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Business Process Management and Robotic Process Automation: Early deployment of a combined approach

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Abstract

Optimizing a process to improve its efficiency is not a new concept. Many scientific areas have been benefited by the application of optimization techniques and so have business processes. The competitive and ever-changing business environments have led organizations into examining and re-designing their core business processes, aiming for improving their performance and market responsiveness. That led to the emergence of Business Process Management (BPM), a methodology a methodology that advocates for constant process re-evaluation and improvement. The optimization and the continuous improvement of business processes within a company, can give the advantage to the company to be more competitive by reducing its costs, improving the delivery quality and efficiency, and enabling adaptation to changing environments. But BPM was not the only methodology that emerged the previous years. Business Process Automation (BPA) is a process of managing information, data and processes to reduce costs, resources and investment. It is proven that BPA increases productivity and saves staff time and effort by automating key business processes through computing technology. A modern technology of process automation, called Robotic Process Automation (RPA), allows configuration computer software to emulate and integrate the actions of human interacting within digital systems to execute a business process. This thesis, after reviewing the most interesting approaches over those streams, focuses on the potential combination of BPA and RPA in order to achieve the greatest optimization of business processes. The result showed that BPM methodology and RPA technology complement each other. Although, the capabilities of BPM are proven over the years, RPA is a new technology and there a lot of dangers that should be considered before taking the strategic decision to implement it.

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1. Introduction

In modern days, business needs are constantly changing at a very fast pace. Therefore, should be well prepared to absorb and adapt to this changes in order to hold their market position and advance with the passage of time. The adaptation involves not only the re-designing of their core business processes and aims for improving the business performance and the market responsiveness, but the adaption of new technologies that automate this processes. The optimization and the continuous improvement of business processes within a company, can give the advantage to the company to be more competitive by reducing its costs, improving the delivery quality and efficiency, and enabling adaptation to changing environments.

This research focuses on business processes optimization deploying Robotic Process Automation to traditional Business Process Managements solutions. This thesis aims to highlight the benefits and the risks of using software to execute human tasks by presenting RPA implementation to complex integration processes of banking industry. This chapter introduces the motivation of this research and the problem statement and concludes with the structure of this thesis.

1.1. Motivation

“Without continual growth and progress, such words as improvement, achievement, and success have no meaning. “ When talking for businesses Benjamin Franklin words should not just be inspirational. They are showing the one-way street that businesses have to follow in order to reach their goals. As the business grows and needs to perform new tasks, it will need new processes and improve the old ones in order to make sure that excellent quality products are being delivered in a timely fashion without much risk involved. Because as Aristotle said: *“Quality is not an act, it is a habit.”* And the quality arises inside the company where the most important entities are humans and processes. Humans and processes, despite their physical entities, are very relevant. They are both responsible to deliver products and services with good quality. Humans are responsible for designing, building and maintaining processes and processes improve and at the end reward or discipline humans.

As a result, a company in order to achieve a good result it is important to have good processes and have employees making profitable work. Two notable paths derive for the spit of the previous sentence. The first path to explore has the label “what makes a process good and how to achieve it?” while the second one has “what does an employee need to make profitable work?”

Regarding the first path over the last three decades a comprehensive set of tools, techniques, methods and entire methodologies has been developed providing support for all stages of the business process lifecycle. Relevant contributions have been made by diverse disciplines such as Industrial Engineering, Operations Management, Quality Management, Human Capital Management, corporate governance, conceptual modeling, workflow management and system engineering. Business Process Management (BPM) is the discipline that now faces the difficult, but rewarding of consolidating and integrating the plethora of these approaches.

Regarding the second one, we will skip areas that have to do with continuous educations, hardware, working methodologies etc. and we will aim at the question: “what disrupt people from doing valuable tasks?” Mary Kay Ash before a lot of years said: *"Everyone has an invisible sign hanging from their neck saying, 'Make me feel important.' Never forget this message when working with people."* Additionally famous psychiatrist Theodore Isaac Rubin completed by saying: ‘*Happiness does not come from doing easy work but from the afterglow of satisfaction that comes after the achievement of a difficult task that demanded our best.’*

In order to have employees available for the difficult tasks you first need to protect them from the repetitive easy tasks. On average across all of the countries, office workers spend 552 hours a year completing administrative or repetitive tasks, the equivalent to 69 work days or roughly one-third of the working year (Magowan, 2017). At the same time 47% of tasks can be automated using RPA. That leads to the conclusion that for office worker automation can save up to 1 working day per week. The potential of automation is pretty clear. Information workers are ready to give some of their daily tasks to automation in order to spend more time on high-value tasks and stay engaged in their work. It’s time for organizations to take a look at the processes (and bottlenecks) they have in place and think about how they might automate them to make their workers more productive. Workers are ready for businesses to leverage automation to increase efficiency and free up time so that everyone can contribute to business success.

More recently, famous consulting firms stated that the financial services industry has embraced automation as a disruptive force that challenges the current state of daily business operations, while simultaneously aligning with organizational drivers (e.g., cost, productivity and efficiency). Despite the continuum of automation ranges from basic workflow through artificial intelligence (including machine learning, natural language processing (NLP) and cognitive processing), organizations have begun to invest in robotic process automation (RPA). This technology allows organizations to automate high-volume, deterministic, system-based tasks by introducing a virtual workforce of “robots.” The business units that embody the first level of defense (particularly, the finance and operations departments) have been the earliest adopters of this advancement. They evaluated their existing processes to identify, prioritize, develop and, ultimately, deploy robotics that may alleviate mundane tasks and departmental pain points. Business units have capitalized on the speed and nimbleness of deploying RPA in partnership with and, at times, autonomously from IT departments.

1.2. Problem statement

Business processes represent a core asset of corporations. They have direct influence on the attractiveness of products and services as recognized by the market. They determine tasks, jobs and responsibilities and by this, shape the work of every employee. Processes integrate systems, data, and resources within and across organizations and any failure can bring corporate life to a deadlock. Processes determine the potential of an organization to adapt to new circumstances and to comply with a fast growing number of lawmaking requirements.

Although integrating systems and data is not the easiest job. To reach its potential any organization may need a helping hand. No matter how great its business processes are sometimes they will need support and the support can ideally come from resources that are not humans, but bots. This problem is getting bigger with the following assumptions:

- The bigger the organization is the more different systems it will have.
- The more different systems it will have the more complex process will contain.
- The more complex process will contain the more support it will need.

1.3. Research Aim

This thesis is based on the studying of the most comprehensive approaches found in literature for business process optimization and RPA. The author aims at analysing them in detail and signifying the room for improvement and extension of these approaches both individually and combined. For the research's needs, complex banking business processes will be analysed in depth and actions will be introduced in order to improve their performance. At the same time the underlying risks will be investigated. The outcome of this research is to promote the need of continuous improvement and automation especially at large organizations, consulting them with the proper way to implement them.

1.4. Research Objectives

The aim of this thesis can be broken down to the main objectives that can be summarized as follows:

1. Studying and understanding the essentials of business processes
2. Studying and understanding the technical challenges of integration processes
3. Reviewing the state-of-the-art of Business Process Management and understanding its properties
4. Introducing Robotic Process Automation for process optimization
5. Developing simple Robotic Process Application solutions at complex banking processes that integrate several departments and organizations
6. Reviewing the benefits and risks of deploying RPA to traditional BPM

1.5. Thesis Structure

The rest of the thesis structure is built in a way that follows the steps within this research and unfolds all the aspects of the new framework.

In more detail:

- The following chapter, **chapter 2** concerns the study and understanding of the main concepts of business process. The main subjects are the definition of business processes, the importance of workflow management and the technical challenges of integration processes in enterprise services as found in literature.
- **Chapter 3** concerns the literature review and discusses of the most widely accepted approaches of business process management. The main subjects are the most

popular modeling techniques, the importance of automation and intelligent usage of the data that are generated from business processes.

- **Chapter 4** introduces the emergence of Robotic Process Automation to business process execution. The subjects that are mainly studied are the capabilities, benefits and risks of RPA that are known so far and a forecast of the upcoming challenges that RPA need to overcome.
- The aim of **chapter 5** is to separate Business Process Management and Robotic Process Automation definitions and promote the potential benefits of deploying RPA to efficient business processes.
- **Chapter 6** presents some case studies of complex integration processes of banking sector where application of RPA could achieve a softer and more efficient execution of business processes.
- **Chapter 8** holds the conclusions extracted from the deployment of RPA to business processes. It also discusses about the contributions of this research, its limitations and provides the author's suggestions for future work.

2. The Essentials of Business Processes

This chapter discusses the main concepts around business process deriving from the problem statement discussed in the previous chapter. The literature survey within this research focuses on the aspects of definition, components and categories of business processes. In this chapter it is going to be highlighted the importance of automation along with the types of data that are being generated from business processes.

2.1. Introduction to Processes

Process is a sequence of interdependent and connected tasks (procedures) that aims to take advantage of some input parameters in order to create outputs. These inputs are often data or material and in order to get transformed into outputs, the process needs at every stage to consume one or more resources (employees, time, machines, funds, etc.). After the completion of one process, its outputs will be served as inputs to the next one, until the goal or end result is reached.

There are a lot of different types of processes such as legal, food, chemical, computing and business processes. At a legal process the input could be the records of a legal case, at a computing process the resource could be the computing energy while at a food process the output could be cheese. Regardless how different are the ingredients of its process, all of them follow the previous definition.

2.2. Introduction to Business Processes

The "chains of events, activities and decisions" that can be included into a process, which is used by a company or an organization in order to serve customers' needs and it is called business process(Dumas et al., 2013). Every organization has to manage a number of processes. Some very typical examples of process are order-to-cash, issue-to-resolution and application-to-approval. As the above examples demonstrate, business processes are what companies do whenever they deliver a service or a product to customers. The way processes are designed and performed affects both the "quality of service" that customers perceive and the efficiency with which services is delivered. An organization can outperform another organization offering similar kinds of service, if it has better processes and executes them better. This is true not only of customer-facing processes, but also of internal processes such as the procure-to-pay process, which is performed for the purpose of fulfilling an internal need.

2.3. Business Processes Components

A business process encompasses a number of events and activities. Events correspond to things that happen atomically therefore they have no duration. An event can trigger the execution of series of activities. When an activity is rather simple and can be seen as one single unit of work, it is called task. For example, the inspection of a raw material delivery can be considered as a task. On the contrary, if the inspection requires also steps like quality assurance and payment completion then it is considered as an activity.

In addition to events and activities, decision points are also involved in a typical process. These are points in time that a decision is made and affects the way process is executed. For example, the inspector may decide that the delivered raw material does not meet the quality standards to proceed with the rest execution and interrupts the process. This decision affects what happens later in the process.

A process also involves a number of actors (human actors, organizations, software etc.), physical objects (equipment, materials, products, documents) and insubstantial objects (data). At the previous example, the inspector was an actor, raw material was a physical object while quality standards can also be counted as an insubstantial object.

Finally, process' execution leads to one or several outcomes. For example, if the raw material was declined and returned to the supplier, the process is interrupted and the final product/service is not completed. As a result the customers' needs will not be served and this corresponds to a negative outcome both for organization, supplier and customer. If the outcome delivers value to the involved actors, it is called positive outcome.

Execution constraints between activities are identified by Davenport, who defines a business process as "a set of logically related tasks performed to achieve a defined business outcome for a particular customer or market"(Davenport, 1992). The term "logically related" puts emphasis on the process activities, while associating the outcome of a business process with a requestor of a product, i.e., a customer. Davenport also considers the relationship of process activities, including their execution ordering, by defining a business process as "a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs." He continues, "business processes have customers (internal or external) and they cross organizational boundaries, i.e., they occur across or between organizational subunits."

2.4. Business Processes Categories

Different categorizations of business process have been proposed. One of the most influential is Michaels Porter's Value Chain Model. It distinguishes two categories of processes: core processes (primary) and support processes (Porter, 1985). Core processes cover the essential value creation of a company which is the production of goods and services for which customers pay (Rowe, 1994).

According to Porter the primary activities are:

- **Inbound Logistics** - involve relationships with suppliers and include all the activities required to receive, store, and disseminate inputs.
- **Operations** - are all the activities required to transform inputs into outputs (products and services).
- **Outbound Logistics** - include all the activities required to collect, store, and distribute the output.
- **Marketing and Sales** - activities inform buyers about products and services, induce buyers to purchase them, and facilitate their purchase.
- **Service** - includes all the activities required to keep the product or service working effectively for the buyer after it is sold and delivered.

Secondary activities are:

- **Procurement** - is the acquisition of inputs, or resources, for the firm.
- **Human Resource management** - consists of all activities involved in recruiting, hiring, training, developing, compensating and (if necessary) dismissing or laying off personnel.
- **Technological Development** - pertains to the equipment, hardware, software, procedures and technical knowledge brought to bear in the firm's transformation of inputs into outputs.
- **Infrastructure** - serves the company's needs and ties its various parts together, it consists of functions or departments such as accounting, legal, finance, planning, public affairs, government relations, quality assurance and general management.

With intensified globalization, the effective management of an organization's business processes became ever more important. Many factors such as:

- the rise in frequency of goods ordered
- the need for fast information transfer
- quick decision making
- the need to adapt to change in demand
- more international competitors
- demands for shorter cycle times(Simchi-Levi et al., 1999)

are challenging the profitability and survival of big and small companies. In a bid to deal with these challenges, information technology (IT) was harnessed to manage business processes (Davenport, 1992). Over the past decades, previously manual hand-filled forms were increasingly replaced by their paperless electronic counterparts. This eventually evolved into what is known as business process management (BPM) today. According to prominent BPM researcher (van der Aalst, 2003), BPM is defined as supporting business processes using methods, techniques and software to design, enact, control and analyze operational processes involving humans, organizations, applications, documents and other sources of information (Ko et al., 2009; Lee et al., 2009).

2.5. Workflows

2.5.1. The Importance of Workflows

The great importance of the explicit graphical representation of process structures in process models and the controlled enactment of business processes according to these models lead to the achievement of workflow management. The model-driven approach facilitates a high degree of flexibility, because process models can be adapted to fulfill new requirements and the modified process models can immediately be used to enact business processes. In the 1990s, the Workflow Management Coalition (WfMC) was founded to bundle workflow related activities by vendors, users, and academia. The Workflow Management Coalition defines workflows and workflow management systems as follows.

Workflow is the automation of a business process(Georgakopoulos et al., 1995), in whole or in part, during which documents, information, or tasks are passed from one participant to another for action, according to a set of procedural rules. A workflow management system is a software system that defines, creates, and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants, and, where required, invoke the use of IT tools and applications.

Workflow management technology can be used to ease the alteration of the process logic realized by applications. The functions of an application system are the steps in the workflow, and a workflow component uses a workflow model to enact the functions. By modification of the process logic specified in workflow models, the behavior of the application system can be modified without coding.

Today, most enterprise application systems, such as enterprise resource planning systems, are armed with workflow component that facilitates the flexible customization of business processes within these systems. Observe that instead of the term workflow management system the term workflow component is used, because a workflow component is not a stand-alone software system; rather, it is embedded in the application.

A single-application workflow, as described in detail by Mathias Weske, consists of activities and their causal and temporal ordering that are realized by one common application system(Weske, 2012). Multiple-application workflows contain activities that are realized by multiple application systems, providing an integration of these systems. In system workflows, the workflow activities are performed automatically by software systems. Accordingly, knowledge workers do not have to interact with the application and graphical user interfaces in general and work item lists in particular are not necessary. The execution constraints are specified in a process model, and the workflow management system makes sure that the regulation of calls to the software systems is in line with the process model. Figure 1 shows a scenario of a system workflow, with a dedicated workflow management system that invokes for each activity a defined application system. Each of these software systems provides an interface that the workflow management system can use, similar to the adapter in the enterprise application integration scenario shaped above. The workflow management system behaves like a centralized hub in an enterprise application integration scenario, but with clarified process representation and enactment control.

A system workflow consists of activities that are implemented by software systems without any user involvement. Enterprise application integration scenarios are typical aspirants for system workflows. The design and implementation of system workflows can be considered as a type of high-level programming, where functionality offered by application systems defines the building blocks that are organized within a system workflow.

2.5.2. Human Interaction Workflows

In order to introduce human interaction workflows, it is useful to discuss its development. An early ancestor of human interaction workflow management systems is the office automation system, developed in the early 1980s. The goal of these systems was supporting the organization and the collaboration of work involving multiple persons. Until then, supporting office work of individuals has been at the center of care. It turned out that it is not sufficient to equip workers with competent software for their individual workplace, but also to consider the relationship of the work activities that are performed by different workers and provide support for their collaboration.

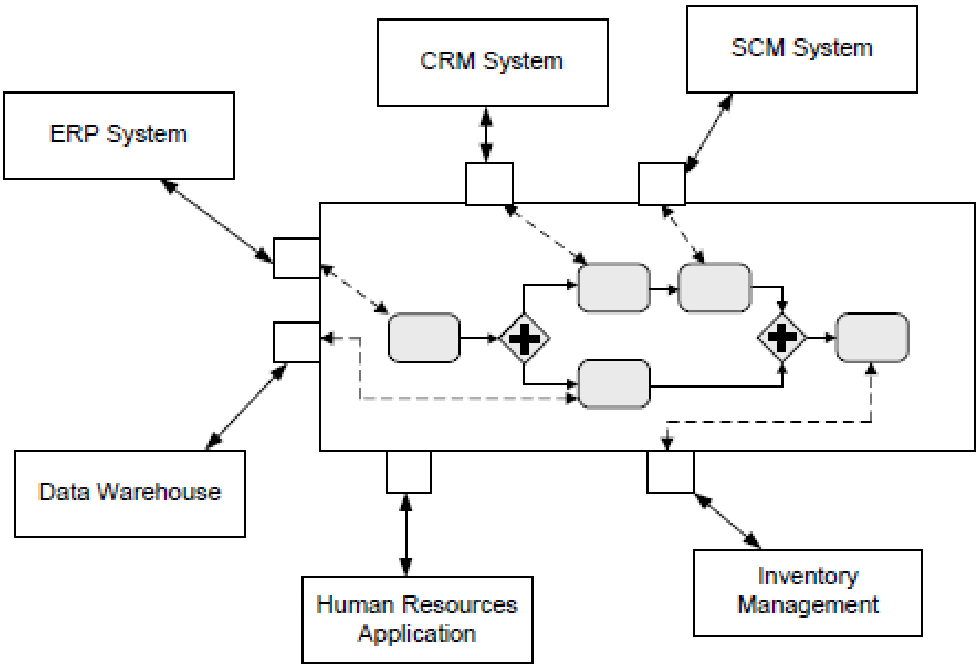


Figure 1 - System workflow integration scenario

Beside consolidated data repositories and by improving the handover of work between employees, a considerable speed-up in office procedures could be realized. However, the scope of office automation was still quite narrow: workers of a given organization process information objects, mainly using form based applications.

Today, human interaction workflows typically actualize parts of a larger business process that has automated alike non-automated parts. The goal of human interaction workflows is to effectively support the automated parts of business processes by actively directing the activities performed according to process models.

2.6. Enterprise Services

The functionality of application systems is commonly described and provided by services in enterprise computing environments. The functionality of the application system is provided through services and depicted by semicircles on top of the application system. Services need to be specified in a way that the definition of services is decoupled from their implementation. Explicit specification of services facilitates the flexible configuration of services by composing services in order to achieve complex functionality.

In an existing application built with several services provided by different business assistants, the partners can modify the realization of their services, as long as the service specification does not change. Based on service specification, a refined service implementation can be integrated seamlessly in a service-based application. New potential business partners can use openly available service specifications to offer their own implementations of the services.

As a result, singular parts of a complex service-based application can be transferred without redesigning the application. Service orientation is also one of the main influencing factors for enterprise application integration. Enterprise services architecture characterizes the development of added-value applications that take advantage of existing functionality provided through regulated interfaces.

Enterprise services architecture is based on the belief that complex applications will be more and more built on top of existing functionality. This functionality is provided by legacy systems, which are a considerable asset of companies. Turning this functionality reusable is a challenging deal. The idea is to encapsulate the functionality of existing software systems in a service, realizing enterprise services. Enterprise services can be used to realize enterprise application integration scenarios.

2.7. Integration

2.7.1. Introduction to Integration

Companies have been facing the challenge of integrating complex software systems in a heterogeneous information technology landscape that has grown in an evolutionary way for decades. Most of the application systems have been developed independently of each other, and each application stores its data locally, either in a database system or some other data store. Data heterogeneity issues occur if a logical data item (for instance, a customer address) is stored multiple times in different applications.

Assume that customer data is stored in an ERP system and a CRM system. Although both systems use a relational database as storage facility, the data structures will be different and not directly comparable.

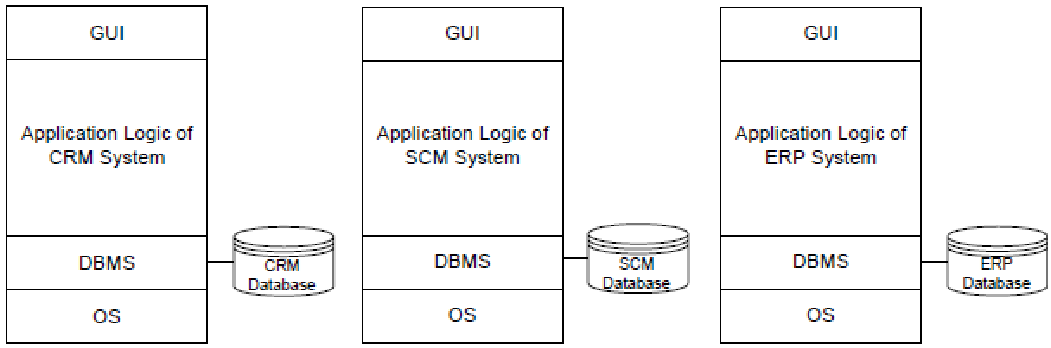


Figure 2 - Siloed enterprise applications

These differences involve both the types of particular data fields (strings of different length for attribute name), but also the names of the attributes. In the customer example, in one system the attribute ExpirationDate will denote the address of the customer, while in the other system the attribute ExpDate denotes the same information.

