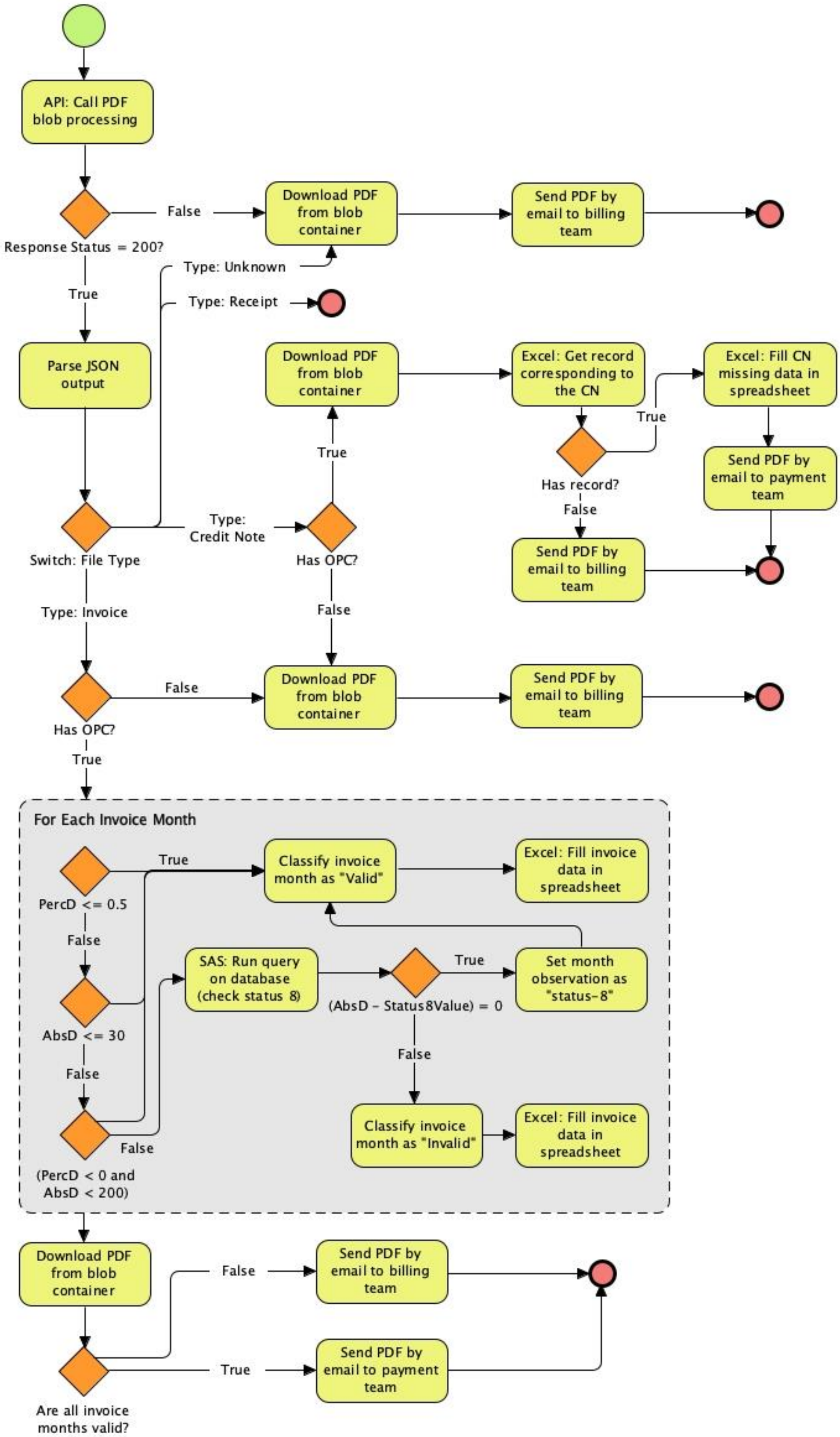

Figure 4.5 - Process Transaction item Workflow

(Source: prepared by the author)