The next level of heterogeneity regards the semantics of the attributes. Assume there is an attribute amount in the transactions' tables of two application systems. The naming of the attribute does not indicate whether the price includes or excludes commission. These semantic divergences must be sorted out if the systems are integrated. Data integration technologies are used to deal with these syntactic and semantic problems.

Process integration is the sharing of events, transactions and data between business processes, typically in real time. In many cases, events and transactions are used as process triggers. For example, a sales transaction may trigger a process to set up an account in a billing system. Process integration is often used to implement complex processes that involve multiple departments in an organization. In many cases, it is also used to widen processes quite apart from an organization to customers or partners.

For any process to remain useful, it should be developed in such a way that it allows for innovation or some level of flexibility to integrate with established processes or institutional cultures (Pretorius, 2011). Processes that are not flexible and remain static may be effective initially in improving the result but as conditions change over time, a static process may lose its effectiveness and impact. Case studies where processes have successfully been integrated for a number of years often indicate that the process modified, expanded or evolved over time to meet ever-changing challenges that followed business needs.

Data integration is an important aspect in enterprise application integration. The traditional point-to-point enterprise application integration approach and an approach based on message brokers following the hub-and-spoke paradigm have been presented by Weske.

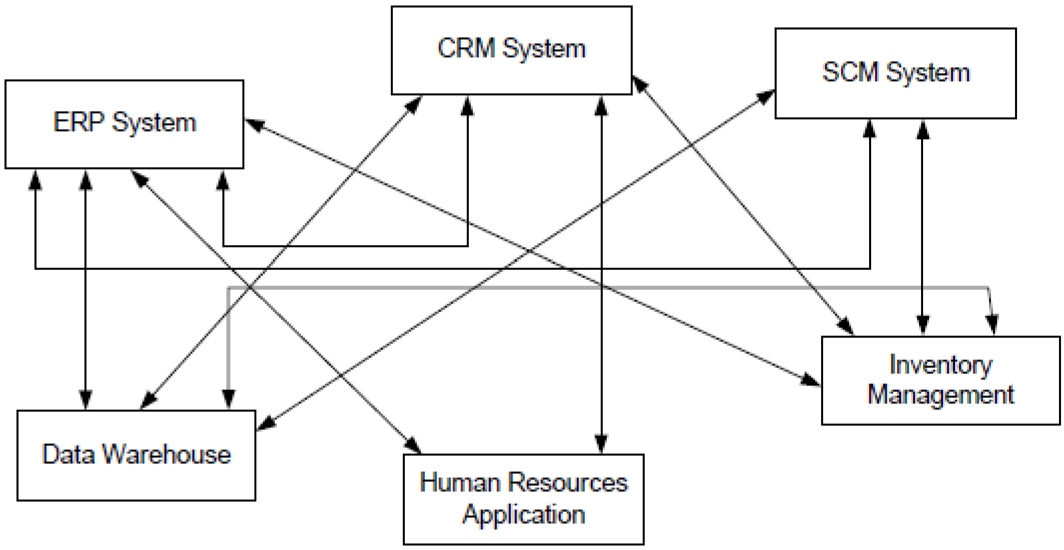


Figure 3 - Early enterprise application integration

2.7.2. Point-to-Point Integration

An exemplary enterprise scenario is represented in Figure 2, where siloed applications are shown. In fact, many more application systems need to be integrated, often even multiple instances of a specific type of application system, such as ERP systems, which often run different versions of the same software.

Enterprise application integration technology is based on middleware technology that has been around for years. The goal is to take advantage of these technologies so that data in heterogeneous information technology landscapes can be integrated accurately. Along with data integration, the processes that the application systems realize also need to be integrated. That means that one system performs certain steps and then assigns control to another system which takes the results and continues operation.

Enterprise application integration faces the issue that each integration project requires design and implementation efforts that might be reasonable. When linking straight each couple of applications, system integrators run into the N × N problem, meaning that the number of interfaces to develop rises to the square of the number N of applications to be integrated.

A description of this integration issue is pictured in Figure 3, where of siloed applications and their integration links are shown. Each link represents an interface that connects the application systems associated with it.

Therefore, the number of interfaces between pairs of application systems to realize grows to the order of N ×N, incurring considerable overhead. If there were links between any pairs of application systems, then the number of interfaces to develop would be 5 + 4 + 3 + 2 + 1 = 15. In the general case, the number of links between N application systems is

$$\sum_{i=1}^{N-1} i = \frac{1}{2}N(N-1)$$

Hence rises to the square of the number of application systems. In the scenario displayed, not all pairs of application systems are connected, but the problem of the large number of interfaces can still be seen.

In enterprise computing, adjustments are sufficient, and a system's architecture has to support adjustments in an efficient and effective way. The enterprise application integration architecture arising from point-to-point integration does not respond pretty well to adjustments. The reason is due to the hard-wiring of the interfaces. Any adjustment in the application landscape requires reworking of the respective interfaces. This reworking is typically realized by reprogramming interfaces, which requires considerable resources.

A specific realization platform of enterprise application integration is message-oriented middleware, where applications communicate by sending and receiving messages. While conceptually the middleware realizes a centralized component, the direct connection between the applications—and therefore the point-to-point integration—is still in place, because each sender needs to encode the receiver of a message.

The main aspect of message-oriented middleware is execution guarantees, such as guaranteed message delivery. However, the problem specified above is not yet solved, since any change in the application landscape needs to be implemented by changing the communication structure of applications.

A sampling message-oriented middleware's architecture is shown in Figure 4. The broker of a message defines the recipients of the message. Respectively, the supply chain management system determines in its interface that a certain message needs to be received by a particular ERP system and a peculiar CRM system, hard-wiring these application systems by the implemented interfaces.

Message queues are used to store messages regularly and to comprehend guaranteed delivery. A client uses an application that integrates a number of application systems; this application is called Integration Application in Figure 4. In order to realize this integration, the integration application sends a message to another application system, for instance, to an ERP system.

In order to do so, it places the message into the message queue of the ERP. The message is then relayed to the ERP system, which invokes the requested functionality and returns a result message to the integration application. This result message is inserted into the incoming message queue of the integration application. Receiving this message, the integration application composes a message and sends it to the supply chain management system. As each sender of a message needs to encode the receiver of the message, adequately a point-to-point connection between the applications is realized. Thus, the difficulties of point-to-point connections in supporting change do not diminish in message-oriented middleware.

This example shows that the collaboration of the application systems is realized in the integration application. As in the early days of information systems evolution, the process that describes how this collaboration takes place is implemented by an application—in this case an integration application.

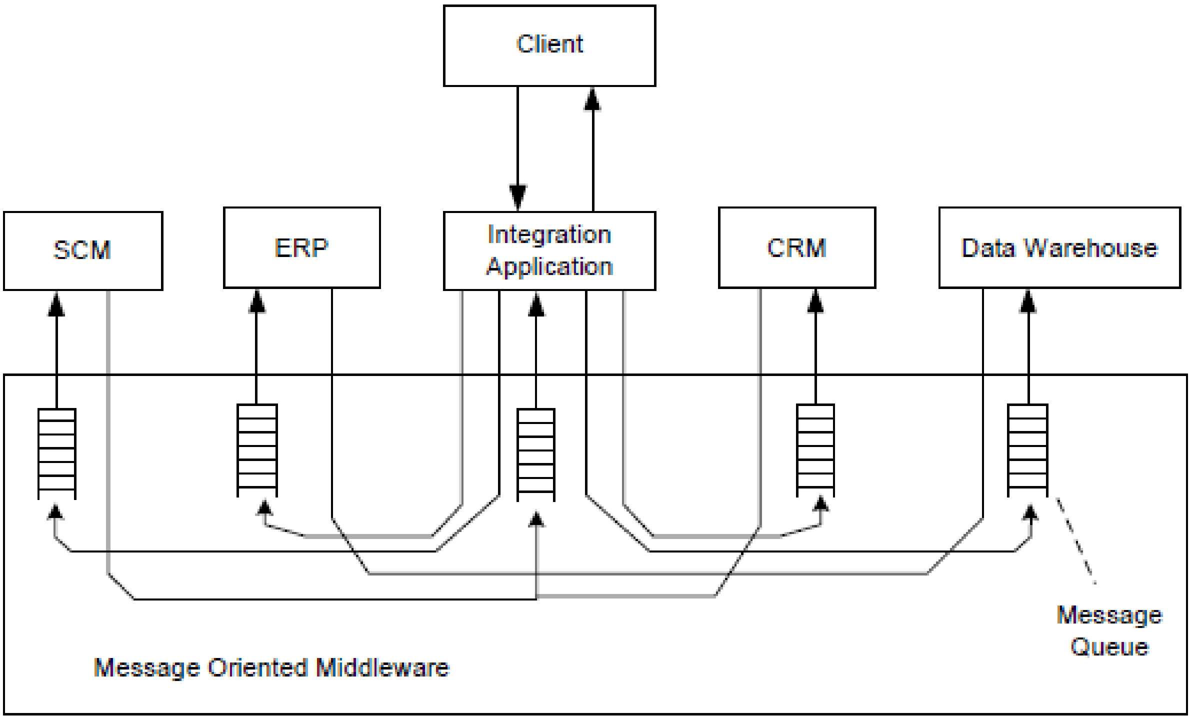


Figure 4 - Message-oriented middleware for communication between applications

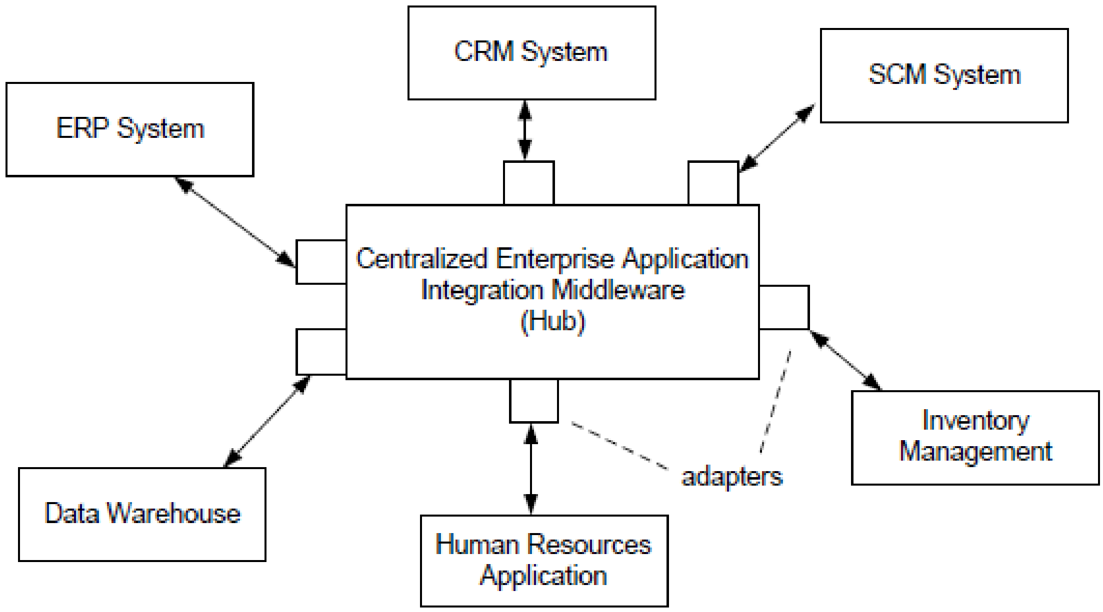
As a result, the process is hardwired within an application, so that there is no accurate process model that can be conveniently communicated and changed, if required. While message-oriented middleware provides important run time guarantees, response to change is not greatly improved. Still, any change in the application structure or in the process behavior needs to be illustrated by a change in the communication structure, implemented for each application one by one.

2.7.3. Hub-and-Spoke Integration

The hub-and-spoke paradigm is based on a centralized hub and a number of spokes that are directly connected to the hub and the spokes are not connected. The centralized enterprise application integration middleware represents the hub, and the applications to be integrated are emulated by the spokes. The applications interact with each other via the centralized enterprise application integration hub.

It is a critical aspect of hub-and-spoke architectures that the sender of a message does not need to encode the receiver of the message. Alternatively, every message is sent to the enterprise application integration layer. This layer is configured in such a way that the message structure and content can be used to automatically identify the receiver or receivers of a message.

The dominance of centralized middleware architecture is that the number of connections can be reduced. No longer connections in the order of N × N are required to connect N application systems. Considering that each application system is attached to the integration



layer, N interfaces will be served. Using these interfaces, the specific relationships between the applications can be reflected in the configuration of the middleware.

A centralized enterprise application integration middleware following the hub-and-spoke paradigm is shown in Figure 5. The centralized hub provides connections that hide the heterogeneity of the application systems from each other. Every application system requires the development of a dedicated connection to attach to the layer.

Depending on the complexity of these systems (and the availability of generic adapters provided by the enterprise application integration vendor) the development of the adapter might consume many resources. When the adapters are in place and the hub is configured, the applications can interact with each other in an integrated manner.

Technically, message brokers can be used to understand a hub-and-spoke enterprise application integration system. Message brokers are software that allows a user to define rules for communication between applications.

Therefore, the concern of implementing and changing communication structures is averted from applications. By representing in an analytical way how communication between applications succeeds, implementation is redeemed by declaration, i.e., by the declaration of the communication structures. Response to change is improved, because the sender is not required to implement these changes locally. These changes can be specified in a declarative way in the central hub, rather than by coding in the applications.

The hub uses rules to handle the dependencies between the applications. Based on these rules, the hub can use information on the identity of the sender, the message type, and the message content to decide on which message queues to relay a message received. Along with relaying messages to recipients, message brokers also reconstruct messages to realize data mapping between the applications, so that data heterogeneity issues can be managed appropriately. Adapters of application systems are used to achieve these message transformations.

2.7.4. Technical Integration Challenges

As system workflows are well equipped to support the process aspect of enterprise application integration scenarios, the same technical integration problems need to be figured out in system workflow projects as those in traditional enterprise application integration projects. Application systems that need to be integrated are usually not equipped with well-documented interfaces that can be used to get hold of the required functionality. The core functionality of application systems might also be implemented in the graphical user interfaces, so that low-level implementation work is required to approach the application system functionality.

Another very important source of trouble is relationships between different applications at coding level. Direct invocation between software systems is an example of these relationships, so that an invocation of an application system automatically spawns off an invocation of another application system. In these environment, the overall process flow is in part realized at the application code level, so that the workflow management system is capable of controlling only parts of the actual process flow, but not the complete process. The granularity of the workflow activities and the granularity of the functionality provided by the underlying application systems might differ. Fine-granular business activities might have been designed in the process model that cannot be realized, because the basic application system only provides coarse-grained functionality. In some cases, the interface to the application can be modified so that fine-grained functionality is available.

This alternative is likely to acquire considerable cost, or it might be unachievable for some applications. Another alternative is changing the granularity of the business activities. In this case, certain properties of the process might not be realizable. As a result, the runtime of the workflow is not going to be optimized. Service-oriented architectures and service-enabling of legacy applications are important conceptions currently being researched to address these technical issues.

As pointed out by Woods, there are a number of business drivers that foster the development of enterprise services (Woods, 2003; Raja, 2013). The main driver is change: the ability to change the enterprise application system infrastructure is a competitive advantage for an enterprise. There are a number of current trends that motivate the development of enterprise services:

- **Rise in the power of the customer:** Value-added services are essential, because customers can change suppliers easily, without much effort. Positive user experience is important, as the success of online auctioning sites and online shops with community building indicates.
- **Systems transparency:** The Internet has brought customers and suppliers inside a company's IT infrastructure. Weak or missing integration of enterprise application systems will be immediately exposed to the customer.

- **Rise in computer mediated interaction with customers and suppliers:** Companies differentiate themselves on their service to their customers. Dan Woods indicates that “Outsiders can now peer into the glass house of the data center and see if it is a mess.” An example of a messy situation is one where a customer cannot be serviced well, because the client interface provides information only about one aspect of the customer, and the other aspects are hidden in application systems that are not accessible. Due to lack of integration, this valuable information is not available, so the customer does not feel well cared for.
- **Products as services:** Corporations are increasingly perceived by the set of services they provide. These services exposed to the market can be realized by enterprise services, which provided by the back end application systems of the enterprise. But also services provided by third parties can be integrated, so that better applications and end user services can be provided to the customer.
- **Multi-tier applications:** There is also a trend towards multi-tier applications, where each tier is provided by a different enterprise. This means that the tier 1 company provides value-added services directly to a customer, using the tier 2 services from a set of business partner companies. These companies might use tier 3 services provided by other companies. By flexible integration based on the service paradigm, many new applications and services can be realized.

2.8. Banking Sector

Banking sector plays significant role in every country for the economic growth as well as currency factor. Bulk development for a country leans on the banking sector as banks maintain the competition between the currencies of many developed and developing countries and there work is always linked directly with people as they store their money in their hands for. One very common type is commercial bank which comprise of public, private or foreign sector banks which accept public deposits, advances loans to the public and offer other related services. All banks basically deal with money as they are financial institute where we do the money exchanges we will either gave or deposit money in banks or will lend/borrow money from banks for our requirement as per we need. Banks do the business of money without any subsidiary business. Their only responsibility is to satisfy their customers. This is also how banks define as they do the business of money interchanging from one hand to other. There are different types of banks. Today’s retail and wholesale banks face bizarre operational pressures that test the efficiency, effectiveness, and agility of their business processes. The typical banking business process often fails the test, struggling to adapt to shifting marketplace demands and regulatory requirements. Lending institutions of all stripes are looking to build a better banking business process, intelligent enough to successfully balance business objectives with customers’ desires, and agile enough to keep pace with a dynamic operational environment.

As practice shows, the main needs that banking industries are to increase the capability of their organization and managing workflows. Some of the most essential benefits of optimizing business process for banking industry are:

- Better streamline at all the critical business processes
- Easier decision-making
- Faster client management processes
- Greater efficiency and cost savings with existing applications and processes
- Well defined details of processes with a complete view of the reporting, activities and duties of responsible departments
- Increased transparency in operations and minimization of the number of faulty operations

2.9. Summary

This chapter examined the basic aspects regarding business process definition. As mentioned at chapter 1, this research attempts to introduce fields that an organization can be benefited by RPA application. After studying the importance of workflows, the great need of human interaction workflows emerged as the proper area to focus on the next chapters. Furthermore, the existence of technical integration challenges was confirmed by this literature survey and enables the identification of the research aim and objectives in the next chapter.

3. Business Process Management: Review of state-of-the-art

This chapter reviews the widespread approaches of business process management deriving from the problem statement discussed in the previous chapter. The literature survey within this research focuses on the aspects of modeling techniques, analysis models and properties of business processes execution models. In this chapter an overview of the existing approaches is provided, in order to highlight their importance, needs and functionality on the top of enterprise services. Furthermore, this chapter describes the challenges that occur on complex processes that integrate several applications, while the overview of these approaches facilitates in the identification of these challenges in banking sector.

3.1. Fundamentals

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

BPM is a subject undergoing intense study because it is highly relevant from a pragmatic point of view while at the same it offers many challenges for software developers and scientists. Traditionally information systems used information modeling as a starting point, i.e., driven by data approaches have dominated the information systems landscape. Nonetheless, over the last years it has become clearer that processes are equally important and need to be supported in a methodical manner. This resulted in a wave of workflow management systems in the mid-nineties. These systems intended to the automation of structured processes. Consequently, their application was restricted to only a few application domains. Anyhow, the basic workflow concepts have been endorsed by different types of process-aware information systems. BPM addresses the topic of process support in an extensive perspective by covering different types of analysis (e.g., simulation, verification, and process mining) and linking processes to business and social aspects. Moreover, the current interest in BPM is supplied by technological developments (service-oriented architectures) triggering standardization efforts (cf. languages such as BPMN and BPEL).

The extensive ground covered by business process management is divided between delegations from two communities: business administration and computer science(Weske, 2012). Due to the progressively important aspect of information systems in the realization of business processes, a common understanding of and productive interaction between these communities are crucial. Due to different viewpoints, however, the interaction between these communities is rarely logical. Business administration professionals tend to consider information technology as a subordinate aspect in business process management that experts will take care of. On the other hand, computer science professionals often consider business goals and organizational regulations as terms that do not deserve much thought, but require the appropriate level of abstraction.

Weske argues that we need to have a common understanding of the different aspects of business process management addressed by all communities involved. Robust and correct realization of business processes in software that increases customer satisfaction and ultimately contributes to the competitive advantage of an enterprise can only be achieved through beneficial communication between these communities. By structuring business process management will produce a step towards a better understanding of the concepts involved in business process management from the perspective of a computer scientist.

Members of these communities are mostly characterized by different educational backgrounds and concerns. People in business administration are interested in improving the operations of companies. Increasing customer satisfaction, reducing cost of doing business, and establishing new products and services at low cost are important aspects of business process management from a business administration point of view. Two communities in computer science are interested in business processes. Researchers with a background in formal methods investigate structural properties of processes. Since these properties can only be shown using abstractions of real-world business processes, process activities are typically reduced to letters. Using this abstraction, interesting observations on structural properties of business processes can be made, which are very useful for detecting structural deficiencies in real-world business processes. The software community is interested in providing robust and scalable software systems. Since business processes are realized in complex information technology landscapes, the integration of existing information systems is an important basis for the technical realization of business processes.

Business process management is based on the consideration that each product that a company provides to the market is the payoff of a number of activities performed. There are also business process activities that can be executed automatically by information systems, without any human involvement. In many companies there is a gap between organizational business aspects and the information technology that is in place. Narrowing this gap between organization and technology is important, because in today's dynamic markets, companies are invariably forced to provide better and more specific products to their customers. Products that are successful today might not be successful tomorrow. If a competitor provides a cheaper, better designed, or more conveniently usable product, the market share of the first product will most likely decrease.

Business process management is turned by concepts and technologies from different areas of business administration and computer science. Based on early work in organization and management, business process management has its roots in the process orientation trend of the 1990s, where a new way of organizing companies on the basis of business processes was proposed. They define a business process as a number of activities that take one or more kinds of input and create an output that is of value to the customer.

The key idea of BPM is to target to processes when organizing and managing work in an organization. This idea may seem intuitive and straightforward at first glance. Surely, if one is concerned with the quality of a particular product or service and the speed of its delivery to a customer, it is very logical to consider the very steps that are necessary to produce it. Even though intuitive, it took several evolutionary steps before this idea became essential part of the work structures of organizations. Figure 6 provides a synopsis of some developments relevant to BPM over the ages.

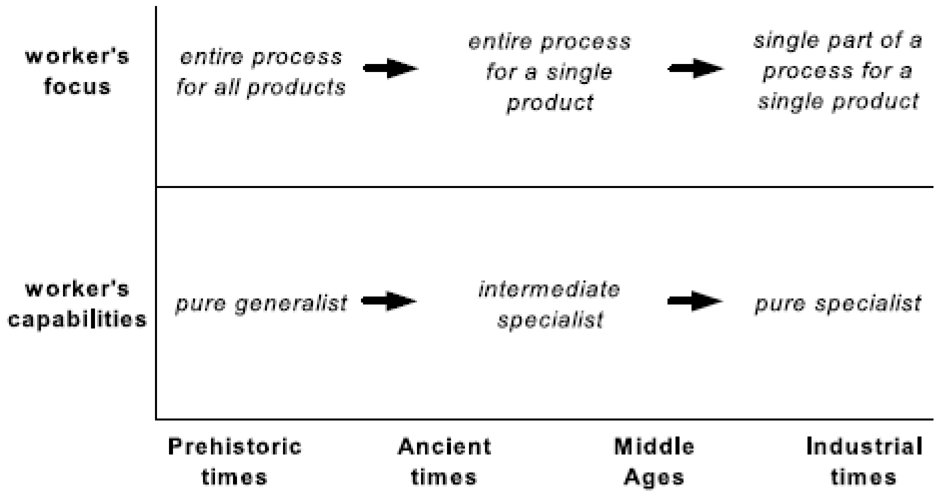


Figure 6 - How the process moved out of focus through the ages

The functional organization that appeared from the mindset of the Second Industrial Revolution, dominated the corporate landscape for the greatest part of the 19th and 20th centuries. Towards the end of the 1980s, however, major American companies such as IBM, Ford, and Bell Atlantic (now Verizon) came to realize that their attention on functional optimization was creating inefficiencies in their operations that were affecting their competitiveness. Costly projects that introduced new IT systems or reorganized work within a functional department targeting to improve its efficiency were not greatly helping these companies to become more competitive. It looked like customers remained unconcerned to these efforts and continued to take their business elsewhere, for example to Japanese competitors.

Generally, the ambition of engaging in a BPM initiative is to assure that the business processes covered by the BPM initiative lead to constantly positive outcomes and deliver maximum value to the organization in servicing its clients. Measuring the value delivered by a process is a crucial step in BPM. As renowned software engineer, Tom DeMarco once famously put it: *"You can't control what you can't measure".* So before starting to analyze any process in detail, it is important to clearly define the process performance measures (also called process performance metrics) that will be used to determine whether a process is in "good shape" or in "bad shape".

Equipped with an understanding of one or several issues in a process and a candidate set of potential remedies, analysts can recommend a redesigned version of the process, in other words a to-be process which would address the issues identified in the as-is process. This to-be process is the main output of the process redesign phase. It is necessary to keep in mind that analysis and redesign are intricately related. There may be multiple redesign options and each of these options needs to be analyzed, so that an informed choice can be made as to which option should be chosen.

Once redesigned, the mandatory changes in the ways of working and the IT systems of the organization should be implemented so that the to-be process can eventually be put into execution. This phase is called process implementation. Deploying such an information system means not only developing the IT components of this system. It would also relate to training the process participants so that they perform their work in the spirit of the redesigned process and make the best use of the IT components of the system.

More generally, process implementation may engage two integral facets: organizational change management and process automation. Organizational change management declares the set of activities required to change the way of working of all participants involved in the process. These activities include:

- Explaining the changes to the process participants to the point that they accept both what changes are being introduced and why these changes are valuable to the company.

- Putting in place a change management plan so that stakeholders know when the changes will be put into effect and what transitional arrangements will be employed to address problems during the transition to the to-be process.

- Training users to the new way of working and monitoring the changes in order to assure a smooth transition to the to-be process.

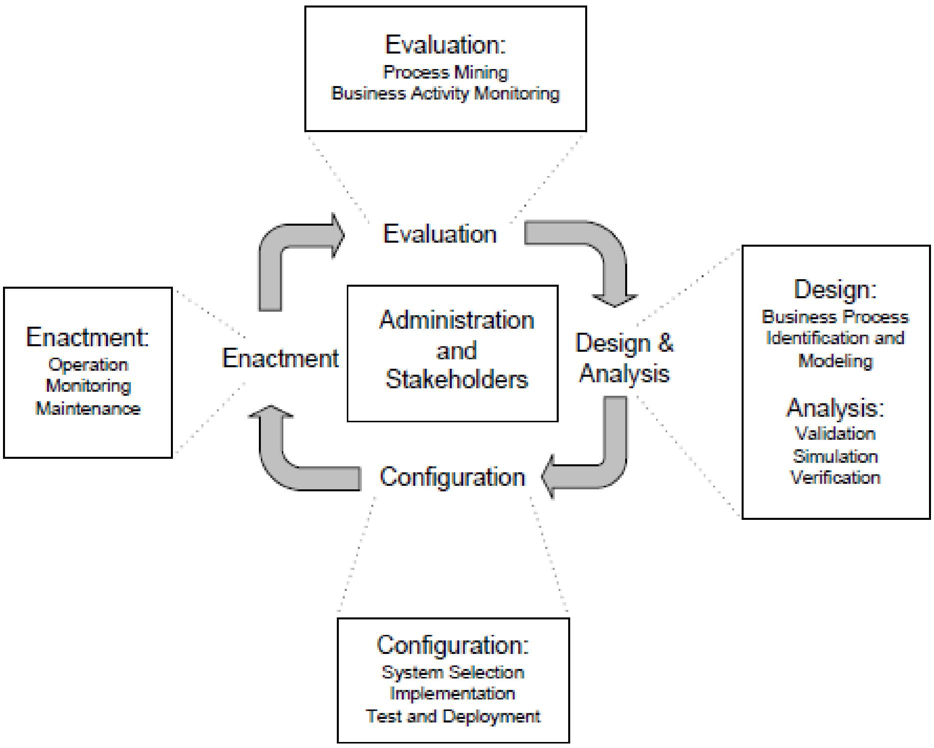


Figure 7 - Business Process Lifecycle

Nevertheless, process automation involves the configuration or implementation of an IT system (or the reconfiguration of an existing IT system) to support the "to-be" process. This system should support process participants in the performance of the tasks of the process. This might include appointing tasks to process participants, helping process participants to prioritize their work, providing process participants with the information they need to perform a task, and performing automated reconciliations and other automated tasks where possible. There are several ways to implement such an IT system.

Over time, some modifications might be required because the implemented business process does not meet expectations. To this end, the process needs to be monitored and analysts ought to investigate the data collected by monitoring the process in order to identify needed adjustments to better control the execution of the process. These activities are encompassed by the process monitoring and controlling phase. This phase is important because addressing one or a handful of issues in a process is not the end of the story. Instead, managing a process requires a continuous effort. Lack of continuous monitoring and improvement of a process leads to degradation.

3.2. Context Framework

The BPM context framework describes the factors in the context of BPM that are relevant to BPM projects based on their settings (vom Brocke, 2016). The model guides to represent a BPM initiative according to elements like its goals, the process's characteristics, and the organization's and external environment's characteristics. The key contribution of the framework is to capture the situation around the BPM initiative so it can be aligned to the organization's specific context. The BPM context framework helps in assessing this context (Fig. 8).

The BPM context framework captures four contextual dimensions:

- **Goal Dimension**: The goal a BPM project is targeting has a major influence on the BPM-related actions to be planned. The difference between exploitation and exploration may serve as an example, as the first fosters optimization, and the second fosters innovation.
- **Process Dimension**: BPM can be applied to a number of processes, so the process characteristics affect the appropriate BPM methodology. Examples of factors include the knowledge-intensity, complexity, creativity, and variability involved in a process.
- **Organizational Dimension**: BPM serves many organizations, but the characteristics of the organization determine the right BPM approach. Organizational factors include industry, size, and culture.
- **Environmental Dimension**: BPM can also be applied in a variety of environments, which are characterized by, for example, differing levels of competitiveness or uncertainty. Considering the dynamics of the environment is important in scoping and positioning a BPM initiative.

Contextual factors	Example characteristics		
Goal-dimension:			
Focus	Exploitation (Improvement, Compliance)	Exploration (Innovation)	
Process-dimension:			
Value contribution	Core process	Management process	Support process
Repetitiveness	Repetitive	Non-repetitive	
Knowledge-intensity	Low knowledge-intensity	Medium knowledge-intensity	High knowledge-intensity
Creativity	Low creativity	Medium creativity	High creativity
Interdependence	Low interdependence	Medium interdependence	High interdependence
Variability	Low variability	Medium variability	High variability
Organization-dimension:			
Scope	Intra-organizational process	Inter-organizational process	
Industry	Product industry	Service industry	Product & Service industry
Size	Start-up	Small and medium enterprise	Large organization
Culture	Culture highly supportive of BPM	Culture medium supportive of BPM	Culture non-supportive of BPM
Resources	Low organizational resources	Medium organizational resources	High organizational resources
Environment-dimension:			
Competetiveness	Low competitive environment	Medium competitive environment	High competitive environment
Uncertainty	Low environmental uncertainty	Medium environmental uncertainty	High environmental uncertainty

Figure 8 - Context Framework

3.3. The BPM Six Core Elements Model

The BPM Six Core Elements Model, also introduced by vom Brocke, describes organizational capability areas that are relevant to BPM. The model helps decision makers to classify the actions an organization undertakes in conducting BPM by conceptualizing six BPM capability areas: strategic alignment, governance, methods, IT, people, and culture. This model expands BPM from a technical concept to a holistic management discipline (Brocke and Mendling, 2018):

- **Strategic Alignment:** BPM contributes to the organization’s superordinate, strategic goals. Related capabilities include the assessment of processes and process management initiatives according to their fit with the overall corporate strategy.

- **Governance:** BPM must be implemented in the organizational structure. Related capabilities include the assignment of BPM-related tasks to stakeholders and applying specific principles and rules to define the required responsibilities and controls along the entire business-process lifecycle.
- **Methods:** BPM must be supported by methods for process design, analysis, implementation, execution, and monitoring. Related capabilities include selecting the appropriate BPM methods, tools, and techniques and adapting and combining them according to the organization's requirements.
- **Information Technology:** BPM must use technology, particularly process aware information systems (PAIS), as the basis for process design and implementation. Related capabilities include the ability to select, implement, and use relevant PAIS solutions that covering, for example, workflow management, adaptive case management, or process-mining solutions.
- **People:** BPM must consider employees' qualifications in the discipline of BPM and their expertise with relevant business processes. Related capabilities include assessing the human-resources impact of BPM-related initiatives and programs that facilitate the development of process-related skills throughout the organization.
- **Culture:** BPM must be met with a common value system that supports process improvement and innovation. Related capabilities include the ability to assess the organizational culture's values and the ability to derive measures to develop these values accordingly.

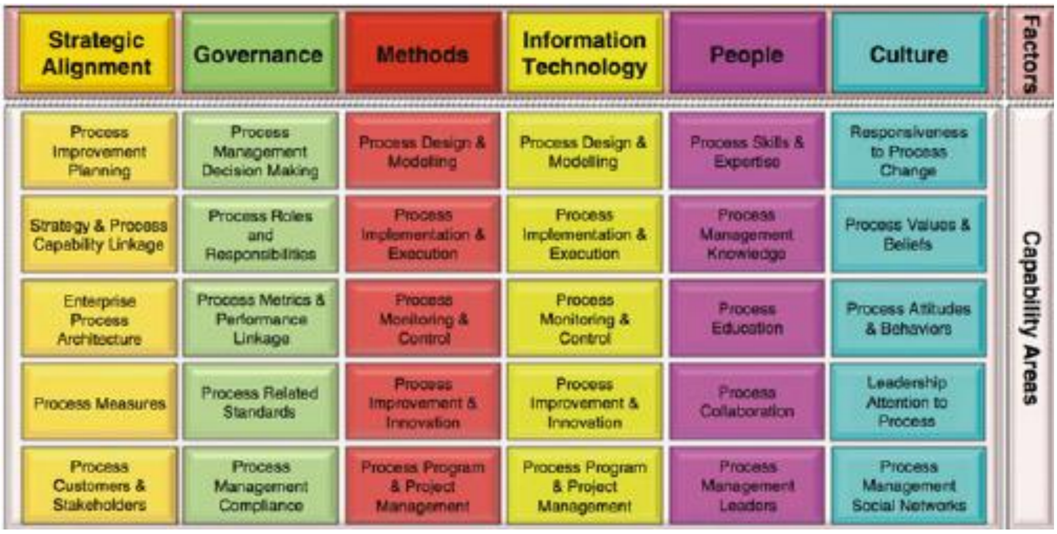


Figure 9 – BPM Six Core Element Model

3.4. Cycle Phase

Michael Hammer once put it: *"every good process eventually becomes a bad process"*, unless it is repeatedly adapted and improved in order to keep up with the ever-changing landscape of customer needs, technology and competition. This is why the phases in the BPM lifecycle should be seen as being circular: the output of monitoring and controlling feeds back into the discovery, analysis and redesign phases. Changing a process is not as painless as it sounds. People are used to work in a certain way and might refuse changes. Moreover, if the change involves modifying the information system(s) underpinning the process, the change may be costly or may require changes not only in the organization that coordinates the process, but also in other organizations.

We can view BPM as continuous cycle (Dumas et al., 2013) comprising the following:

- **Process identification**. W. Edwards Deming famously said: *"If you can't describe what you are doing as a process, you don't know what you're doing."* In this phase, a business problem is posed and processes relevant to the problem being addressed are identified, delimited and related to each other. The outcome of process identification is a new or updated process architecture that provides an overall view of the processes in an organization and their relationships. In some cases, process identification is done in parallel with performance measure identification. However, we will associate performance measure identification with the process analysis given that performance measures are often used for process analysis.

- **Process discovery** (also called as-is process modeling). Here, the current state of each of the relevant processes is documented, typically in the form of one or several as-is process models. The importance of this process can be more clear after giving a look at Albert Einstein great quote*: "If I had one hour to save the world, I would spend fifty-five minutes defining the problem and only five minutes finding the solution."*

- **Process analysis.** In this phase, issues associated to the as-is process are identified, documented and whenever possible quantified using performance measures. The output of this phase is a structured collection of issues. These issues are typically prioritized in terms of their impact, and sometimes also in terms of the estimated effort required to resolve them.

- **Process redesign** (also called process improvement). The goal of this phase is to identify changes to the process that would help to address the issues identified in the previous phase and allow the organization to meet its performance objectives. To this end, multiple change options are analyzed and compared in terms of the chosen performance measures. This entails that process redesign and process analysis go hand-in-hand: As new change options are proposed, they are analyzed using process analysis techniques. Eventually, the most promising change options are combined, leading to a redesigned process. The output of this phase is typically a to-be process model, which serves as a basis for the next phase.

- **Process implementation.** In this phase, the changes required to move from the as-is process to the to-be process are prepared and performed. Process implementation covers two aspects: organizational change management and process automation. Organizational change management refers to the set of activities required to change the way of working of all participants involved in the process. Process automation on the other hand refers to the development and deployment of IT systems (or enhanced versions of existing IT systems) that support the to-be process. Our focus with respect to process implementation is on process automation, as organizational change management is an altogether separate field.

- **Process monitoring and controlling.** Once the redesigned process is running, relevant data are collected and analyzed to determine how well the process is performing with respect to its performance measures and performance objectives. Bottlenecks, recurrent errors or deviations with respect to the intended behavior are identified and corrective actions are undertaken. New issues may then arise, in the same or in other processes, requiring the cycle to be repeated on a continuous basis.

The BPM lifecycle helps to understand the role of technology in BPM. Technology commonly, and especially Information Technology (IT), is a key instrument to improve business processes. Not surprisingly, IT specialists such as system engineers often play a significant role in BPM initiatives. However, to achieve maximum efficacy, system engineers need to be aware that technology is just one instrument for managing and executing processes. System engineers need to work together with process analysts in order to understand what the main issues affecting a given process, and how to best address these issues, be it by means of automation or by other means. Bill Gates, once famously put it: *"The first rule in any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency".* That means that learning how to design and improve processes and not only how to build an IT system to automate a narrow part of a business process is a fundamental skill.

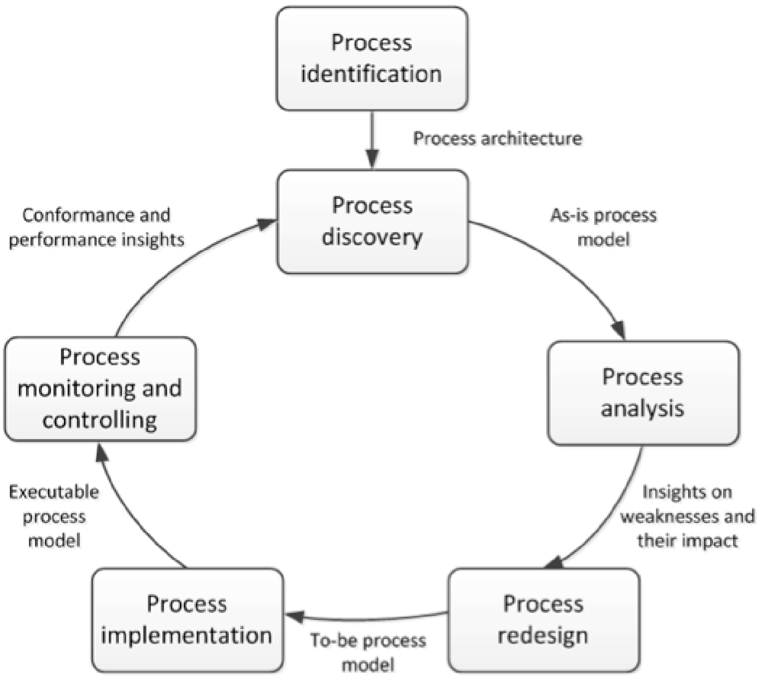


Figure 10 – BPM Lifecycle

The total processes that are identified in the Designation phase must display a trade-off between impact and manageability. The smaller the number of the processes one wish to identify, the bigger their individual scope is. In other words, if only a small number of processes are identified then each of these will cover numerous operations. The main advantage of a large process scope is that it potentially increases the impact one can have with actively managing such a process. The more operations are considered to be part of a process, the easier it will become, for example, to spot opportunities for efficiency gains by rooting out redundant work.

On the other hand, a large scope of a business process brings along a range of issues that make it more difficult to manage it as a process:

- The involvement of a large number of staff will make effective communication among them problematic
- It will become more difficult to keep models of a large process up-to-date
- Improvement projects that are related to a large process are more complex

In addition to a rather accurate view on what business processes exist, an understanding must be developed about the relations between the numerous processes. In a situation where organizations define both narrow and broad processes, to avoid confusion, it is important to map how narrow processes relate to broader processes. A broad process like order management, for example, can be related to the more narrowly defined processes of order booking, billing, shipment, and delivery. All of these can be considered sub-processes of order management. We can call this an example of hierarchical relations between processes. Processes may also be related to one another variously. Billing, in the example we just used, is an upstream process compared to shipment: for the same order the bill is sent out usually before the ordered goods are shipped. Another way of expressing this relation is, of course, that shipment can be considered a downstream process comparing to billing. This illustrates how processes can be sequentially related.

3.5. Process Analysis Models

3.5.1. Value-Added Analysis

According to Dumas, analyzing business processes is both an art and a science. In this respect, qualitative analysis is the artistic side of process analysis. Value-added analysis typically consists of two stages: value classification and waste elimination. Value classification is a technique by which an analyst decorticates a process model, extracts every step in the process and classifies these steps into one of three categories, namely:

- **Value-adding (VA):** This is a step that produces value or satisfaction of the customer. When determining whether or not a step is value-adding, it may help to ask the following question: Would the customer be willing to pay for this activity?

• **Business value-adding (BVA)**: The step is necessary or useful for the business to run smoothly, or it is required due to the regulatory environment of the business.

• **Non-value adding (NVA):** The step does not fall into any of the other two categories.

Having identified and classified the steps of the process as discussed above, one can then proceed to determining how to eliminate waste. A general rule is that one should strive to minimize or eliminate NVA steps. Some NVA steps can be eliminated by means of automation (makes these NVA steps transparent to the performers of the steps).