Workflow Breakdown

1. **PDF Processing via API Call:**
   - The system invokes an API that processes each PDF attachment, extracting structured data and classifying document types into:
     - Invoice
     - Credit Note
     - Receipt
     - Unknown Documents
2. **Data Extraction & Validation:**
   - Extracted invoice data is cross-referenced with the SAS database to verify amounts for the OPC in that invoice month and other key attributes.
   - The system applies a series of business rules, including:
     - **OPC Check:** Determines if the invoice corresponds to an OPC transaction.
     - **Threshold-Based Classification:** Uses parameters such as PercD (percentage deviation) and AbsD (absolute deviation) to classify invoices as valid or requiring further review.
     - **Status-8 Validation:** When the invoice is not valid in the previous validation, it is checked if the deviation corresponds to charges in “status-8” (excessive time charging) and if so, the invoice proceeds to payment with a note saying it has “status-8” charges.
3. **Invoice Routing Based on Classification:**
   - **Valid Invoices:** Forwarded to the payment team for processing.
   - **Invalid Invoices:** Sent to the billing team for manual reconciliation, which may require the exchange of emails with suppliers asking for additional information.
   - **Credit Notes:** If a corresponding invoice record exists in the system, the automation completes the missing data and sends it for payment; otherwise, it is routed to the billing team for further investigation, similar to the invoice flow.
4. **Exception Handling & Logging:**
   - **Retry Mechanisms:** Automatic retries for transient failures (e.g., email server issues, API timeouts).
   - **Comprehensive Logging:** Detailed logs, available on UiPath Orchestrator, ensure process visibility and traceability, with logs accessible to both developers and the business team for auditability and control.
   - **Scalability & Parallel Processing:** By leveraging UiPath Orchestrator queues, the automation can process multiple invoices in parallel, significantly reducing turnaround time.

The fact that the API pulls the invoice due dates is another important consideration. This allows the IPA to include alerts in emails sent to the billing and payment teams when invoices are due within the next eight days. As a result, the teams are better able to prioritize tasks.

The implementation of this IPA solution delivers multiple strategic advantages to the organization:

1. **Increased Efficiency:** Automating invoice validation significantly reduces manual workload and accelerates billing cycles.
2. **Enhanced Accuracy:** GPT-powered extraction minimizes human errors in data entry and validation.
3. **Operational Resilience:** The automation is designed to handle high volumes, unexpected failures, and business rule exceptions with minimal human intervention.
4. **Compliance & Auditability:** The structured logging and validation process ensures regulatory compliance and simplifies audit requirements, with logs made available to both the development and business teams for transparency and oversight.

By implementing this UiPath-based automation, the organization optimizes its billing operations, enabling the billing team to focus on strategic decision-making rather than repetitive manual tasks. The integration with external systems and the adoption of intelligent automation principles contribute to a more resilient, scalable, and cost-effective invoice validation process.

4.4. PHASE 4: EVALUATION

In this chapter, the evaluation of the Intelligent Process Automation implementation for the OPC billing process will be conducted based on four key operational pillars: time, costs, quality, and capacity. These dimensions provide a comprehensive framework for assessing the benefits brought by automation, allowing for a structured comparison between the manual (As-Is) and automated (To-Be) processes. By analyzing these aspects, this evaluation will highlight the improvements achieved in terms of cost reduction, efficiency, process accuracy, and capacity improvement.

4.4.1. Cost Reduction

The cost evaluation of the implementation of Intelligent Process Automation in the billing process is crucial to understanding its financial impact. This section analyzes the cost savings achieved by automating the process, considering document volumes, validation efforts, execution times, and the operational costs of automation.

Before automation, the manual billing process required significant effort to handle invoices and credit notes. The following table presents the monthly document volumes processed:

Table 6 – Document Volumes per type

Document Type	Monthly Volume	Annual Volume	Time of Validation (minutes)	Validation Team
Invoice	80	960	9	BPO
Credit Note	25	300	6	EDP Billing Team
Total Documents	105	1260	-	-

(Source: prepared by the author)

Certain invoices required additional validation, from the EDP billing team, either due to non-validation in initial steps or requiring status 8 verification. Per month, in average, 2 invoices are only validated after status-8 and 7 are not validated initially, only after a meticulous investigation or by reaching out the OPCs, and so, a total of 9 invoices per months require additional 7 minutes of the billing team attention. The manual process involved an additional time burden for such cases, as shown below:

Table 7 – Additional times for invoice validation

Validation Type	Monthly Count	Time per Invoice (minutes)	Total Time (minutes)
Invoices not validated initially	7	7	49
Invoices validated only after status 8	2	7	14
Total Additional Validation Time	**9**	**-**	**63**

(Source: prepared by the author)

Each biweekly execution of this operation also takes 7 minutes from the billing team to manually run the SAS query, and in average 2 minutes per document, to check the email box and send each document to the BPO team.