While elimination of NVA steps is generally considered an expedient goal, elimination of BVA steps should be considered as a trade-off given that BVA steps play a role in the business. Prior to eliminating BVA steps, one should first map BVA steps to business goals and business requirements, such as regulations that the company must comply to and risks that the company seeks to minimize. Given a mapping between BVA steps on the one hand and business goals and requirements on the other, the question then becomes the following: What is the minimum amount of work required in order to perform the process to the satisfaction of the customer, while fulfilling the goals and requirements associated to the BVA steps in the process? The answer to this question is a starting point for process redesign.

When analyzing a business process, it is worth keeping in mind that *"even a good process can be made better"*. Experience shows that any non-trivial business process, no matter how much improvement it has undergone, suffers from a number of issues. There are always errors, misunderstandings, incidents, needless steps and other forms of waste when a business process is performed on a day-to-day basis.

3.5.2. Process Performance Dimensions

Any company would ideally like to make its processes faster, cheaper, and better. This simple observation leads us already to identify three process performance dimensions: time, cost and quality. A fourth dimension gets involved in the equation once we consider the issue of change. It is not always what we want to make a process faster, cheaper or better. A process might perform remarkably well under normal circumstances, but then perform poorly in other circumstances which are perhaps equally or more crucial. Therefore sometimes all it is needed is to make the process more flexible and this view leads us to identify a fourth dimension of process performance, flexibility.

We briefly discuss each of the four dimensions and how they are typically refined into specific performance measures:

1. **Time:** Usually the first performance dimension that comes to mind while analyzing processes is time. Clearly, a very common performance measure for processes is cycle time. Cycle time is the time that it takes to handle one case end to end. Although it is frequently the aim of a redesign effort to minimize cycle time, there are many different ways of further specifying this aim. For instance, one can aim at a reduction of the average cycle time or the maximal cycle time. It is also possible to focus on the ability to

meet cycle times that are agreed upon with a client at run time. Still another way of looking at cycle time is to focus on its deviation, which is markedly behind approaches like Six Sigma. Different aspects of the time dimension come into view while considering the constituents of cycle time(Dumas et al., 2013), namely:

- Processing time (also called service time): the time that resources (e.g. process participants or software applications invoked by the process) spend on actually handling the case.
- Waiting time (also called idle time): the time that a case spends in idle mode. Waiting time includes queuing time (waiting time due to the fact that no resources available to handle the case) and other waiting time, for example because synchronization must take place with another process or because input is expected from a customer or from another external actor.

2. **Cost:** Another common performance dimension while analyzing and redesigning a business process that has a financial nature. While we refer to cost here, it would also have been possible to put the attention on turnover or profit. Apparently, a profit increase may have the same effect on an organization's profit as a decrease of cost. However, process redesign is more often related with reducing cost. There are different viewpoints on cost. At first, it is feasible to differentiate fixed and variable cost. Fixed costs are overhead costs which are not affected by the intensity of processing. Typical fixed costs follow from the use of infrastructure and the maintenance of information systems. Variable cost is certainly correlated with some variable quantity, such as the level of sales, the number of purchased goods, the number of new hires, etc. A cost approach which is closely related to productivity is operational cost. Operational costs can be directly associated to the outputs of a business process. A substantial part of operational cost is usually labor cost which can be related to human resources in producing a good or delivering a service. Within process redesign efforts, it is very common to focus on reducing operation cost, particularly labor cost. The automation of tasks is often noticed as an alternative for labor. Obviously, although automation may reduce labor cost, it may cause incidental cost involved with developing the respective application and fixed maintenance cost for the life time of the application.

3. **Quality:** The quality of a business process can be examined from at least two different points: from the client's side and from the process participant's side. This is also known as the contrast between external quality and internal quality. The external quality can be measured as the client's satisfaction with either the product or the process. Satisfaction with the product can be indicated as the extent to which a client feels that the specifications or expectations are met by the delivered product. On the other hand, a client's satisfaction with the process concerns the way how it is executed. A typical issue is the amount, relevance, quality, and timeliness of the information that a client receives during execution on the progress being made. On the other hand, the internal quality of a business process related to the process participants' perspective. Typical internal quality concerns are: the level that a process participants feels in control of the work performed, the level of variation experienced, and whether working within the context of the business process is felt as challenging. It is very interesting to mark that

there are various direct relations between the quality and other dimensions. For example, the external process quality is often measured in terms of time like the average cycle time or the percentage of cases where deadlines are missed.

4. **Flexibility** The criterion that is least marked to measure the effect of a redesign measure is the flexibility of a business process. Flexibility can be defined in general terms as the ability to react to changes. These changes may concern various parts of the business process, for example:

    - The ability of resources to execute different tasks within a business process setting.
    - The ability of a business process as a whole to handle various cases and changing workloads.
    - The ability of the management in charge to change the used structure and allocation rules.
    - The organization's ability to change the structure and responsiveness of the business process to wishes of the market and business partners.

Another way of approaching the performance dimension of flexibility is to separate run time and build time flexibility. Run time flexibility concerns the opportunities to handle changes and variations while executing a specific business process. Build time flexibility concerns the possibility to change the business process structure. It is more and more important to distinguish the flexibility of a business process from the other dimensions.

3.5.3. Simulation

Process simulation is by far the most famous and most widely supported technique for quantitative analysis of process models. The initial idea underpinning process simulation is quite simple. Basically, a process simulator generates a large number of hypothetical instances of a process, executes these instances step-by-step, and records each step in this execution. The output of a simulator includes the logs of the simulation as well as some statistics related to cycle times, average waiting times and average resource utilization.

During a process simulation, the tasks in the process are not literally executed. Actually, when a task is ready to be executed, a so-called work item is created and the simulator first tries to find a resource to which it can assign this work item. If there is not any resource able to perform the work item is found, the simulator puts the work item in waiting mode until a suitable one is freed up. At the time that a resource is assigned to a work item, the simulator determines the duration of the work item by drawing a random number according to the probability distribution of the task's processing time. This probability distribution and the corresponding parameters need to be defined in the simulation model. Once the simulator has determined the duration of a work item, it puts the work item in sleeping mode for that duration. This sleeping mode simulates the fact that the task is being executed. Once the time interval has passed (according to the simulation's clock) the work item is declared to be completed, and the resource that was assigned to it becomes available.

In reality, the simulator does not effectively wait for tasks to return from their sleeping mode. For instance, if the simulator determines that the duration of a work item is 2 days and 2 hours, it is not going to wait for this amount of time to pass by. Imagine how long a simulation would take if that was the case. Fortunately, simulators use smart algorithms to complete the simulation as fast as possible. Modern business process simulators can effectively simulate thousands of process instances and tens of thousands of work items in a matter of seconds.

For each work item created during a simulation, the simulator records the identifier of the resource that was assigned to this instance as well as three time stamps:

- The time when the task was ready to be executed.
- The time when the task was started, meaning that it was assigned to a resource.
- The time when the task completed.

The simulator can compute the average waiting time for each task, using the collected data. Bottlenecks in the process are mostly identified by these measures. Indeed, if a task has a very high average waiting time, it means that there is a bottleneck at the level of this task. The analyst can then consider multiple options for addressing this bottleneck.

Also, since the simulator records which resources perform which work items and it knows how long each work item takes, it can find out the total amount of time during which a given resource is busy handling work items. By dividing the amount of time that a resource was busy during a simulation by the total duration of the simulation, we can obtain the resource utilization, that is, the percentage of time that the resource is busy on average.

Considering the above description of how a simulation works, we can view that the following information needs to be specified for every task that is included in the process model in order to simulate it:

- Probability distribution for the processing time of each task.
- Other performance attributes for the task such as cost and added-value produced by the task.
- The set of resources that is able to perform the task. This set is usually called a resource pool. For example, a possible resource pool could be the “Claim Handlers” or “Clerks” or “Managers”. Separately, the analyst needs to specify for each resource pool the number of resources in this pool (e.g. the number of claim handlers or the number of clerks) and other attributes of these resources such as the hourly cost (e.g. the hourly cost of a claims handler).

It should be noted that the mostly simulation but also the rest quantitative analysis techniques are based on models and on simplifying assumptions. The reliability of the output produced by these techniques generally depends on the accuracy of the numbers that are given as input. Simulation also assumes that process participants work over and over on the process being simulated. In practice though, process participants are not robots.

Well, they can be robots as we will discuss in chapter 4. They get distracted due to interruptions, they display varying performance depending on various factors, and they may adapt differently to new ways of working. In this respect, it is good practice whenever possible to derive the input parameters of a simulation from actual observations, meaning from historical process execution data. This can happen when simulating an as-is process that is being executed in the company, but not necessarily when simulating a to-be process. In the same spirit, it is fully recommended to cross-check simulation outputs against expert advice. This can be achieved by presenting the simulation results to process stakeholders and including process participants. The process stakeholders are usually able to provide feedback on the credibility of the resource utilization levels calculated via simulation and the actual manifestation of the bottlenecks shown in the simulation. For example, if the simulation points to a bottleneck in a given task, while the stakeholders and participants perceive this task to be minor, there is a clear indication that inaccurate assumptions have been made. Feedback from stakeholders and participants can be used to reconfigure the parameters so that the results can meet the matching the actual behavior. Particularly, process simulation is an iterative analysis technique with potentially multiple validation loops.

Certainly, it is desirable to perform **sensitivity analysis** of the simulation(Zhu, 2005). Categorically, that means that observing how the output of the simulation changes when adding one resource to or removing one resource from a resource pool, or when changing the processing times by 20 % for example. If such minor changes in the simulation input parameters significantly affect the conclusions from the simulation outputs, a question mark can be putted on these conclusions. The methodology of Heuristic Process Redesign involves the phases of initiation, design, and evaluation. Various heuristics are available to support the design phase. They target on the seven areas being related to processes, including customers, business process operations, business process behavior, organization, information, technology, and the external environment.

3.6. Individual Group Roles and Stakeholders in BPM Lifecycle

According to Magdaleno and Dumas here are different stakeholders involved with a business process throughout its lifecycle(Dumas et al., 2013; Magdaleno, 2017). Among them we can distinguish the following individuals and groups.

- **Management Team**. Depending on how the management of a company is organized, one might find the following positions. The Chief Executive Officer (CEO) is responsible for the overall business success of the company. The Chief Operations Officer (COO) is responsible for defining the way operations are set-up. In some companies, the COO is also responsible for process performance, while in other companies, there is a dedicated position of Chief Process Officer (CPO) for this purpose. The Chief Information Officer (CIO) is responsible for the efficient and effective operation of the information system infrastructure. In some organizations, process redesign projects are driven by the CIO. The Chief Financial Officer (CFO) is responsible for the overall financial performance of the company. The CFO could also be responsible for certain business processes, particularly those that have a direct impact on financial performance. Other management positions that have a stake in the lifecycle of processes include the Human Resources (HR) director. HR directors and their teams play a key role in processes that involve significant numbers of process participants. In any case, the management team is responsible for overseeing all processes, initiating process redesign initiatives, and providing resources and strategic guidance to stakeholders involved in all phases of the business process lifecycle.

• **Process Owners.** Process owner is responsible for the efficient and effective operation of a given process. A process owner is responsible on the one hand for planning and organizing and on the other hand for monitoring and controlling the process. In their planning and organizing role, the process owner is responsible for defining performance measures and objectives as well as initiating and leading improvement projects related to their process. They are also responsible for securing resources so that the process runs smoothly on a daily basis. In their monitoring and controlling role, process owners are responsible for ensuring that the performance objectives of the process are met and taking corrective actions in case they are not met. Process owners also provide guidance to process participants on how to resolve exceptions and errors that occur during the execution of the process. Thus, the process owner is involved in process modeling, analysis, redesign, implementation and monitoring. Note that the same individual could well be responsible for multiple processes. For example, in a small company, a single manager might be responsible both for the company's order-to-cash process and for the after-sales customer service process.

• **Process Participants.** Process participants are human-actors who perform the activities of a business process on a day-to-day basis. They conduct routine work according to the standards and guidelines of the company. Process participants are coordinated by the process owner, who is responsible to deal with non-routine aspects of the process. Process participants are also involved as domain experts during process discovery and process analysis. They support redesign activities and implementation efforts.

• **Process Analysts**. Process analysts conduct process identification, discovery (in particular modeling), analysis and redesign activities. They coordinate process implementation as well as process monitoring and controlling. They report to management and process owners and closely interact with process participants. Process analysts typically have one of two backgrounds. Process analysts concerned with organizational requirements, performance, and change management have a business background. Meanwhile, process analysts concerned with process automation have an IT background.

• **System Engineers**. System engineers are involved in process redesign and implementation. They interact with process analysts to capture system requirements. They translate requirements into a system design and they are responsible for the implementation, testing and deployment of this system. System engineers also liaise with the process owner and process participants to ensure that the developed system supports their work in an effective manner. Oftentimes, system implementation, testing and deployment are outsourced to external providers, in which case the system engineering team will at least partially consist of contractors.

• **The BPM Group** (also called BPM Centre of Excellence). Large organizations that have been engaged in BPM for several years would normally have accumulated valuable knowledge on how to plan and execute BPM projects as well as substantial amounts of process documentation. The BPM Group is responsible for preserving this knowledge and documentation and ensuring that they are used to meet the organization's strategic goals. Specifically, the BPM group is responsible for maintaining the process architecture, prioritizing process redesign projects, giving support to the process owners and process analysts, and ensuring that the process documentation is maintained in a consistent manner and that the process monitoring systems are working effectively. In other words, the BPM group is responsible for maintaining a BPM culture and ensuring that this BPM culture is supporting the strategic goals of the organization. Not all organizations have a dedicated BPM Group. BPM Groups are most common in large organizations with years of BPM experience.

3.7. Automating Business Processes

Automation is the technique of making an apparatus, a process, or a system operate automatically. However, society is already reaping the automation applications in day to day life. Automation includes the processing capability of any system. Integrating people and systems to achieve automation is not a simple matter. Human factors, especially the cognitive aspects, are often misunderstood and neglected in system design (Sheridan, 2002; Sheridan and Parasuraman, 2005). A system for generating, editing, executing, monitoring and debugging an application program for controlling an industrial automation mechanism comprising components of logic, motion and/or process control(Sadre et al., 1996). Process automation is a subject that may be approached from different perspectives. In a broad sense, it may refer to the intent to automate any probable part of procedural work that is involved within a business process, both for simple operations and complex processes.

3.7.1. Business Process Management Systems

A specific kind of process automation applies knowledge about how different process activities are related to each other. In other words, the types of information systems that we consider are process aware. The primary category of process-aware information systems is the so-called Business Process Management Systems (BPMSs). While there are other types of process-aware system, such as Customer Relationship Management (CRM) systems and Enterprise Resource Planning (ERP) systems, the special feature of BPMSs is that they exploit an explicit description of a business process, in the form of a process model, to coordinate that process. In that sense, a BPMS can be tailored to specific processes of any kind.

The purpose of a BPMS is to coordinate an automated business process in such a way that all work is done at the right time by the right resource. To explain how a BPMS accomplishes that, it is useful to see that a BPMS is in some way similar to a Database Management System (DBMS). A DBMS is a standard, off-the-shelf software package offered by many vendors in many different flavors, such as Microsoft SQL Server, IBM DB2 or Oracle Database. With a DBMS it is possible to capture company-specific data in a structured way, without ever having to consider how the exact retrieval and storage of the involved data takes place. These tasks are considered by standard facilities of the system. Obviously, it is necessary to configure the DBMS, fill it with data, and it may also be necessary to periodically update the system and its content to actual conditions.

Likewise, a BPMS is also a standard type of software system. Vendors offer different BPMSs with a alternating set of features, extending the whole process lifecycle: from simple systems only catering for the design and automation of business processes, to more complex systems also involving process intelligence functionality (e.g. advanced monitoring and process mining), complex event processing, SOA functionality and integration with third-party applications and social networks. In defiance of the variety of functionality a BPMS can offer the core feature of such a software system consists in the automation of business processes. With a BPMS it becomes achievable to support the execution of a specific business process using the standard facilities offered by the system. Anyhow, it is crucial that a business process is captured in such a way that the BPMS can deal with it. By the moment of capturing a process in a format that the BPMS can work with, it is necessary to keep that description of the business process up-to-date so that the process is supported accurately over time.

Ahead, mostly before the emergence of BPMSs, there existed a large number of tools focused on process automation, which did not encompass process intelligence functionality and which had relatively minimum support for process modeling. These tools were known under the name of Workflow Management Systems (WfMSs). Over time, many of these tools evolved towards BPMSs. Plenty of stand-alone tools exist that cover a single feature of advanced BPMSs, such as stand-alone process modeling tools, process simulation tools and process analytics tools. All these tools provide value in supporting various parts of the BPM lifecycle, but do not widely support process automation. As a result, they will not be the focus of this chapter.

3.7.2. Architecture of a BPMS

Figure 11 shows the main units of a BPMS, namely the execution engine, the process modeling tool, the worklist handler, and the administration and monitoring tools. The execution engine may interact with external services (Dumas et al., 2013).

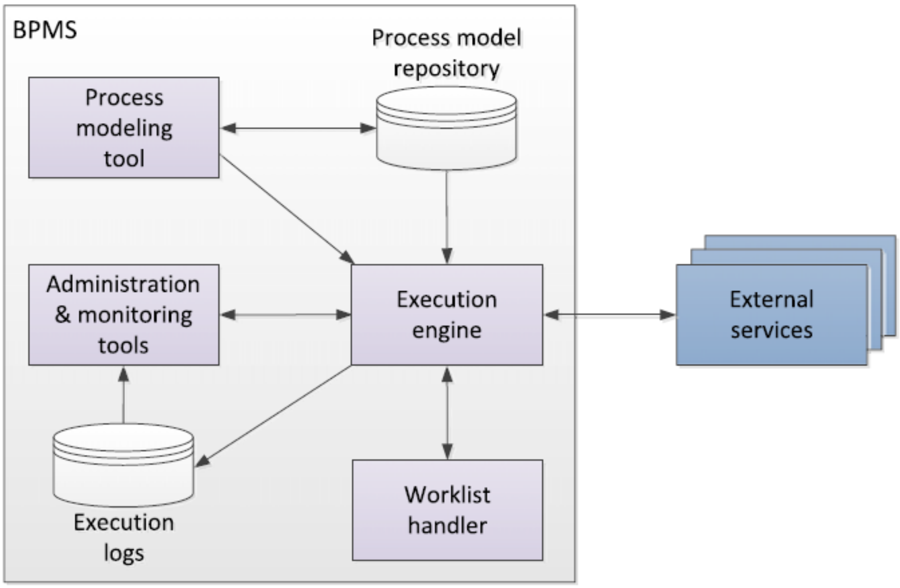


Figure 11 - The architecture of a BPMS

Execution Engine: Central to the BPMS is the execution engine. The engine provides different functionalities including the ability to create executable process instances, the ability to distribute work to process participants in order to execute end to end a business process and the ability to automatically retrieve and store data needed for the execution of the process and to delegate automated activities to software applications crosswise the organization. Collectively, the engine is monitoring continuously the progress of different cases and coordinating which activities to start next by generating work items, i.e. instances of process activities that need to be taken care of for specific cases. Work items are allocated to resources which are both adequate and authorized to carry out these. Respectively, the execution engine also interacts with the other components, as discussed next.

Process modeling tool: The process modeling tool component offers functionality such as the ability for users to create and modify process models, the ability to annotate process models with additional data, such as data input and output, participants, business rules associated with activities, or performance measures associated with a process or an activity and the ability to store, share and retrieve process models from a process model repository. A process model could be set up to the engine in order to be executed. This can either be done directly from the modeling tool or from the repository. The engine uses the process model to determine the temporal and logical order in which the activities of a process have to be executed. So it determines which work items will be generated and to whom they should be allocated or which external services should be called.

Worklist handler: A worklist handler is the component of a BPMS through which process participants are offered work items and commit to these. It is the execution engine that keeps track of which work items are due and makes them available through the worklist handlers of individual process participants. The classic worklist handler of a BPMS can easily be considered as an inbox, similar to that of an email client. Through that, participants can see what work items are ready for execution. The worklist handler can use electronic forms for an activity's input and output data. When a work item of this activity is selected and started by the participant from their worklist, the corresponding form is rendered on screen (check-out step). Then participants can enter data into the form and signal completion to the engine (check-in step). The engine eventually determines the next work items that must be executed for the specific case. Usually, participants can extent exert control over the work items in their worklist, e.g. with respect to the order in which they are displayed and the priority they assign to these work items. Furthermore, a worklist handler will sometimes support a process participant in temporarily suspending work items or passing on control to someone else. The exact features that are available depend on the BPMS request and its individual configuration. It is very frequent to customize worklist handlers, for instance according to corporate design, to feed its efficient usage and acceptance within an organization.

Administration and monitoring tools: Administration and monitoring tools are the tools that administration of all operational matters of a BPMS. Consider as a paradigm the actual availability of specific participants. If someone is unavailable to work because of illness or a vacation, the BPMS must be made aware of this fact in order to avoid allocating work items to such a participant. Administration tools are also required to deal with exceptional situations, for example to remove outdated work items from the system. Administration tools are also equipped with process monitoring functionality. One can use these tools to monitor the performance of the running business processes, in particular with respect to the progress of individual cases. These tools can aggregate data from different cases, such as average cycle times of cases, or the fraction of cases that are delivered too late. The BPMS records the execution of a process model step by step. The events that are related to execution recorded in this way are stored and can be exported in the form of execution logs. Some monitoring tools can also analyze historical data extracted from the logs and compare it with current ones.