Prior to automation, the process required manual handling by EDP collaborators, whose annual cost per employee is estimated at €45,000. Additionally, part of the work was outsourced to a BPO provider at a rate of €17.39 per hour. The automation significantly reduced manual intervention, leading to direct labor cost savings.

Table 8 - Total Labor Costs

Cost Component	Annual Cost (€)
Total Cost – EDP Collaborators	€2,064.78
Total Cost – BPO Services	€2,504.16
Total Annual Cost (Manual Process)	**€4,568.94**

(Source: prepared by the author)

The automation incurs some operation expenses (OPEX), but these are relatively minor compared to the savings achieved. The main costs include:

Table 9 - Total Automation Costs

Cost Component	Cost per Unit	Frequency	Annual Cost (€)
Azure Function App	€2.50 per day	365 days	€912.5
GPT API Processing	€0.008 per doc	1,260 docs	€10.08
Total Operational Cost	-	-	**€922.58**

(Source: prepared by the author)

The costs associated with databases, UiPath licensing, and virtual machines have not been considered in this analysis. These infrastructure costs are already accounted for within the company's broader automation strategy and do not represent additional expenses specific to this implementation.

The automation of the billing process has yielded significant cost benefits. The transition from a biweekly manual process to an automated system with increased execution frequency has not only reduced validation efforts but also ensured timely invoice payments and improved overall financial efficiency.

With the reduction in manual labor, fewer errors requiring correction, and increased processing speed, the total estimated annual cost savings significantly outweigh the relatively minor operational costs of automation. This cost reduction, combined with increased accuracy, demonstrates the strong financial case for automation implementation.

4.4.2. Efficiency

Efficiency is a key pillar in evaluating the benefits of process automation. By replacing manual tasks with an Intelligent Process Automation solution, the time required for executing various steps in the billing process has significantly decreased. This section presents a detailed comparison of manual processing times versus the new automated times and highlights the improvements achieved.

Below, Table 10 provides a breakdown of the time spent on key tasks in the manual process compared to the IPA solution:

Table 10 - Comparative Analysis of Manual vs. Automated Processing Times and Annual Efficiency Gains

Task	Manual Time per Execution (min)	IPA Time per Execution (min)	Annual Volume	Total Manual Time per Year (min)	Total IPA Time per Year (min)
SAS Query Execution	7	5	156 (IPA) / 26 (Manual)	182	780
Document and Email Processing	2	0.03	1260	2520	37.8
Invoice Analysis	9	3	960	8640	2880
Credit Note Analysis	6	2	300	1800	600
Possible Status-8 Deviation Analysis	7	5	108	756	540
Total	-	-	-	**13,898**	**4,837.8**

(Source: prepared by the author)

From the table above, we can observe significant efficiency gains due to automation. The total processing time required annually for manual execution was 13,898 minutes, whereas after automation, it was reduced to approximately 4,838 minutes. This represents an overall time reduction of around 65.2%.

The most significant reductions occur in:

- **Document and Email Processing:** A drastic drop from 2,520 minutes to just 37.8 minutes per year, leading to a 98.5% reduction.

- **Invoice Analysis:** Previously consuming 8,640 minutes annually, now requiring only 2,880 minutes, representing a 66.7% improvement.
- **Credit Note Analysis:** Reduced from 1,800 minutes to 600 minutes, achieving a 66.7% efficiency gain.
- **SAS Query Execution:** Although only a 28% time reduction per execution (from 7 to 5 minutes), the increased execution frequency in the IPA process (from 26 times manually to 156 times automatically, this means, from biweekly to three-times-per-week) led to an overall increase in time spent on this step. However, the elimination of manual involvement compensates for this increase, allowing employees to focus on higher-value tasks.

It is important to note that the billing team's investigation times for deviations not supported by status-8 were ignored since, as they necessitate a case-by-case study and discussion with the OPCs, they ultimately remain an as-is procedure for the future process.

The implementation of IPA has drastically improved the efficiency of the billing process. Time savings of over 9,000 minutes annually equate to a substantial reduction in operational burden, enabling more frequent processing, early error detection, and better workload distribution. These efficiency gains translate into not only cost savings but also enhanced process agility and reliability, making a strong business case for the automation initiative.

4.4.3. Accuracy

The quality of the billing process has also seen a measurable improvement with the adoption of automation. A comparative analysis was conducted between the last three months of the manual process and the first three months of the automated workflow. The results highlight a substantial increase in accuracy, directly impacting the reliability of invoice validation.

In the manual process, human accuracy was approximately 90% of all the analyzed documents, necessitating a manual double-checking by the billing team to review and correct errors made during data entry by the BPO team. Errors included incorrect invoice values, mismatched months, wrong document type classification, and typographical mistakes in invoice numbers, all of which required manual intervention to ensure correctness before payment execution.

Conversely, in the automated process, the accuracy rate of the Generative AI-powered system reached approximately 97%. While not entirely error-free, this improvement significantly reduces the need for human intervention, freeing up valuable time for the billing team to focus on higher-value tasks. The reduction in errors also minimizes the risk of incorrect payments and subsequent reconciliation efforts, mostly through credit notes, leading to greater financial accuracy and process reliability.

Moreover, the automation framework ensures consistency and coherence in data extraction and processing, eliminating the variability introduced by human operators. By standardizing the approach, the system enhances the overall quality of invoice management, reducing the likelihood of overlooked discrepancies and improving the integrity of those records. These advancements contribute to a more streamlined and reliable billing operation, reinforcing the overall effectiveness of the automation initiative.

4.4.4. Capacity

The implementation of Intelligent Process Automation has significantly enhanced the capacity of the OPC billing process. Previously conducted on a biweekly basis, the process is now executed three times per week, allowing for a more dynamic and responsive approach to invoice processing. This increased frequency ensures that invoices are processed in a timelier manner, reducing bottlenecks, and enabling a more continuous workflow.

The reduction in processing time directly impacts resource allocation. The external BPO team, which previously handled invoice processing with a manual approach, has seen a significant decrease in workload, freeing up resources for other critical tasks. Internally, EDP employees who were once engaged in time-consuming manual validations can now shift their focus to higher-value activities such as financial analysis, exception handling, and process improvement. Furthermore, the IPA system introduces scalability, enabling the organization to handle increased invoice processing volumes without proportionally increasing labor costs or workload, ensuring that the process remains future proof as demand grows.

A key advantage of this automation is its ability to handle an increased workload without additional human intervention. The system processes invoices rapidly, extracting relevant data and executing payments efficiently. This acceleration reduces the likelihood of late payments and ensures that all invoices are settled within their due dates. Additionally, the automation includes a built-in alert system that identifies invoices approaching their due date. If an invoice is due within the next eight days, an automated notification is added to the emails, prompting the necessary stakeholders to take immediate action. This proactive measure minimizes the risk of overdue payments and associated penalties.

Automation also improves the visibility and traceability of potential deviations. Any discrepancies or anomalies in the invoice processing workflow are detected earlier, allowing for faster resolution. This early detection capability is particularly relevant in identifying errors, inconsistencies, or irregularities that could impact operations. The increased processing capacity not only enhances the operational efficiency of the billing team but also strengthens financial control and compliance, ensuring that the company maintains a well-structured cash flow for this business operation.

4.5 PHASE 5: COMMUNICATION

This phase, which continues throughout the project lifecycle, entails drafting the document that supports all the research and development of this project as well as disseminating the study findings. This stage guarantees that the study is fully recorded, examined, and prepared for submission. The project's conclusions can be particularly found in the 5th Chapter of this document.

5. CONCLUSIONS

5.1. SUMMARY OF THE DEVELOPED WORK

The primary objective of this research was to investigate how Intelligent Process Automation could enhance the efficiency of business process automation, using the OPC billing process at EDP Comercial as a focal point. The project was meticulously organized into five distinct phases, each contributing to a comprehensive and systematic approach. The initial phase involved a thorough literature review, which established a solid theoretical foundation by highlighting the limitations of traditional Robotic Process Automation and underscoring the potential benefits of IPA. This review also provided insights into the state of art of automation technologies and set the stage for the subsequent research steps.

The second phase focused on defining the methodology, where a detailed work plan was developed to guide the integration of IPA into EDP Comercial's existing systems. This phase included the creation of a structured approach that aligned with the research goals, ensuring a robust framework to guide the design and development of the IPA solution.

In the third phase, the design and development of the IPA solution took place. This critical phase began with identifying the specific process at EDP Comercial that would benefit most from an IPA solution. After careful deliberation, it was decided that the Charging Station Operators' invoices validation process would be automated using IPA. The actual design and development involved aligning objectives and requirements, designing the solution architecture, and iterative testing to ensure it met quality standards and performed as expected.