External services: It may be advantageous to involve external applications in the execution of a business process. It is very common in business processes to be activities which are not being executed in a completely standard way. Some of these activities can be performed totally automatically, so that the execution engine can directly call an external application. The external application has to expose a service interface with which the engine can interact. As follows, we simply refer to such applications as external services. The execution engine provides the invoked service with all the necessary data that will be needed for performing the activity for a specific case. Above request's completion, the service will return the outcome to the engine and signal that the work item is completed. As regular, this is stored in the execution log. Some other activities in a business process are neither completely manual nor completely automated. Instead, such activities are being performed by process participants with some help of automated support. For this category of activities, the execution engine will invoke the appropriate services with the right parameters, directly when that the employee selects a particular work item to work on. A typical example would be the invocation of a Document Management System (DMS) to display to the process participant a file that is important to carry out a specific work item. Also sometimes, a BPMS may need to transfer control over cases between different organizational units or organizations. A possible way is by interacting with an external BPMS which exposes a service interface for this purpose.

3.7.3. WfMC Reference Model

The Workflow Management Coalition (WfMC) is a standardization organization, founded in 1993, in which BPMS vendors, users and researchers have a seat. The purpose of the WfMC is to achieve widely accepted standards for terminology and interfaces for the components of a BPMS.

The WfMC has produced the so-called WfMC reference model which has become well-established in the world of process automation. The idea behind this reference model is that any supplier of a BPMS can explain the functioning of its specific system on the basis of it. The original reference model included six components, which resemble the components of the BPMS architecture in Fig. 11. They are: workflow engine, process modeling tools, administration and monitoring tools, worklist handler, external applications and external BPMSs. In the reference model, the interactions between its components take place through so-called interfaces, which are numbered from 1 to 5:

- Interface 1 concerns the interaction between the engine and process modeling tools
- Interface 2 concerns the interaction between the engine and the worklist handler
- Interface 3 governed the interaction between IT applications and the execution engine, but this has become outdated by the advent of standard service interfaces over the Web (e.g. Web services).
- Interface 4 (which addressed the integration with external BPMSs) has also been subsumed since this can also be realized through standard service interfaces.
- Interface 5 concerns the interaction between the engine and the administration and monitoring tools

While most components of the WfMC reference model reappear in the BPMS architecture of Fig. 11, it should be noted that the WfMC architecture does not include the process model repository and does not explicitly represent execution logs. These elements, however, have become crucial assets in the area of process automation, analysis and redesign.

3.7.4. Types of BPMS

There are several ways to distinguish between the available BPMSs. One classification is based on the use of two axes: one that captures the degree of support that the BPMS delivers and the other that expresses how those systems differ from each other with respect to their orientation on process or data. We describe and illustrate four different types of system: groupware systems, adhoc workflow systems, production workflow systems, and case handling systems. These systems can be positioned in the spectrum of BPMSs as shown in Fig. 12.

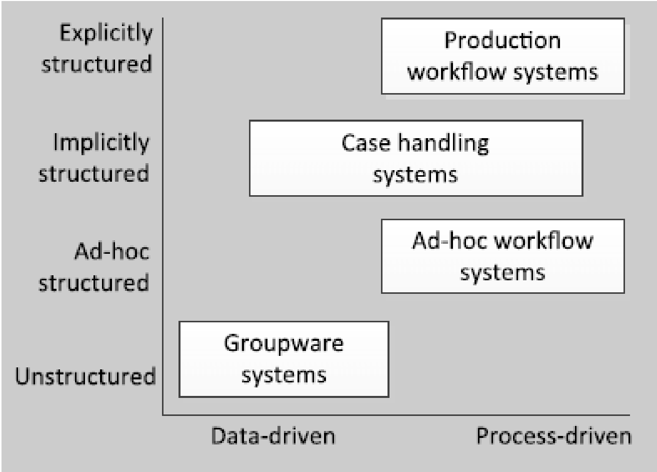


Figure 12 - The spectrum of BPMS types

3.7.5. Flexible System Integration

Originally, the most voiced argument to start with a BPMS is the increased flexibility that organizations achieve with this technology. To explain this best, a short reflection on the history of computer applications is due. There is an interesting trend, that generic functionality is split off from applications at some point (vanderAalst and vanHee, 2004). Roughly throughout the period 1965–1975, computer applications were run directly on the operating systems (OS) of a computer. Each application would take care of its own data management and would be using proprietary techniques to do this efficiently. As a result, it turned out to be difficult to share data among applications and to maintain consistency. Clearly, programmers of different applications would be involved with developing similar routines to solve similar problems. From 1975 onwards, DBMSs as a new type of standard software emerged that took on the generic task of managing data efficiently. As a result, data could be shared rather easily and programmers of new applications would not need to worry anymore about ways to store, query, or retrieve date. Some 10 years later, around 1985, User Interface Management Systems (UIMS) were introduced to provide a very generic interface component to many applications. Through the provision of facilities like drop-down boxes or radio buttons in accessible libraries, each computer programmer would be able to make use of these. By 1995, the first commercial BPMSs enter the market place (considerable time before, research prototypes have been available). Like DBMSs and UIMSs in their focus area, BPMSs would provide generic support for the area of business process logic.

The preface of a BPMS is a logical sequel to the segregation of generic functionality of what were one monolithic computer programs. Even in the 1990s, it was estimated that 40% of all the lines of code running on the mainframe computers of banks would have to do with business process logic, not with the calculations or data processing themselves. The typical kind of information processing in the context relates to the identification of activities, their order of execution, and or the participants responsible for carrying them out. For example, it would be specified that after a mortgage offering was completed, this needed to be signaled to the manager of the department, triggering a signal on her monitor.

The clear advantage related to this development is that it has become a lot easier with a BPMS to manage business process logic on its own. This is because of the fact that it is much more convenient to update the description of a business process without having to review the application code. Additionally, the reverse would become easier, i.e. modifying an application while not touching on the order of how things on the business process level would need to unfold. Shortly, BPMSs would enable organizations to become much more flexible in managing and updating their business processes as well as their applications. BPMSs also provide the means to glue together separate systems. Large service organizations typically deploy myriads of IT systems, which all exist more or less independent of each other. Often, such a situation is referred to as island automation.

A BPMS will safeguard that all the independent systems will act in the business process they support. A word of caution is due here. The BPMS itself will not offer any direct solution to the problem that there is often an unnecessary storage of information across many different IT systems. In fact, a BPMS will overall have no knowledge of the actual data that end users will manipulate using the various IT systems. If the BPMS is to operate as integrator between all the existing systems, this will require a thorough information analysis to map which data is used and available.

3.8. Turning Process Executable

In this section we will provide how to automate a business-oriented process model in order to execute it on a BPMS. Particularly, we will consider the case of production BPMSs. Mapping processes for automation requires an approach to process modeling that is quite different from what is needed for communication or analytically focused process models. In fact, because of their intent, business-oriented process models are not necessarily strict, so they may contain ambiguities. Conversely, executable process models must be precise specifications in order to be interpreted by a BPMS. A five-step method is proposed to incrementally transform a business-oriented process model into an executable one, as follows:

1. Identify the automation boundaries

2. Review manual tasks

3. Complete the process model

4. Bring the process model to an adequate granularity level

5. Specify execution properties

Through those steps, the business-oriented model will become less abstract and more IT-oriented. These steps should be carried out on a process model that is both correct in terms of structure and behavior. For instance, if the model contains behavioral errors like a deadlock, the BPMS may get stuck while executing an instance of this process model, with a potential impact on the operations of the organization. From now on we assume that the process model is correct.

3.8.1. Execution Properties

By giving a closer look at the last step, we need to specify how each model element is effectively implemented by the BPMS. For example, take the first service task of a simple example: “Check balance availability”. Saying this task requires the purchase order as input to contact the Deposit system is not enough. We need to specify the service provided by the Deposit system to check amount levels and its holds and the information produced by the service (i.e. the format of the output object). These implementation details are called execution properties. More, specifically, these are:

- Process variables, messages, signals and errors
- Task and event variables and their mappings to process variables
- Service details for service, send and receive tasks, and for message and signal events
- Code snippets for script tasks
- Participant assignment rules and user interface structure for user tasks
- Task, event and sequence flow expressions
- BPMS-specific properties

There is not any visual representation for these properties in the BPMN diagram. Although, they are stored in the BPMN 2.0 interchange format that is a textual representation of a BPMN model in XML format. It is predetermined to support the interchange of BPMN models between tools and also to serve as input to a BPMN execution engine. BPMN modeling tools provide a graphical interface to edit most of these non-graphical properties, so mostly there is no need to write the XML directly. Still, the understanding of standard Web technology, especially XML, XML Schema (XSD) is required, in addition to the familiarity with the notion of (Web) service, to be able to implement a process model. This section assumes that you have basic knowledge of these technologies.

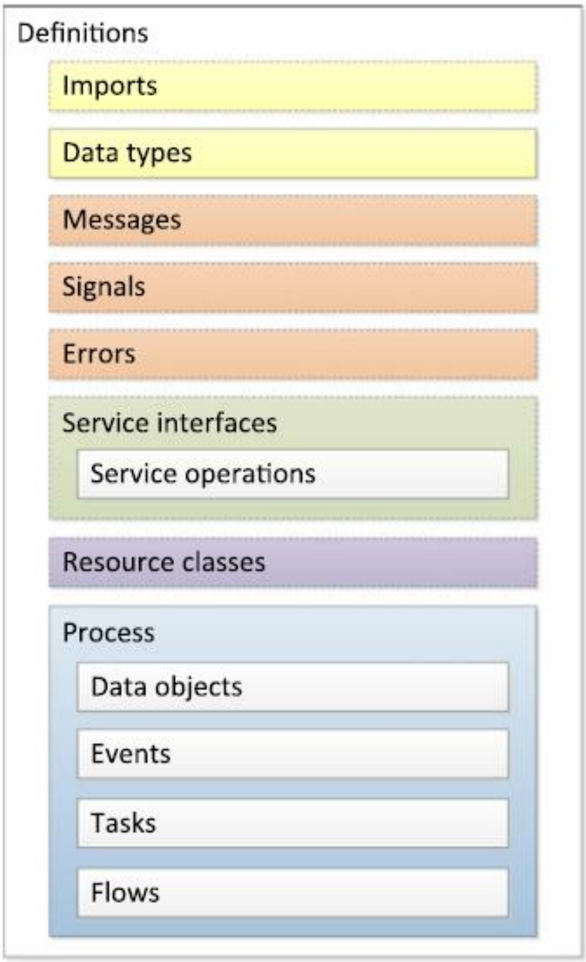


Figure 13 - Structure of the BPMN format

Figure 13 shows the structure of the BPMN format(Dumas et al., 2013). It consists of a list of elements, where some are optional and others are mandatory. The process element is mandatory and stores information about the process model. This consists of electronic data objects, events, tasks and flows. The elements outside the process are reusable components needed by the various process elements, like message definitions and service interfaces which are used by service, send and receive tasks, and by message and signal events. With reference to this structure, let us now go through each of the execution properties above.

Process Variables, Messages, Signals and Errors Process variables are managed by the BPMS engine to let data exchange between process elements. Each electronic data object represents a process variable. The lifetime of a process variable is restricted to the life of the instance in which the variable is created and is visible only to the process level in which it is defined and to all its subprocesses. That means that a variable defined in a subprocess is not visible in the parent process.

A data type needs to be assigned to each process variable in order for a BPMS to be able to interpret and manipulate these variables. In BPMN, each process variable's type is specified as an XSD type. The type of a variable can be simple or complex. Simple types are strings, integers, doubles (numbers containing decimals), booleans, dates, times, etc., and are already defined in the XSD specification. For instance, the object Stock availability can be represented as a process variable of type integer (representing the number of available units of a product). Complex types are hierarchical compositions of other types. A complex type can be used for example to represent a business document, such as a purchase order or an invoice.

Furthermore, an error code must me assigned to each error. This code must be unique and identify an error within the process model, so that a catching error event can be related to a throwing error event.

Task and Event Variables Apart from the above data elements, we need to define the internal variables of each task, called data inputs and data outputs in BPMN. Data inputs and outputs act as interfaces between a task and its input and output data objects. They also need to refer to an XSD type defining their structure, but different from process variables, they are only visible within the task (or sub-process) in which they are defined. Data inputs capture all the data that are required by the task to be executed and also data outputs capture data that is produced by the task upon completion.

Thus, data inputs are populated with the content of input data objects while data outputs are used to populate the content of output data objects. For instance, we need a data input for task “Check balance availability” in order to store the content of the purchase order. Thus, the type of this data input should match that of the input object, i.e. purchaseType. Likewise, the data output must be of type numeric to store the amount of available balance, so that this information can be copied into stock availability upon task completion.

The mapping between data objects and task data inputs/outputs is defined via the task data associations. Data associations are also used to define complex data assignments beyond one-to-one mappings. For instance, consider task “Manufacture product”. The service invoked by this task requires only the order product id and quantity in order to start the manufacturing of the product. Hence, we can use a data association to extract the product id and quantity from the input purchase order, and populate a data input containing two sub-elements of types string, respectively, integer. Mostly, the BPMS will automatically create all the exhausting data mappings between data objects and tasks.

Similar to tasks, events that transmit or receive data also have internal variables. Specifically, the catching version of these events has one data output only, to store the content of the event being caught, whereas the throwing version has one data input only, to store the content of the event being thrown. Therefore, we also need to assign these data inputs and outputs a type that has to match that of the message, signal or error associated with the event. For instance, the start catching message event “Purchase order received” in the order fulfillment example uses a data output to store the purchase order message once this has been received. Thus, this data output must match the type of the incoming message, which is precisely purchaseType. In turn, the output object must have the same type as the output data, to contain the purchase order. The complex types for all data elements of the process can be defined directly in the BPMN model or imported from an external document.

Service Tasks As the types of all data elements are defined and task and event data inputs and outputs to these types are marked, how tasks and events have to be implemented should be designed. For service tasks we need to specify how to communicate with the external application that will execute the task. Be it a complex system or a simple application, from the perspective of the BPMS all that is required is that the external application provides a service interface that the service task can use. A service interface contains one or more service operations, each describing a particular way of interacting with a given service. For instance, a service that retrieves inventory information provides two operations: to check the current stock levels and to check the stock forecast for a given product. An operation can either be in-out or in-only. In an in-out operation (also called synchronous operation), the service expects a request message and replies with a response message once the operation has been completed, or optionally with an error message if something goes wrong. For example, the service invoked by task "Check balance availability" receives an account's number as input message and replies with an amount as output message. Alternatively, if the service experiences an exception, it replies with an error message which triggers the boundary error event of this task so that the relative exception handler can be performed. Conversely, in an in-only operation (also called asynchronous operation), the service expects a request message but will not reply with a response message.

Every message of a service operation needs to reference a message in the BPMN model, so that it can be assigned a data type. For example, the request and the response messages to interact with the inventory service have data type purchaseType, respectively, XSD integer. For each interface, we also need to specify how this is concretely implemented, i.e. what communication protocols are used by the service and where the service is located in the network. By default, BPMN uses Web service technology to implement service interfaces, and relies on WSDL 2.0 to specify this information. In practice, this corresponds to defining one or more external WSDL documents and importing them into our BPMN model (Chinosi and Trombetta, 2012). Once again, other implementations are possible, e.g. one could implement a service interface via Java remote procedure call or plain XML over HTTP.

Send and Receive Tasks, Message and Signal Events Send and receive tasks work similarly. A "send" task is a specific case of the service task as it sends a message to an external service using its data input, but it receives no response. An example task is "Notify incorrect PIN". A "receive" task waits for an incoming message and uses its data output to store the message content. Task "Insert PIN" is an example of this. Both task types need to reference an in-only service operation where the message is defined. However the message being received is seen as a request coming from an external service requester. Thus, in this case the process itself acts as the service provider.

A "receive" task can also be used to receive the response of an asynchronous service which has previously been invoked with a send task (Dumas et al., 2013). This is the case of tasks "Request new PIN" and "Get new PIN". The asynchronous service is provided by the customer. Consequently, in the send task the seller's process acts as the service requester sending a request message to the customer. In the receive task the roles get swapped, as a result the seller acts as the service provider to receive the response message from the customer. This pattern is used for long-running interactions, where the response may arrive after a while. The defect of using a synchronous service task in place of a send-receive is that this task would block the process to wait for the response message. Message and signal events work exactly like send and receive tasks. For signal events, it is assumed that the service being contacted has published-subscribed capabilities, e.g. a Web service for subscribing to RSS feeds.

Script Tasks For script tasks, we need to provide the snippet of code that will be executed by the BPMS. This code can be written in a programming language such as JavaScript or Groovy. BPMN does not define the use of a specific programming language so the choice depends on the BPMS used. The task data inputs store the parameters for invoking the script while the data outputs store the results of executing the script. For instance, for task "Debit foreign currency commission" we can define a script that extracts transaction amount and the currency from two data inputs mapped to the input objects, uses this information to compute a commission of 0.02% for each euro spent, and copies this value to the data output.

User Tasks For each user task we need to specify the rules for assigning work items of this task to process participants at runtime, the technology to communicate with participants and the details of the user interface to use. Furthermore we need once more to define data inputs to pass information to the participant, and data outputs to receive the results.

Process participants that can be assigned user tasks are called potential owners in BPMN. A potential owner is a member of a resource pool. In the context of user tasks, a resource pool identifies a static list of participants sharing certain characteristics, e.g. belonging to the same department or unit. An example of resource class for the order fulfillment process is order clerk, which groups all participants holding this role within the sales department of the seller organization. Note that these resource classes are unrelated to pools and lanes, which are only notational elements in a business-oriented process model. A resource pool can be further characterized by one or more resource parameters, where a parameter has a name and a data type. For instance, we can specify two parameters product and region of type string to indicate the particular products that an order clerk deals with along with the region they work in. As we have defined all required resource pools and optionally their parameters, each user can be assigned task to one or more resource pools based on an expression.

It is also needed to be specified the implementation technology used to offer the work item to the selected participants. This requires aspects such as the channel to reach the participant, how to render the content of the task data inputs on screen (e.g. via one or more web forms organized through a particular screen flow), and the strategy to assign the work item to a single participant out of those satisfying the assignment expression (e.g. assign it to the order clerk with the shortest queue or randomly). The configuration of these aspects, as well as the association of participants to resource pools is dependent on the specific BPMS being used.

Task, Event and Sequence Flow Expressions Finally, expressions needs to be written for the various attributes of tasks and events and for the sequence flows bearing conditions. For example, in a loop task we need to write boolean expressions that implements the textual annotation indicating the loop condition (e.g. “until response approved”). This boolean expression will determine when will the loop task be repeated. This expression can be defined over data elements. Instance attributes can also be used inside these expressions. These are variables that vary by instance at execution. An example is loop count, which counts the number of iterations for a loop task. For the timer event we need to specify an expression to capture the temporal event informally expressed by its label. There are three options: we can either provide a temporal expression in the form of a precise date or time, a relative duration, or a repeating interval. Once again, these expressions can be linked to data elements and instance properties so as to be resolved dynamically at execution. For instance, we can set an order confirmation timeout based on the number of line items in an order.

At last, a boolean expression also needs be written in order to capture the condition attached to each sequence flow following an (X)OR-split. For instance, condition “product in stock” after the first XOR-split in the order fulfillment example can be implemented as an XPATH expression that checks whether the value of variable stock availability is at least equal to the product quantity contained in the purchase order. There is not any need to assign an expression to a default sequence flow, since this arc will be taken by the BPMS engine if the expressions assigned to all other arcs emanating from the same (X)OR-split evaluate to false.

BPMS-Specific Properties Rigorously speaking, the only BPMS-specific properties that needs configuration in order to make a process model executable are those of user tasks. In practice, we will presumably need to connect our executable process with the enterprise system of our organization. This is called system binding. Fortunately, BPMSs offer a variety of predefined service task extensions, called service adapters (or service connectors), to implement regular system binding functions in a convenient way. Examples of such binding functions include: performing a database lookup, sending an email notification, reading or writing a file and adding a customer in a CRM system. Each adapter comes with a list of parameters that requires configuration. Anyhow, BPMSs provide wizards with capabilities to discover automatically some of the parameter values. For example, to use a database lookup we need to provide the type of the database server (e.g. Microsoft SQL Server, Oracle DB) and the connection string where the server can be reached, the schema to be accessed, the SQL query to run and the credentials of the authorized user to run the query. Instead of implementing task “Check balance availability” as a service task, we could implement this task with a generic database lookup adapter, provided we know what to search for and where. Similarly, we could implement the tasks for communicating with the customer like “Expired Documents Notification” as email adapters, so that we do not need to implement a dedicated email service in our organization. The number and variety of adapters that a BPMS provides largely contribute to increasing the value of the product over competing solutions.

3.8.2. Exceptions

A process' execution does not always have the wishing results and the root causes of these abnormal executions are the exceptions. Exceptions are events that deviate a process from its normal course, or more specific from what is commonly known as the "sunny-day" scenario. These "rainy-day" situations happen frequently in reality, and as such they should be modeled when the objective is to identify all possible causes of problems in a given process. Exceptions include business faults like an exception due to balance unavailability, and technology faults like a network outage, a database crash or a program logic violation. They deviate the normal process course since they possibly cause the interruption or abortion of the running process.

3.9. Business Intelligence

It is a central concept of BPM that processes are explicitly defined, then executed, and that information about process execution is prepared and analyzed. To this extend, this information provides a feedback loop on how the process could be redesigned. Data about the execution of processes can arise from BPMSs in which processes are specified, asides from systems that do not work with a clear process model, for example ERP systems. Data from those systems have to be transformed to meet the requirements of intelligent process execution analysis. This field is widely known as process mining. This chapter deals with intelligently using the data generated from the execution of the process. We refer to such data as event logs, covering what has been done when by who in relation to which process instance. First of all, we investigate event logs' structure, their relationship to process models and their usefulness for process monitoring and controlling.

Earlier, we investigated how a process model can be specified in such way that a BPMS can support its execution. Both process participants and owners are involved in the execution of business processes. Though, their perspective is quite distant. Process participants work on tasks that produce execution data as a side product. These data are named event logs. Process owners are particularly interested in drawing conclusions from such event logs.

<u>What is the actual process model?</u>

Automatic process discovery is concerned with the question of how a process actually works in reality. Event logs are used as an input process discovery that is based in evidences. Automatic process discovery utilizes event logs for the generation of a corresponding process model. By doing this, event logs are valuable to find a process model where no model existed before, and to adjust an existing model according to how the process really works.

<u>What is the performance of the process?</u>

Process analyses like flow analysis suffer from the fact that the average cycle time for each task in the process model has to be estimated. Additionally, often strong assumptions are required such that the behavior of the process will not be influenced by the load. Using event logs, we are able to observe the actual behavior of a process and compare it with insights from process analysis. Moreover, historic information about process execution can be leveraged for making operational decisions.

To which extent are the rules of the process model followed?

Compliance checking is a collection of techniques that analyze a set of event logs with a set of constraints or an existing process model. There are cases when process models are defined, but they are not rigorously enforced by a corresponding BPMS. In these cases, compliance checking can be applied in order to determine how often the process is executed as expected and otherwise at which stages deviations can be found. Event logs help to understand either where the model needs to be corrected or where the behavior of the participants working in the process has to be adapted.

The process owner can use event logs as input to two different control mechanisms: on an aggregated level and on an instance level. The mechanisms are called process controlling and process monitoring, respectively.

Process Controlling deals with the analysis of historic process execution. The inputs for process controlling are event logs that are related to a particular period of time. Process controlling provides insights into whether the general objectives of a process have been met and whether the KPIs are in line. Typically, process controlling is an offline activity, which involves logs of completed process executions.

Process Monitoring is concerned with the quality of currently running process instances. Event logs of individual process instances or situations are the inputs for process monitoring. As Dumas stated, process monitoring deals with objectives and rules that are formulated for these individual cases and triggers counteractions when these rules are violated, for instance when a customer request is not responded in time. In general, process monitoring is an online continuous activity which engages events of presently running instances. Both process monitoring and process controlling have an important role in aligning the process with its overall business objectives. In that aspect, they are closely related to ideas of quality management and the Plan-do-check-act (PDCA) cycle. PDCA can be considered as an influence for the concept of BPM. Process monitoring and controlling examine the data from executing processes (do) such that redesign measures (act) can be taken to realign the execution with the objectives (plan). All these conceptions have influenced the idea of a process compartment as a software tool where data on the execution of processes is provided online using charts and appropriate visualization. Regularly, these tools are also named Business Activity Monitoring (BAM) tools or Process Performance Measurement (PPM) tools.

The starting point for process intelligence is the availability of event logs and data on the execution of processes. These data provides the basis for process monitoring and process controlling. Such event logs have to refer to a specific case, a task and a point in time in order to simplify process-related analysis. Commonly, it is a challenge to extract data in such a way that it can readily support process intelligence.

An extensive area of process intelligence is automatic process discovery. Interrelated techniques like the α-algorithm yield process models representing how a process runs actually according to the log data. The α-algorithm is a good example for how automatic process discovery works. However, there are some limitations in terms of durability, which are addressed by more recent process mining algorithms. Event logs also support the assessment of the performance of a process. We discussed the four dimensions of the Devil's Quadrangle. The time dimension of a process can be visualized as a dotted chart and further inspected using a timeline chart. Then, we demonstrated that the calculation of costs for a process heavily depends upon the level of detail with which execution times of tasks are captured. We turned to quality and related it to the number of repetitions that are encountered in a log. Finally, we discussed ways of quantifying the flexibility of a process based on the number of distinct executions, optionality and discovered decision points. The area of conformance checking can be related to various types of constraint. There are various types of constraints that can be checked for control flow including mandatoriness, exclusiveness and ordering of activities. Fitness' notion can be determined based on reproducing the logs in a normalized process model. After all, as H. James Harrington famously said: "If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it."

3.10. Process Models

3.10.1. Orchestration

Business process models specify the activities, with their relationships, that are performed within a single organization. Service orchestration represents a single centralized executable business process (the orchestrator) that coordinates the interaction among different services. Orchestration models imply a single coordinating point of view. An orchestration Process describes a process within a single business entity. An orchestration is contained within a Pool and normally has a well-formed context. The orchestrator is responsible for invoking and combining the services.

The relationships between all the participating services are described by a single endpoint (i.e., the composite service). The orchestration includes the management of transactions between individual services. Orchestration employs a centralized approach for service composition.

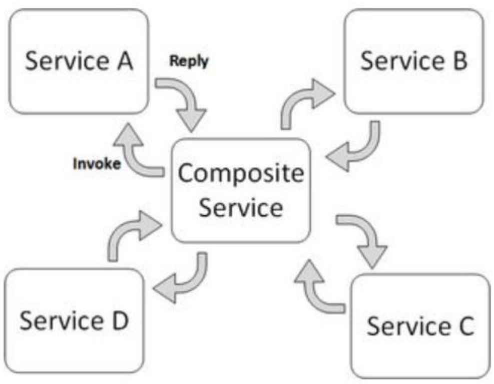


Figure 14 - Orchestration

3.10.2. Choreography

Dependencies do not exist only between activities of the same process orchestration, but also between activities of different process orchestrations. This is the case if they participate in a business-to-business collaboration (Weske, 2012). To realize these collaborations, process orchestrations interact with each other, typically by sending and receiving messages.

Service choreography is a global description of the participating services, which is defined by exchange of messages, rules of interaction and agreements between two or more endpoints. Choreography employs a decentralized approach for service composition. The choreography describes the interactions between multiple services, whereas orchestration represents control from one party's perspective. This means that choreography differs from an orchestration with respect to where the logic that controls the interactions between the services involved should reside.

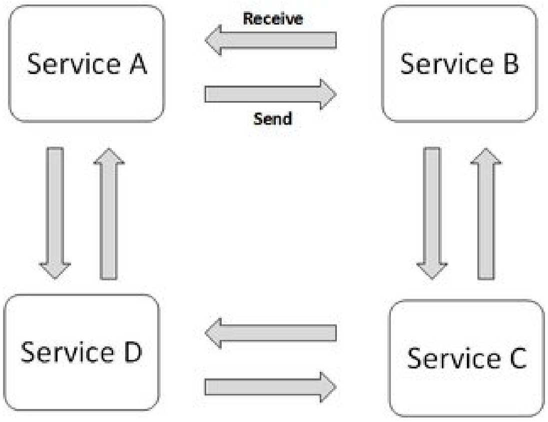


Figure 15 - Choreography

In today's business scenarios, companies increasingly join forces to combine their services and products to provide added-value products to the market. These products are typically realized by business processes, which in many cases take advantage of the existing software infrastructures of the participating companies.

Because business-to-business collaborations are quite complex and any failure in the collaboration might have an immediate effect on the operational business of the company, the cooperation between companies should be designed very carefully. Process choreographies can be used for this endeavor. The requirements of process choreography development depend on the number of interacting partners and the desired level of automation. In business environments, where the cooperation of business partners is realized through traditional means like fax messages being sent and read and understood by humans, where humans can pick up the phone and settle any ambiguities, detailed and formal process choreographies are not essential. However, if the cooperation is to be realized (at least in part) by information systems, so that a high level of automation is achieved, there need to be unambiguous models that specify in detail the nature of the collaboration of business partners in the context of a process choreography.

The design of process choreographies involves a series of activities. In each of these activities, artifacts are developed. These activities are described as follows:

1. High-level Structure Design: In high-level choreography design, the participant roles as well as their communication structures are identified. High-level structure design is conducted during the Participant identification phase.

2. High-level Behavioral Design: High-level behavioral models specify the milestones of the collaboration and the order in which the milestones are reached. High-level behavioral design is done during the milestone definition phase.

3. Collaboration Scenarios: High-level choreographies are refined by introducing dedicated collaboration scenarios that relate the reaching of milestones to the communication between process participants. Collaboration scenarios are developed during the choreography definition phase, based on the scenarios informally specified during scenario modeling.

4. Behavioral Interfaces: From these collaboration scenarios, for each participant role, a behavioral interface is derived.

3.11. Summary

This chapter examined the basic aspects regarding business process management. As mentioned at chapter 1, this research attempts to introduce fields that an organization can be benefited by RPA application. In order to apply RPA to a process first we needed to identify how this solution is going to be applied and what are the wishing results that are expected. The execution properties and the exceptions that are described at section 'Turning Process Executable' are considered more than enough in order to army RPA with all the needed information. Finally the importance of automation, as described at section 'Automating Business Process', enhances the motivation to continue our research and try to solve the technical automation challenge by our first proposed technology.

4. The Emergence of Robotic Process Automation

This chapter is going to introduce Robotic Process Automation software by focusing on the capabilities that are created after analyzing the generated data from process execution at the previous chapter. Furthermore, the literature survey within this research focuses on the benefits and risks that organizations should be aware of.

4.1. Fundamentals

Visions and missions are very exciting to be discussed. But the real hitch lies in getting them executed “successfully.” Similarly, there are various valid reasons to implement business process automation in BPM, which would ultimately redeem things thereby making the efforts constructive. On the flip side, automating the business processes would thrive only when it is done in the way it should be.

The most common Business Process Management approach is to identify and automate ideal working practices of the company or industry, the so-called “best practices”. Once best practices have been captured process excellence teams then disseminate them as work standards throughout the company. This happens through so-called “super-users” that are trained to find their ways through the enterprise system and calm down their colleagues. The ideal is a maximum degree of automation and a minimal degree of manual handling of employees.

When an organization decides to automate its business processes, it’s quite natural to want to automate all the processes in a go. Nevertheless, that could be deadly to your automation efforts. During the first time, only very little about automation are known. Hence, “it is ideal to pick lightweight processes like travel expense approval, reimbursement approval etc. as opposed to mission-critical ones, in order to test the impact of automation, identify the roadblocks and arrive at the potential solutions to dispense with the problems”. After unveiling the pros and cons of automation, the organization may gradually automate the mission-critical and customer-centric processes. Another important tip to choose the first process prudently is to avoid picking a process that requires human intervention.

“Automation is not a one-time process but an ongoing one”. Without continuous monitoring of the results that automation brings to your organization, it’s impossible to improve the efficiency of the process. It is the responsibility of the process owner to persistently gauge the performance of automation and make continuous amendments to get the best out of it. Usually, it is difficult to measure the process because their data is vaguer. But if it is determined what specific types of data want to look at, then the key performance indicators (KPIs) can be used to break them down and make continuous improvements. The “Monitor and optimize” approach is pivotal to the success of BPM implementation. Overlooking it may leave your BPM system ineffective over a period of time.

Any initiative would achieve the desired results, only when the foundation is laid right. For an automation initiative, the kind of chosen tool is pivotal to decide the outcome. The market is teeming with BPM and automation tools, where their representatives tout their product to be the best. However, the choice of the tool that best suits the organizational needs in terms of scalability, level of capabilities, the types of users(technical or non-technical). For instance, some tools are designed to offer application development capabilities while some are built for transparency and process tracking. Also, “it is essential to choose easy-to-use software which non-technical business users can easily adopt without having to depend on expensive consultants.”

For more than 130 years, managers have been busy at work systematically trying to convert humans into robots by structuring, routinizing, and measuring work, all under the guise of organizational efficiency. The automation software that is being developed today by companies (such as Blue Prism, Celaton, UiPath, Redwood, and Automation Anywhere) enables a reversal of this process. Robots can be used to amplify and augment distinctive human strengths, enabling large economic gains and more satisfying work. However, given the widespread skepticism and fears about how many types of employment will fare in the future, managers are in a difficult spot. Media headlines such as the “Rise of the Robots: Technology and the Threat of a Jobless Future” and “A World without Work” only serve to fuel the anxiety.

Although the term “robot” connotes visions of electromechanical machines that perform human tasks, the term as it relates to service automation refers to something less threatening: software that performs the repetitive and dreary service tasks previously performed by humans so that humans can focus on more unstructured and interesting tasks. Service automation includes a variety of tools and platforms that have various capabilities. To help make sense of the landscape, we can classify the tools along a service automation continuum based on specific types of data and processes.

Robotic process automation (RPA) tools and platforms deal with structured data, rule-based processes, and **deterministic outcomes**. It is more interesting to focus on RPA area (as opposed to the more recent and more advanced automation technology known as “cognitive automation,” or CA) because this is where most companies begin their service automation journeys.

Vice President of Research at the Everest Group stated that: Robotic Process Automation is the next wave of innovation, which will change outsourcing. We already are seeing the beginnings of a race to become the top automation-enabled service provider in the industry. In time, we are likely to see an arms-race for innovation in automation tools leading to new offerings and delivery models.

RPA takes the robot out of the human. The average knowledge worker employed on a back-office process has a lot of repetitive, routine tasks that are dreary and uninteresting. RPA is a type of software that mimics the activity of a human being in carrying out a task within a process. It can do repetitive stuff more quickly, accurately, and tirelessly than humans, freeing them to do other tasks requiring human strengths such as emotional intelligence, reasoning, judgment, and interaction with the customer. There are four streams of RPA(Lacity and Willlcocks, 2016). The first is highly customized software that will work only with certain types of process in, say, accounting and finance. The more general streams I describe in terms of a three-lane motorway. The slow lane is what we call screen scraping or web scraping. A user might be collecting data, synthesizing it, and putting it into some sort of document on a desktop. You automate as much of that as possible. The second lane in terms of power is a self-development kit where a template is provided and specialist programmers design the robot. That is usually customized for a specific organization. The fast lane is enterprise/enterprise-safe software that can be scaled and is reusable.

In RPA parlance, a “robot” is equivalent to one software license. For business processes, the term RPA most commonly refers to configuring the software to do the work previously done by people. Although several service automation providers are calling their software “RPA”, RPA has three distinctive features compared to other automation tools:

<u>1. RPA is easy to configure, so developers don’t need programming skills.</u> RPA interfaces work a lot like Visio, by dragging, dropping and linking icons that represent steps in a process. As users drag and drop icons to automate a process, code is generated automatically. Business operations people with process and subject matter expertise but with no programming experience can be trained to independently automate processes within a few weeks. This distinguishes RPA from BPM solutions because BPM requires programming skills. Additionally it is lightweight in the sense that not a lot of IT involvement is needed to get it up and running. Business-operations people can learn quite quickly how to configure and apply the robots. It is lightweight also in that it only addresses the presentation layer of information systems. It does not have to address the business logic of the underlying system or the data-access layer.

<u>2. RPA software is non-invasive.</u> The second distinctive feature is that RPA technology sits on top of existing systems, without the need to create, replace or further develop expensive platforms. RPA software accesses other computer systems the way a human does through the user interface with a logon ID and password. RPA software accesses other systems through the presentation layer, so no underlying systems programming logic is touched. Furthermore, RPA products do not store any data. This distinguishes RPA from BPM solutions because BPM solutions are invasive, create new applications, and access business logic and data access layers in the IT architecture stack.

<u>3. RPA is enterprise-safe.</u> RPA is a robust platform that is designed to meet enterprise IT requirements for security, scalability, auditability, and change management. RPA robots are deployed, scheduled and monitored on centralized, interconnected IT supported infrastructure to ensure transactional integrity, compliance with enterprise security models and continuity of service in line with the enterprises’ business continuity plans. This distinguishes RPA from earlier generations of scripting and screen scraping which users locally deploy from their desktops. Screen scrapers, for example, are an older technology that recorded users as they moved fields around systems. Screen scrapers only understood that a field located in one specific position on one screen should be moved to another specific position on another screen. If the field was moved without reconfiguring the screen scraper, the technology would no longer function. In contrast, RPA software does not rely on X and Y coordinates but instead finds data fields through Html, Java Access Bridge, and surface automation for Citrix. The Head of Global Financial Services for a large Financial Services Company explained it this way: “Well I think what distinguishes RPA from scripting and screen scraping, it is a level above. I describe it as a more integrated, more holistic solution. It is basically taking the products of workflow, process mapping and super macros

putting them into a nice thin client that sits on top of your platforms and basically automates the keystrokes of an employee."

The main difference between RPA and cognitive automation is that RPA deals with simpler types of task. It takes away mainly physical tasks that do not need knowledge, understanding, or insight as these tasks that can be done by codifying rules and instructing the computer or the software to act. With cognitive automation, you impinge upon the knowledge base that a human being has and on other human attributes beyond the physical ability to do something. Cognitive automation can deal with natural language, reasoning, and judgment, with establishing context, possibly with establishing the meaning of things and providing insights. So there is a big difference between the two. In addition, whereas RPA is pretty ripe as a technology, cognitive automation is not. That is the reason that there is not a wave of powerful, cognitive automation tools appear in the market or many companies using them yet.

4.2. Capabilities

RPA bots can use the operating system applications like a human user. Bots are capable of these but please note that this is not a comprehensive list. RPA is too flexible for us to provide a full list of bot actions.

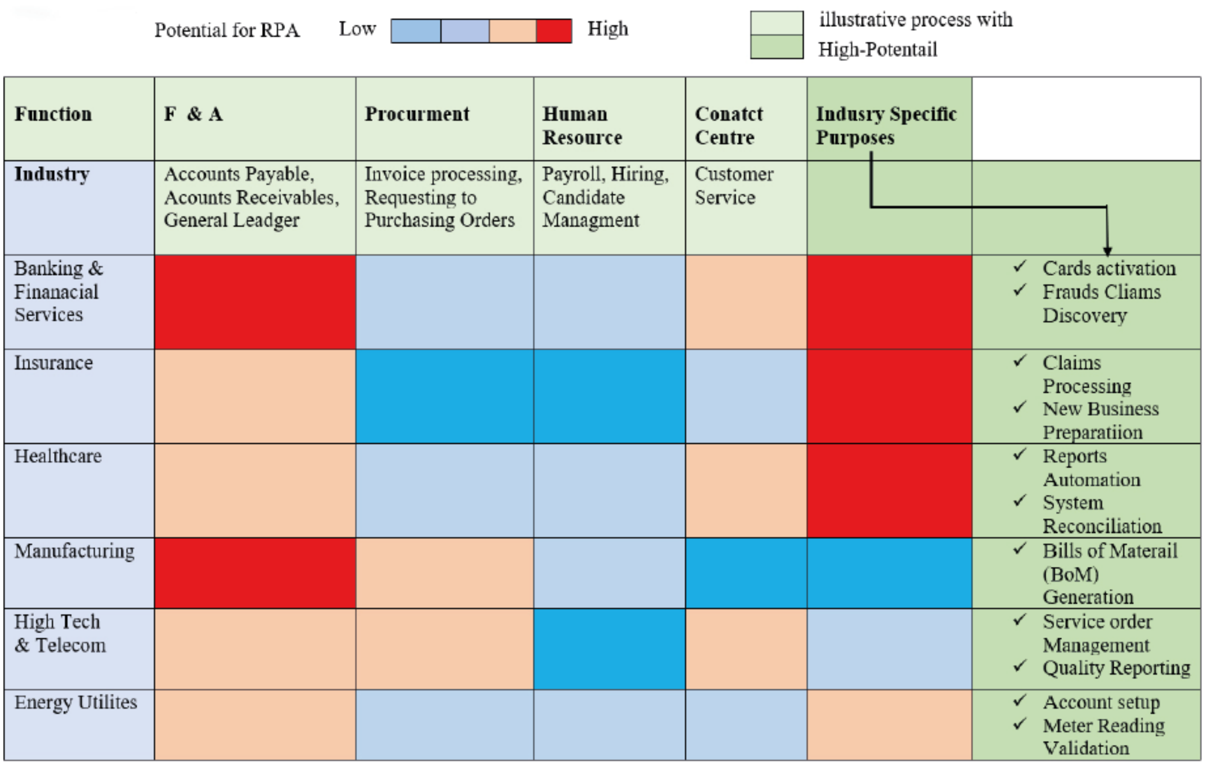


Figure 16 – Potential of RPA according to industry

- Launching and using various applications including
  - Opening emails and attachments
  - Logging into applications
  - Moving files and folders
- Integrating with enterprise tools by
  - Connecting to system APIs

    - Reading and writing to databases
- Augmenting data
    - Scraping data from the web including social media
- Data processing
    - Following logical rules such as "if/then" rules
    - Making calculations
    - Extracting data from documents
    - Inputting data to forms
    - Extracting and reformatting data into reports or dashboards
    - Merging data from multiple sources
    - Copying and pasting data

Bots can do these functions on virtualization solutions like Citrix or on Windows environment. Most vendors do not support other OS environments like Mac OS or Linux. This is because most office work is conducted on PCs.

All RPA tools can be categorized by the functionality they provide in these 3 dimensions:

- Programming options: RPA bots need to be programmed and there are a few ways to program bots which involve trade-offs between complexity of bots and programming time
- Cognitive capabilities: Programmed bots need to have cognitive capabilities to determine their actions based on inputs they gather from other systems. RPA tools provide a range of cognitive capabilities
- Usage: Bots serve specific functions. Though most RPA tools can be used to build bots that serve all these functions, some tools are more optimized for attended or unattended automation. While unattended automation is batch-like background processes, in attended automation users, for example customer service reps, invoke bots like invoking macros.

4.3. How it works

As industrial robots transformed the factory floor, RPA bots transform back offices. RPA bots replicate employee actions like opening files, inputting data, copy pasting fields in an automated way. They interact with different systems via integrations and screen scraping, allowing RPA tools to perform actions like a white-collar employee.

Bot is the unit of automation

This is the most fundamental unit and there are already free bots offering free trials or limited functionality. Robots can be run from employees' desktops or from the cloud.