The fourth phase was dedicated to evaluating the performance and impact of the IPA implementation. This phase included analyzing the financial impact and performing a detailed results analysis. The findings from this evaluation phase confirmed the numerous benefits brought by automation, showcasing significant improvements in cost reduction, efficiency, accuracy, and capacity.

The final phase focused on communicating the research findings and recommendations. This involved writing the developed work and its conclusions, outlining limitations, and suggesting future work and development directions, ensuring continuous improvement and innovation in business process automation at EDP Comercial.

This project's IPA solution introduced Generative-AI to the OPC billing process by utilizing cutting-edge technology like the GPT API. The automation system was built using UiPath's REFramework and integrated various Azure services. This transition from manual to automated processing yielded substantial gains in operational efficiency, significantly reduced human error, and provided scalable solutions capable of handling increased workloads without additional human intervention.

Key findings from the evaluation phase highlighted a remarkable 65.2% reduction in processing time, and more than 3.6k euros of OPEX savings, and a notable increase in accuracy from 90% to 97%. The new automated system not only streamlined the invoice and credit note validation process but also allowed the billing team to focus on higher-value tasks, thereby enhancing overall productivity and job satisfaction.

5.2. LIMITATIONS

Despite the successful implementation and the numerous benefits achieved, the project encountered several limitations that are worth noting. One of the primary limitations was the initial investment and setup costs associated with the transition to IPA. The implementation required a considerable upfront investment in terms of Azure infrastructure and development efforts. While the long-term benefits outweigh these costs, the initial financial burden can be a significant barrier for some organizations, particularly smaller ones with limited resources.

Another significant limitation revolves around ethical concerns associated with the deployment of IPA technologies. The automation of tasks traditionally performed by humans raises important questions about job displacement and the potential impact on employment. While automation can lead to increased efficiency and cost savings, it can also result in the loss of jobs, particularly those involving repetitive and routine tasks. This raises concerns about the social and economic implications of automation, including the potential for increased unemployment and the need for retraining and reskilling of the workforce. Ethical considerations also extend to the transparency and accountability of AI-driven processes. Ensuring that automated systems operate fairly and without bias is crucial, as is maintaining transparency in decision-making processes to build trust among stakeholders. Addressing these ethical concerns is essential for the responsible and sustainable adoption of IPA technologies.

Integrating the IPA solution with existing legacy systems posed significant technical challenges and required substantial customization efforts. Legacy systems often lack the flexibility needed for seamless integration, necessitating additional resources and time to ensure interoperability. This integration complexity can be a limiting factor, especially in organizations with a heterogeneous IT landscape.

The project also introduced a dependency on external services, such as cloud providers and third-party applications. The reliance on cloud services such as Azure and UiPath introduces vulnerabilities related to service disruptions or changes in service terms, which can impact the stability and performance of the automation system. Managing these dependencies requires careful planning and risk mitigation strategies.

Additionally, the scope of automation in this project was limited to the OPC billing process. While the IPA solution significantly improved this specific workflow, extending automation to other complex processes within the organization will require further customization, investment, and possibly overcoming additional technical challenges.

5.3. Future Work

Building on the foundation laid by this project, several avenues for future work can be explored to further enhance the capabilities and benefits of Intelligent Process Automation at EDP Comercial. One promising direction is the expansion of IPA to other business processes within the organization. The success of the IPA solution in the OPC billing process demonstrates the potential for similar improvements in other areas. Identifying and prioritizing processes that would benefit most from automation can lead to further enhancements in operational efficiency, costs, and effectiveness across the organization.

Continuous improvement and adaptation of the IPA system are essential to leverage new advancements in this kind of technologies. As these technologies evolve, regular updates and retraining of AI models will ensure that the system remains effective and adapts to changing business needs. Implementing a continuous improvement framework will allow the organization to stay at the forefront of technological innovation and maintain a competitive edge.

Enhancing data analytics capabilities can provide deeper insights into process performance and help identify areas for further optimization. Integrating advanced data analytics, including predictive analytics and real-time monitoring, can enhance decision-making and proactive management of business operations. This will enable the organization to anticipate and address potential issues before they become critical, further improving efficiency and effectiveness.

Scalability and resilience are crucial aspects to consider in future work. Enhancing the scalability of the IPA system will ensure that it can handle increasing workloads without compromising performance. Implementing robust error-handling mechanisms, failover strategies, and redundancy will enhance the resilience of the system, ensuring its stability and reliability even under varying workloads and unexpected disruptions.

Successful automation requires effective change management and employee training. Providing ongoing training and support to employees will help them adapt to new tools and workflows, ensuring a smooth transition and maximizing the benefits of automation. Addressing employee concerns and fostering a culture of continuous learning and improvement will be essential for the long-term success of the automation initiative.

In conclusion, this project has demonstrated the transformative potential of Intelligent Process Automation in optimizing business processes. By addressing the identified limitations and pursuing future work, EDP Comercial can continue to harness the power of automation to drive efficiency, accuracy, and innovation in their operations. The broader implications of this project underscore its importance, as it aligns with global trends toward digital transformation and intelligent automation, ultimately contributing to the development of smarter and more adaptive business environments.

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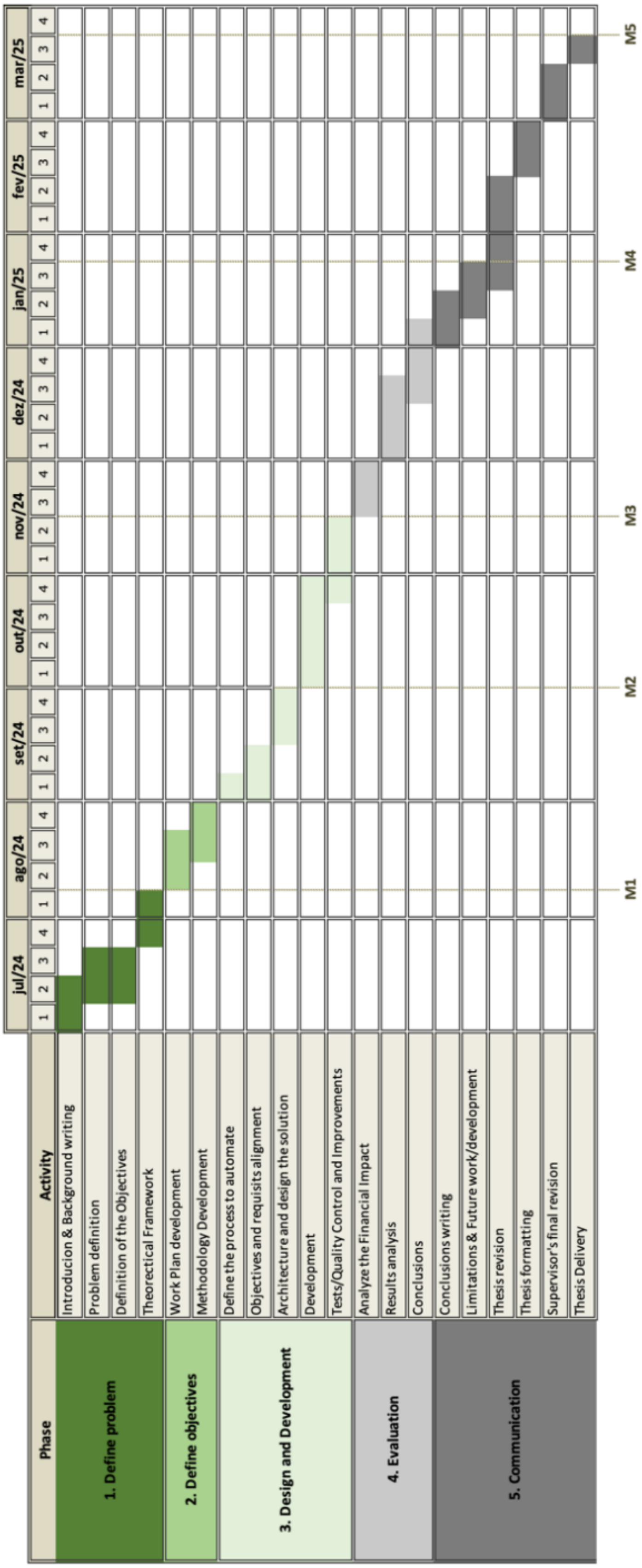
APPENDIX A



Legend:
M - Milestone

M1 - Introduction and Literature Review
M2 - Plan and Design the Solution
M3 - Solution Deployment
M4 - Impact and Performance Analysis
M5 - Thesis Delivery

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