Key features:

- **Integrations** are necessary for your bot to work with your enterprise applications. It is also possible for the bot to screen scrape and still perform tasks however it is more reliable to have app integration compared to screen scraping as screen scraping tends to have a higher probability of causing errors. Most bots in the market work with legacy applications (though coverage depends from vendor to vendor), web applications, desktop applications and other major enterprise software including SAP, Citrix, Java and mainframe applications.

- **Programming interfaces** are required because bots need to be programmed. RPA programming is relatively simple compared to other types of programming and there are code-free ways to program RPA bots.

Orchestration modules facilitate management of bots

Management console is needed for bots and processes. This allows us to start/stop or schedule bots and analyze bot activity. Orchestrators highlight issues that bots encounter and provide a dashboard for the processes that are managed by RPA.

Key features:

- **Business exception handling:** No matter how well programmed, your bots will run into issues with the diverse data they encounter. These exceptions need to be highlighted, managed via queues and seamlessly assigned to personnel to be resolved before they lead to any bottlenecks or delays for customers in your processes.
- **Different user access levels:** Several user access levels enable orchestrator to be used by different personnel for various functions.
- **Analytics capabilities:** Bots will be working with legacy systems uncovering a trove of data that may not be available in other analytics modules. Capabilities to run advanced analysis and combine different data sources are critical

4.4. Benefits

Forecasting possible financial and time savings are considered. Here, the indicators of Return of Investment (ROI) and Full Time Employee (FTE) are important. Researches show that the level of ROI after the first year of automation varies from 30% to 200%(Iyengar, 2016; Lhuer, 2016; Willcocks, 2016). Possible reduction of human resource number in process has a dual meaning in this context: it allows relocating financial resources to new investment. Although while evaluating the business benefits of RPA it would be wrong to look just at the short-term financial gains, particularly if those are simply a result of labor savings. That approach does not do justice to the power of the software, because there are multiple business benefits. For example, companies in highly regulated industries such as insurance and banking are finding that automation is a cheap and fast way of applying superior capability to the problem of compliance. You also get better customer service because you have more power in the process. A company that receives lots of customer inquiries, for example, can free staff to deal with the more complex questions.

Additionally, there are benefits for employees too. The technology is more than welcomed especially in cases where people hate the tasks that the machines now do and it relieved them of the rising pressure of work. This phenomenon is very usual mostly when we have to deal with bigger workloads. There is also a massive increase in audit regulation and bureaucracy. We need automation just to relieve the stress that creates in organizations. One online retailer measures the success of RPA in terms of the number of hours given back to the business. So it is not just the shareholders, the senior managers, and the customers who benefit, but also employees.

There are a lot of different cases where RPA implementation gave great impact to the companies. Some remarkable cases are below:

- **Human Error**

After releasing earnings, a multinational home mortgage funding company restated its unrealized gains by $1.2 billion due to "honest mistakes made in a spreadsheet used in the implementation of a new accounting standard." *Source: Gartner*

- **Fraud**

A global investment bank identified a macro with intentionally inappropriate linkages utilized to create fictitious transactions and depict inaccurate growth. *Source: Forrester*

- **Data Privacy error**

Forty-six percent of data privacy incidents are a result of compromised files by internal resources due to uncontrolled access to data fi les residing on shared drives. *Source: CIO World*

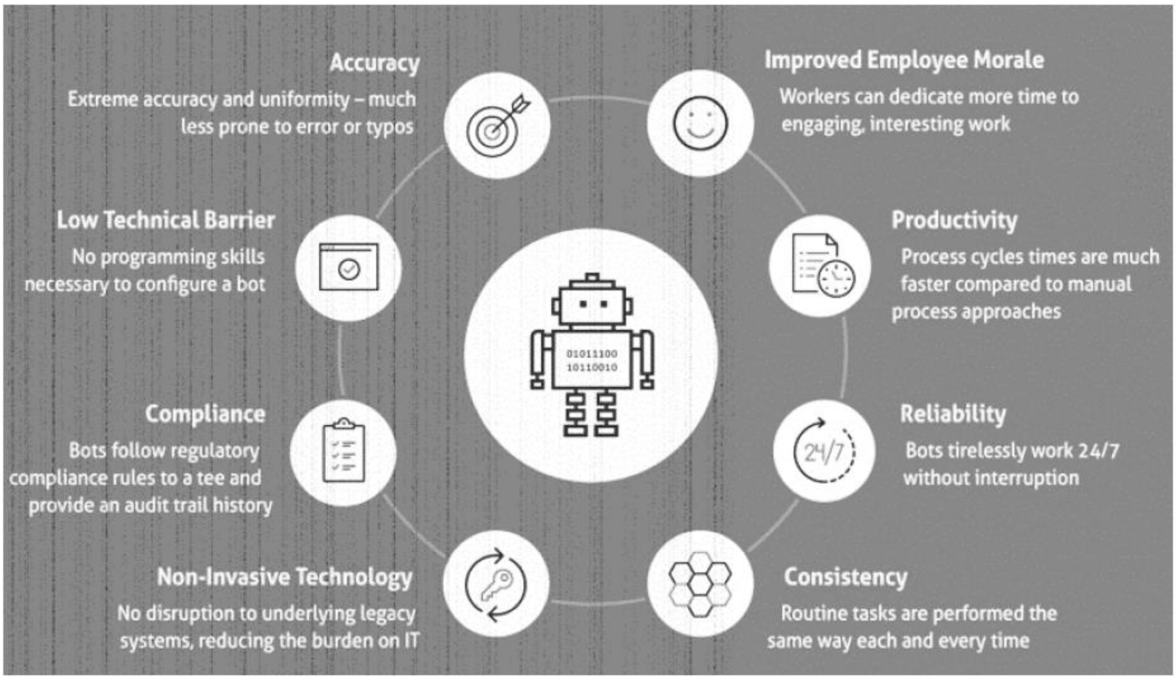


Figure 17 – Benefits of RPA

Organizations possess the luxury of hindsight to reflect on future improvements. EUC (end-user-computing) is a comparable example whereby an investment to harness risk and control up front may have minimized a perennial dilemma across the financial services industry. It is imperative for organizations to address the risks presented and consider the potential implications introduced relative to the vision, reputation and success of an organization (e.g., inaccurate financial reporting, operational losses and inefficiencies, fraud, reputational risk, consumer concern, regulatory sanctions and strategy growth limitations).

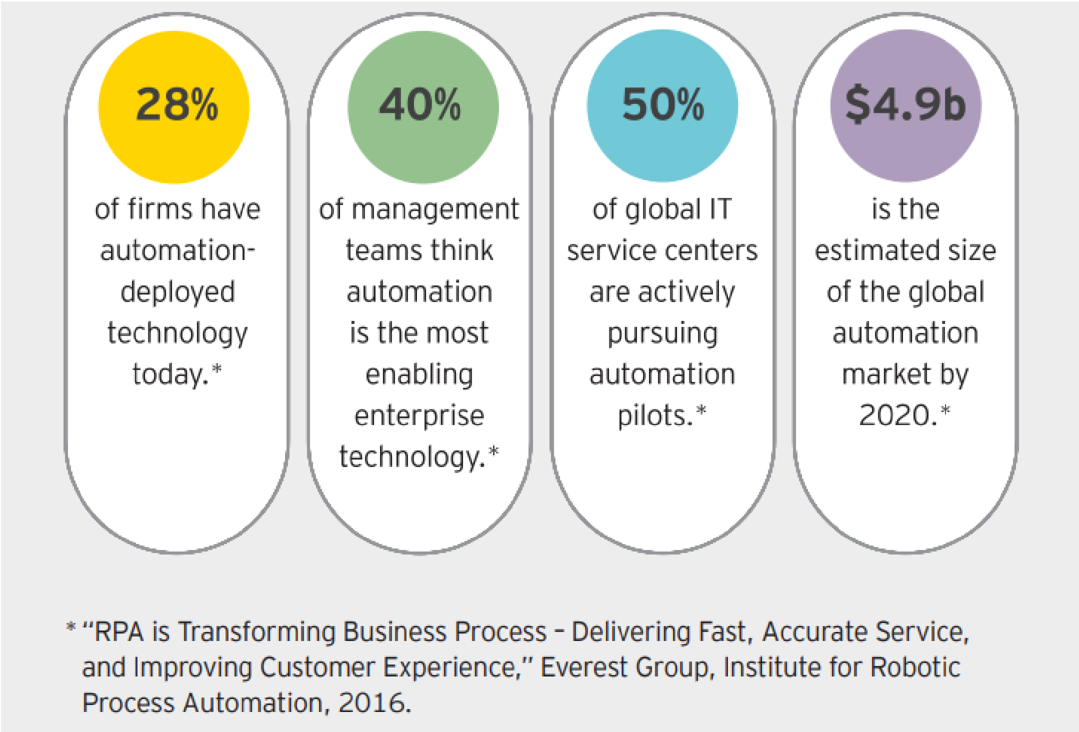


Figure 18 – Adoption of RPA in Business Processes

By integrating attended bots into the desktop workspace to automate specific tasks, organizations create an environment where robotic and human work complement each other – automatically executing repetitive, low-value tasks, and completing work far more quickly and accurately. These desktop RPA implementations also free up staff to focus on more complex, nuanced, and high-value work that is difficult to automate. The ROI is even more significant when desktop-based attended bots are leveraged as part of an overall end-to-end case automation.

4.5. Risks

As the financial services industry entertains this inflection point of puzzlement, curiosity and concern surrounding RPA across organizations, the question is no longer "if," but rather "why," "when," "how many," "where" and "how fast" robotics have been deployed. Boards, executives, committees, regulators, risk management and compliance functions, and internal audit departments are receptive to leveraging technology to reduce costs and streamline processes, yet queries have arisen about the parallel degree of focus on risk, control and compliance. Instances have also been identified whereby control consciousness has been viewed as secondary to deploying RPA and realizing business returns.

Risk mitigation remains the foundation for strong business performance, and organizational trepidation has surfaced that robotic deployments may be a new vehicle that presents both traditional risks and also introduces new, unforeseen risks. Minimally, from a risk and control perspective, organizations are tackling the following representative apprehensions with their RPA journey.

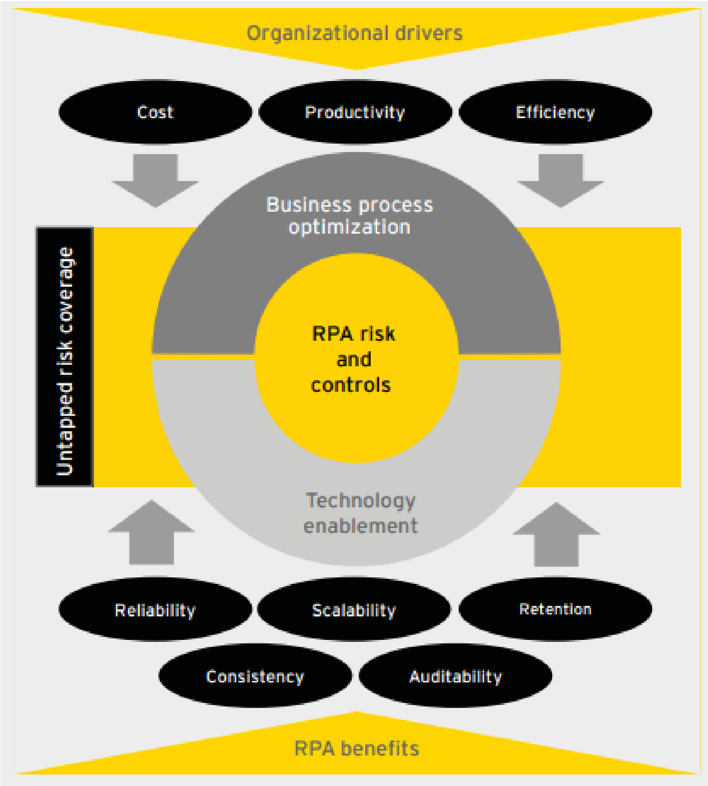


Figure 19 – RPA Risks and Controls

• **Rationalization** - Although organizational direction may be communicated with regard to RPA, anxieties exist regarding the improper usage and deployment of robotics. RPA sometimes may rightly serve in a bridge capacity, but situations have occurred whereby RPA is not the appropriate technology and was solely selected due to a speed-to-market goal. As a result, the advantages of flexibility and convenience have been a curse, and led to knowingly circumventing extensive queues within development teams and cumbersome technology controls.

• **Maintenance and operations** - Similar to an employee, robots require guidance to perform the activities desired. Although robots are configured as of a point in time based upon defined business requirements, broader architecture and system changes can severely affect the expected performance. Modified data field mappings, orphan and dangling robots, vendor upgrades, system integrations, capacity and performance monitoring, and forward compatibility considerations require attention to preserve the original intentions of the robot and manage the perceived brittleness of the application and RPA dependencies.

• **Cybersecurity and resiliency** - As robotics become mainstream, these new entrants to the IT environment represent additional vectors for compromise. Abuse of privileged access, mismanaged access entitlements and disclosure of sensitive data are valid concerns. Additionally, platform security vulnerabilities, privacy implications and denial of service may yield ramifications that impact the RPA integrity, reliability and downstream business processes.

• **Methodology and documentation** - Granted that agile development methodologies encourage improved iterative communication and coordination between key stakeholders, adherence to documentation standards should be a staple of this approach to support the risk and control mindset. Although business functionalities may be delivered more timely and accurately, the traceability of artifacts related to RPA decisions often is absent, and even an afterthought.

Potential RPA adopters will need to verify that the tool they are considering meet these three distinctive features. A number of advisors have reported evidence of “RPA washing”. The terms “RPA washing” refers to the phenomenon of companies spending more resources on advertising and marketing claiming to have new RPA capabilities than actually building new automation capabilities. Derek Toone, Managing Director of Robotic Process Automation Alsbridge, said “RPA washing absolutely occurs – not only from the software vendors, but also the outsourcing providers. Old tools being paraded under a new banner – sometimes they’ve at least been updated to mimic RPA functionality but even so they’ve yet to be tested and refined over hundreds of implementations.”

Finally, Robotic Process Automation is an emerging form of business process automation technology based on the notion of software robots or artificial intelligence workers(Howell et al., 2016; Torlone et al., 2016). They rightly pointed out that the Robotic Process Automation is coming in reality from pilot projects. Hence the organizations need to define their own RPA models to increase the operational efficiency and reduce the cost. These authors mean to say that the RPA operational models vary from companies to companies and industry to industry. In their opinion, the Robotic Process Automation operating models are not “one-size-fits-all”.

Regardless of an employee’s role within an organization, it is widely appreciated that regulatory, financial and reputational risk management are simply “good business.” Automation agendas are exciting and groundbreaking, yet they require an effective challenge from a risk management perspective to proactively protect organizations. As robots extract, aggregate, transform and upload data, risk and control considerations become paramount discussion topics.

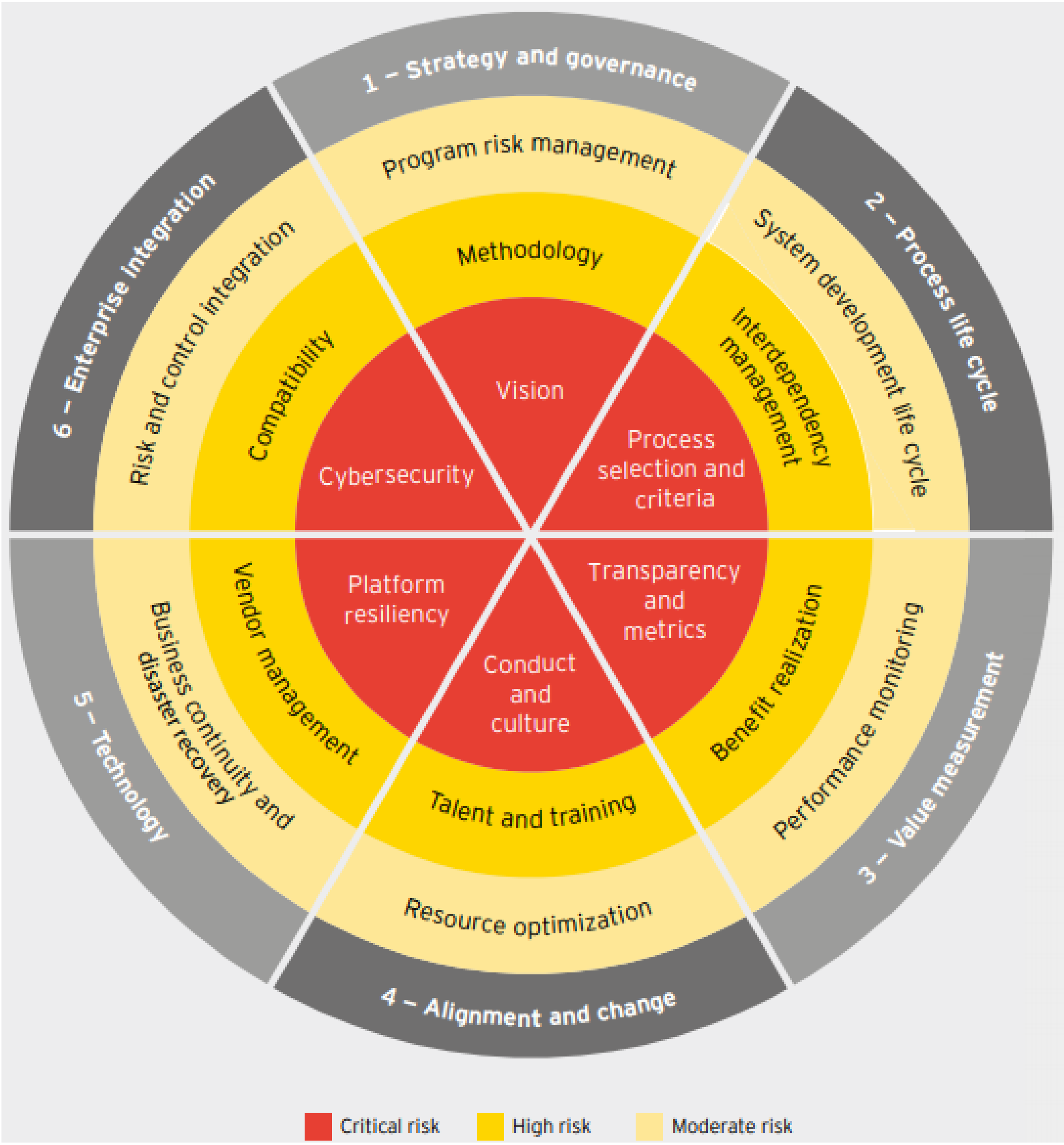


Figure 20 - Most dangerous areas for RPA

At 2017 a Deloitte's survey of 400 global firms found that 63 percent of surveyed organizations did not meet delivery deadlines for RPA projects. For the ones that succeeded, longer-than-anticipated bot implementations delayed return on investment (ROI). And an EY study found 30 to 50 percent of initial RPA projects fail.

Yet, we're seeing expectations for RPA spending increase nearly 60 percent over last year, with no signs of slowing down. The narrative being pushed is RPA technology can automate and transform every aspect of every business. This enthusiasm for RPA has even spilled into the investment market, leading firms to make investments based on what I believe are unrealistic valuations. The industry needs a reality check to better understand where and how RPA can best add value and plan accordingly.

The challenge in using robotics effectively comes from the misuse of the "P," or "Process," in "Robotic Process Automation." In fact, most bots are designed to automate tasks, a far cry from redesigning and automating the end-to-end business processes that are at the heart of real transformation. Used appropriately, RPA can be a very useful tool in a strategic transformation initiative. But if approached incorrectly, they can perpetuate legacy system problems.

RPA goes wrong when organizations that have been promised significant savings by using lots of bots to try to automate as much as possible, including increasingly complex operational processes. Most bots are designed to automate tasks – they won't address the transformational need to optimize or redesign processes for the digital world. And they can't deliver meaningful digital transformation on their own.

Business leaders that have high hopes for huge returns from massive RPA process implementations are frequently disappointed. Problems arise when organizations mistake tasks for processes, and either vastly underestimates the complexity of the processes they're trying to automate or the time it takes to fully integrate and automate unattended bots. The result can be delayed or abandoned projects.

Poorly planned RPA implementations can create an additional problem. Unattended RPA can become another silo – another group of disconnected legacy apps in the IT stack that fragment workflow and processes. Plus, when bots are designed with custom-built logic, it makes them difficult to modify and scale. Lacking the benefit of centralized rules management and orchestration, they inevitably become elaborate, siloed, background batch processors.

RPA can't fix bad processes – it just speeds them up. When a business try to use unattended RPA to remedy poor processes, not only is the process not improved, but the resulting errors and bottlenecks are typically shifted down the line, creating new problems that diminish real transformation and ROI. Organizations need to shift their thinking to reevaluate existing processes and modify or redesign them to give customers and employees better experiences.

4.6. Design Thinking Approach

Both attended and unattended RPA has a place in digital transformation, but instead of saying, "We need RPA," what leaders should think about is how an organization's interconnected processes are automated from end-to-end. Real digital transformation is bigger than bots. First, it requires a design thinking approach to identify desired outcomes, and then a holistic look at sales, service, AI/decisioning, and robotics as an integrated, end-to-end workflow. Once organizations understand those, they can begin to execute on a vision of how their systems for process automation, case management, email automation, app development, APIs, and data can be orchestrated together to seamlessly deliver the outcomes that will improve customer engagement.

What's the right way to implement RPA? Instead of trying to build a program around staff reduction and thinking about how to achieve 100 percent automation to replace a handful of FTEs, focus on some level of basic task automation for every staff member. Then focus on refining overall processes and streamlining operations. In many organizations, staff are responsible for a series of very complex workflows or decisions, making them difficult to replace with full automation. Organizations will see a much faster and higher return on investment using an attended desktop bot to automate the low-value, repetitive task work that almost every employee performs.

For example, the process of copying and pasting information from one electronic form to another can be automated with assisted desktop bots, shaving seconds or even minutes off-task time. Now multiply that by hundreds, thousands, or tens of thousands of workers. The ROI is immediate.

4.7. Cycle Phase

While we discussing on Robotic Process Automation a question that comes up is "Does software development model in RPA life cycle is similar?" The answer here is yes, but still there are some differences of work. Below is the life cycle which we may use for RPA software development.

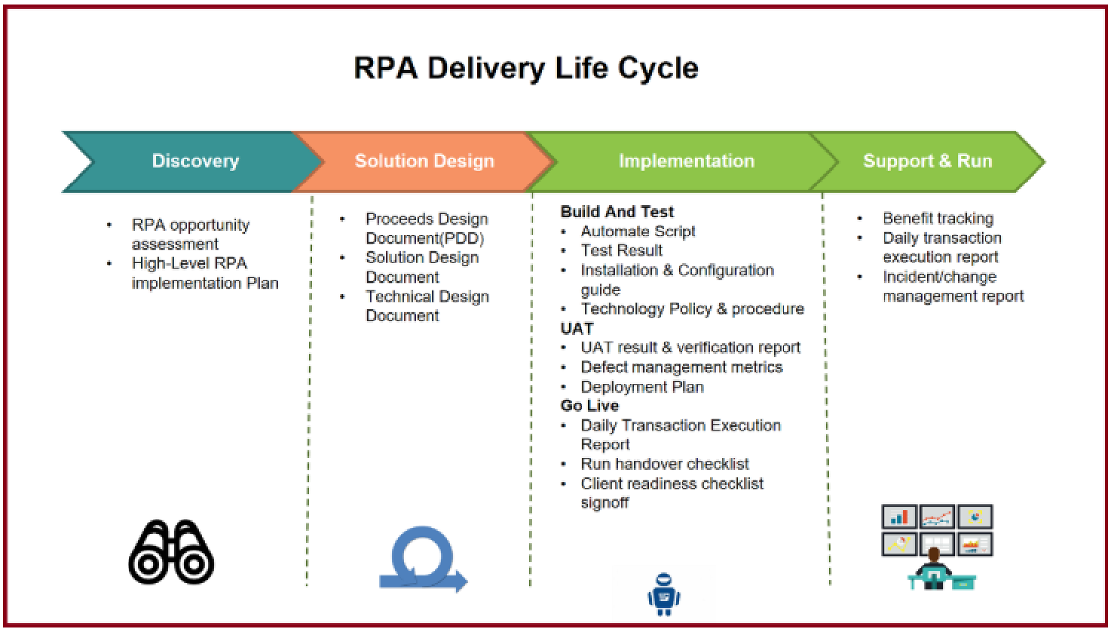


Figure 21 – RPA Delivery Lifecycle

Discovery Phase:

- RPA opportunity assessment: It is very crucial phase for RPA life cycle so while doing assessment of processes we must do it very carefully. Business team and RPA strategist/Architect work together to identify a business process for RPA development. Every software has some limitation and it is really important to make sure we are doing a right assignment.

- High-Level RPA implementation Plan: In discovery phase we should bit focus on high level implementation plan, which will make our analysis more bullet proof. As "what" and "how" may lead you in right direction.

Solution Design Phase:

In this phase the documents, as drafting details will need to be created. Below given documents are required to complete before start RPA development.

- Proceeds Design Document(PDD)
- Solution Design Document(SDD)
- Technical Design Document(TDD)

Implementation Phase:

Implementation phase we have following action item which we need to take care

- Build And Test
  - Automate Script
  - Test Result
  - Installation & Configuration guide
  - Technology Policy & procedure
- UAT
  - UAT result & verification report
  - Defect management metrics
  - Deployment Plan

- Go Live
  - Daily Transaction Execution Report
  - Run handover checklist
  - Client readiness checklist sign off

- Support And Run
  - Benefit tracking
  - Daily transaction execution report
  - Incident/change management report

Organizations are also instituting formal centers of excellence (COEs) that align with this broader operating model. These COEs represent dedicated groups with specialized competencies that focus on orchestrating the RPA life cycle. These organizational structures (e.g., operating models and COEs) remain governance focused, yet their primary business objectives are optimizing the connectivity of disparate processes to build "bridge" functionalities, creating efficiencies and improving productivity. As the continuum of automation progresses beyond RPA, organizations ultimately should reflect upon the lessons learned from their RPA journey to proactively institute similar COE constructs and recognize risk and control considerations.

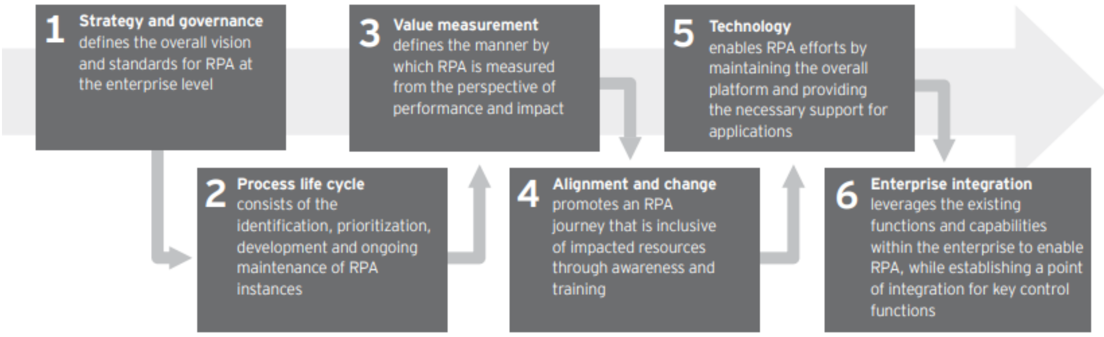


Figure 22 – RPA Lifecycle

4.8. Individual Group Roles

Rethinking talent development and skills needed for an enterprise automation capability according to Willcocks (Willcocks and Lacity, 2016). As organizations build automation capabilities, they need to rethink the skill sets needed to perform business services. They should have a clear idea of the skillsets for the various service automation roles. Two new roles required for RPA are RPA developers to build automation solutions and RPA controllers to schedule, run, and monitor the software robots. For example, the utility company set out to recruit RPA developers from its own operations staff with a strong understanding of the business, process experience, , and preferably systems analysis backgrounds. According to the RPA project manager at the utility, the most important requirement was the ability to extract logical structures from chaotic business data to build algorithms. IT skills were also seen as critical. He noted, “We’re not IT staff, but we have staff with IT skills.”

To staff its control room with RPA controllers, for instance, the utility targeted people who were organized, methodical, and logical and had a consistent approach to work. It also needed people with good communication skills because these individuals interacted with business operations people when they spotted any issues or anomalies. At peak times, two human controllers orchestrate the work of 300 software robots that produce an output equivalent to that of more than 600 people.

Beyond the skills of the command center staff, the skills of the retained human workforce also need consideration. If robots are doing all of the repetitive and structured tasks, it means that the remaining humans increasingly need more creativity, problem-solving skills, judgment and emotional intelligence to tackle the unique, emergent and unstructured tasks.

One the other hand, Madakam tried to give a more detailed structure of the individual group roles that participate in an RPA operating model which is largely cantered around three key roles (Madakam et al., 2019):

Process Architects

They who help design future state processes empowered by Robotic Process Automation. The process is nothing but task completion. It is associated with many factors of software like Interactive Voice Response, hardware like robots, few human interventions. There are different types of the process including of long-term and short-term process/round robin, priority / First Come First Served Process (FCFS) / Last in First out (LIFO). The process architects are responsible for defining all these processes in both the centralized process and decentralized process systems. First, they have to understand the existing system flow, identify the loopholes in the system components, tasks handling, time requirements, and cost reductions along with systems efficiency. In one way is the business analysts are also responsible for process automation. The process architects design the consistent methodology, process, and standards of Robotic Process Automation system.

Technologists

They develop the code that translates the business logic into a robotic workflow? We know that a technologist is a scientist or an engineer who specializes in a particular technology, or who uses technology in a particular field. In the market right now the companies are having more. These are the coders, programmers, they take the input from functionalist and designers, executors and develop the code based on the Software Requirement Specifications (SRS). All these coded software is able to help the routine work handling automatically without human interventions at a certain level. The authors also point out that a Robotic Process Automation Centre of Excellence will usually put a team of dedicated developers in a low-cost location to scale a Robotic Process Automation program. The technical skills required for RPA tools are relatively less sophisticated compared to traditional application development.

Ongoing Support and Maintenance Staff

They execute newly automated tasks and make updates to the code when required. This process happens generally through annual maintenance contract (AMC) with the software vendor or supplier. They easily debug the errors if any fault and failure in the system software and applications. They give technical support 24x7 round the year if AMC is valid. This kind of technical support really reduces the in-house technical people recruitments cost and time. There would not be any training cost also. The ongoing support packages from the companies are tailored to suit the needs of customer business, not the needs of the many. Whether customer need assistance with an individual problem or weekly reviews and advice have the package to suit customer's needs, giving customer total peace of mind.

4.9. Differences between RPA and AI

Robotic Process Automation and Artificial Intelligence has a lot of common tasks. Both technologies execute actions and organize planning. The software entities that perform the actions in RPA are called robots, whereas in AI are called agents. Although, robots are not actually agents and RPA has a lot of differences with AI.

RPA is a software robot that mimics human actions, whereas AI is the simulation of human intelligence by machines. Many people often asked about the difference between Robotic Process Automation (RPA) and Artificial Intelligence (AI). Some even confused the two to be the same. To make matters worse, many vendors are now brandying about terms like

Intelligent Automation (IA) or Intelligence Process Automation (IPA). For the uninitiated, all these jargon can be very confusing, and perhaps daunting.

To help you out, we have to highlight the key differences between RPA and AI, particularly in the context of process automation. The IEEE Standards Association (IEEE SA), led by a diverse panel of industry participants, published the IEEE Guide for Terms and Concepts in Intelligent Process Automation ("IEEE 2755-2017 - IEEE Guide for Terms and Concepts in Intelligent Process Automation," 2017). The purpose of this standard is to promote clarity and consistency in the use of terminologies in this still nascent industry.

According to IEEE SA, RPA refers to the use of a "preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution of a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with human exception management."

And AI is "the combination of cognitive automation, machine learning (ML), reasoning, hypothesis generation and analysis, natural language processing and intentional algorithm mutation producing insights and analytics at or above human capability."

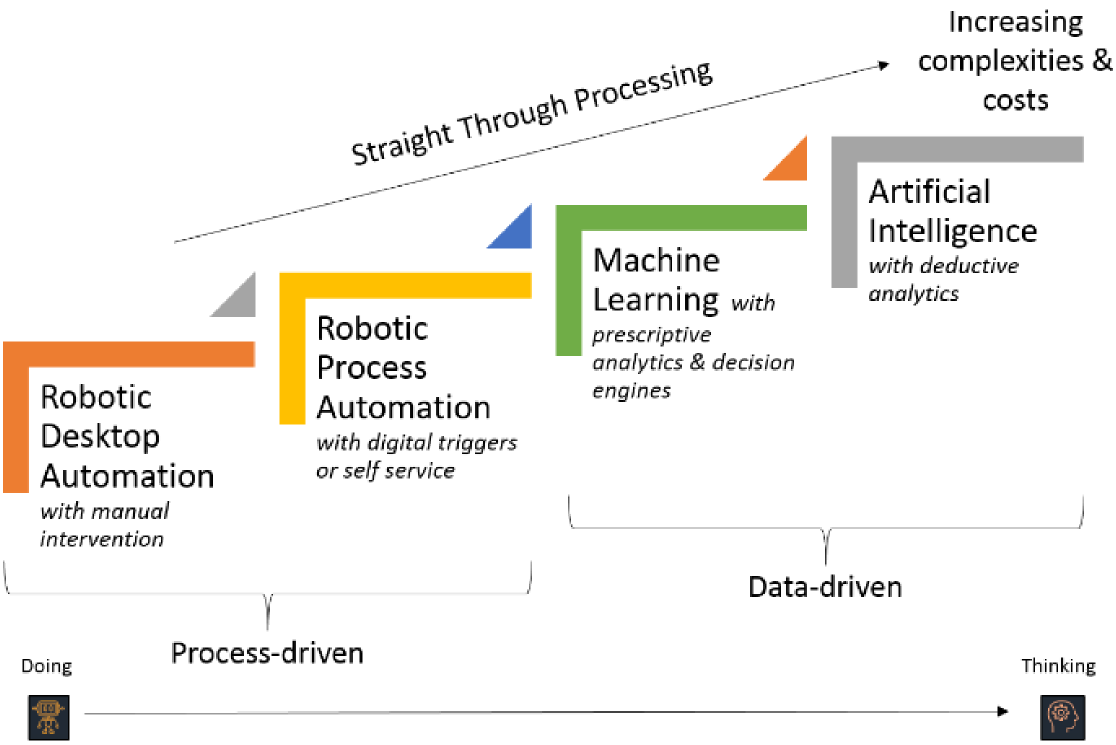


Figure 23 – Process-driven vs Data-driven approach

<u>For simplicity, you can think of RPA as a software robot that mimics human actions, whereas AI is concerned with the simulation of human intelligence by machines.</u>

Before we go into the differences between the two technologies, it is important to realize that RPA and AI are nothing but different ends of a continuum known as IA.

Doing versus Thinking

On the most fundamental level, RPA is associated with “doing” whereas AI and ML are concerned with “thinking” and “learning” respectively. “Brawn versus brains” if prefer. Let’s use invoice processing as an example. Your suppliers send you the electronic invoices by email, you download the invoices into a folder, extract the relevant information from the invoices, and finally create the bills in your accounting software.

In this scenario, RPA is suitable for automating the grunt work of retrieving emails (for simplicity, retrieval is based on the email’s subject), downloading the attachments (i.e. invoices) into a defined folder, and create the bills in the accounting software (mainly through copy and paste actions).

On the other hand, AI is required to intelligently “read” the invoices, and extract the pertinent information such as invoice number, supplier name and invoice due date, product description, amounts due, and many more. This is because the invoices are essentially unstructured or at best, semi-structured data. For example, different suppliers have different invoice templates and formats. There are also varying number of line items across the different invoices.

Since every activity in RPA needs to be explicitly programmed or scripted, it is practically impossible to teach the bot exactly where to extract the relevant information for each invoiced received. Hence the need for AI to intelligent deciphers the invoice just as a human would. To be sure, it is possible to handle invoice processing through RPA alone. In this case, we will deploy what is commonly known as attended automation. Attended automation, or Robotic Desktop Automation (RDA), is like a virtual assistant that works hand-in-hand with your human employees.

Going back to our example, after the invoices have been downloaded, they will be passed through Optical Character Recognition (OCR) software which will attempt to extract the required information. A human operator will then validate this information, before handing over the work back to the RPA bot to create the invoices in the system. The key advantage, therefore, of using a RPA and AI solution is that you can achieve straight through processing (with minimal human intervention). The downsides are increased costs and project complexities.

Process-centric versus Data-centric

Another key difference between RPA and AI lies in their focus. RPA is highly process-driven — it is all about automating repetitive, rule-based processes that typically require interaction with multiple, disparate IT systems. For RPA implementations, process discovery workshops are usually a prerequisite in order to map out the existing “as is” process, and to document them in the Process Definition Document (PDD) (as described at RPAs’ Cycle Phase chapter).

AI, on the other hand, is all about good quality data. For our example of invoice processing, we will concern ourselves with finding sufficient sample invoices to train our ML algorithms, ensuring our samples are of good quality (particularly if the invoices are scanned), making sure the invoices are representative of the data set, among others. Thereafter, the task is to select an appropriate ML algorithm, and then train the algorithm sufficiently so that it is able to recognize other new invoices faster and more accurately than a human could.

Digital Stairways to Intelligent Automation

At the end of the day, RPA and AI are but valuable toolkits which you can use to aid your organization's digital transformation. The choice of implementing either RPA or AI (or both) really depends on your specific use case, and ensuring "fit for purpose" is the key. For the case of RPA, many organizations have cited reasons such as wanting to capture the "low hanging fruits", quick implementation and time-to-market (usually in a matter of weeks or months), low costs and complexities, and others. And many are making the smart bet of using RPA as the first step in the digital stairways to intelligent automation.

4.10. The Future of RPA

RPA has been a sector on fire. In order to carry momentum in the coming months and years some things need to change and unfold while delivering on tactical benefits. The will be a shift from a reduction of labor exclusively to more of a business outcome driven approach. Listed below are the changes I see coming in RPAs future. Make no mistake that automation will continue to be a big theme, but additional factors are needed to keep the momentum at a fever pitch.

RPA must target multiple business outcomes:

Traditionally RPA has made a great living reducing labor costs while adding accuracy and moving dull labor to automated bots. Mimicking human actions will continue, but there are other business outcomes that need servicing by RPA. As Bots grow in capability, it can act as a listening post for patterns of interest, bid on available work and assist as a digital assistant to customers. Bots need to be goal driven as well to adjust to changing business needs.

RPA must get smarter:

Bots today are rather simple and single function in orientation. Over time these bots will leverage algorithms, statistical models, and multiple forms of AI and extend their functional impact and reach. As they get smarter they will become more autonomous and start to bid on tasks. Automating process modeling using system logs and videos of users working on the process can be the start of great self-learning RPA. Enriching RPA with advanced functionality such as image processing and Natural Language Processing would also be a great achievement, as then a new era about Cognitive RPA will rise.

RPA has to be governed on the edge:

Autonomous bots will live on the edge and act with high levels of freedom. This brings the challenge of setting up governance boundaries and constraints. Swarming agents/bots will likely be goal driven and bidding to win business, so dynamic governance will rise in importance.

RPA must assist the human experience:

Bots should not only assist employees and other labor focused resources, bots should assist customers. These bots should sense the personas and behave in context to assist people on either their work or consumer journeys. The famous 'Chatbots' can gain great assist from RPA. Chatbots interact with human customers by giving them the required information, resolving issues, answering questions. Intelligence chatbots can handover interactions to live agents in case of a specific need or if an issue arises that chatbot cannot handle. Chatbot increases brand value by sharing the true voice of the customers. Combining them with RPA, they can be integrated with CRM and CMS to better serve customers by pulling out the details of the person they are interacting with. Smart chatbots can quickly learn and make sense of data and context in the real time. Many self-service channels can handle different portfolios replacing humans and taking over all tedious work.

RPA will be embraced as part of end-to-end automation

We have seen what happens when organizations jump on the latest technology only to find they have wasted time and money on an incomplete project or created yet another disconnected data island or channel. Do some honest analysis of your organization's process needs, identify the outcomes that matter most, then develop a robotics strategy that deploys bots as part of an end-to-end operational approach. In most cases, the fastest way to earn ROI is to automate repetitive task work with attended desktop bots and use unattended RPA for the last mile of integration, automating integrations to apps, data, and legacy systems.

4.11. Summary

The research at this chapter showed that business processes generate valuable data that create a lot of capabilities for potential RPA implementation. The great percentage of RPA projects that fail to meet the delivery dates was the biggest concern that came out of this research, but considering RPA is a new approach this percentage will possibly be reduced as more experience on how to implement RPA will be gained. After studying about RPA it was noticed that there might be confusion between RPA and AI. It would be wise to repeat that RPA is a software robot that mimics human actions, whereas AI is concerned with the simulation of human intelligence by machines. The future of RPA, though, demands to make the bots smarter. As a result these two technologies may be much related in the near future.

5. RPA Deployment to BPM

This chapter tries to separate the definitions of BPM and RPA. In order to achieve effective confrontation of confusion it is needed to cite a quick synopsis of BPM and RPA, as studied at the previous chapter. Then the great results of a successful combination of these to disciplines will be reviewed as described at literature.

5.1. Differences between RPA and BPM

There is a lot of discussion around RPA and a lot of people often supports that RPA replaces BPM. There are others that believe that BPM can be leveraged to do what RPA does in most cases. Right now RPA works on specific tasks. BPM works on orchestrating all kinds of tasks that involve RPA or not while dynamically delivering changing business outcomes. Over time they will have more overlap as both leverage more intelligence through AI and Algorithms. In order to start comparing these two streams, it would help if we make a quick synopsis of what we discussed at the previous chapters:

5.1.1. Synopsis of BPM

BPM is a strategic approach that focuses on remodeling an organization's current business processes to achieve optimal efficiency and productivity. BPM software is the fundamental spine to facilitate completion of an organization's projects, providing a variety of tools to help improve and streamline how business processes are performed. BPM software components can include business analytics, workflow engines, business rules, web forms, and collaboration tools. Often large-scale projects, BPM process improvement initiatives can impact an organization's technology, employees, and customers, bringing about significant transformational returns.

BPM manages tasks and sequences in an end to end style while monitoring results and making vital adaptations to keep goals and business outcomes on point. BPM has task or event coordination/orchestration capability that makes sure the best sequencing (flows), even in parallel streams, is chosen at any point in time. BPM applies to simple or complex system and human tasks associated and dynamically optimized for SLAs. Processes are great at exception handling and are often supported by decisioning capabilities (usually visual rules). Processes and process snippets (smaller sequences of tasks) are great at delivering best practices and emerging better practices recognized in cases.

5.1.2. Synopsis of RPA

By definition, RPA is a software code that runs virtual workforce (robots) for process operation. It enables employees to better focus on high priority tasks by pushing routine, monotonous tasks to software "robots" to complete. These robots work directly across application user interfaces, automatically inputting data and triggering actions across multiple systems acting on the behalf of an employee. As a business user-friendly tool that does not involve any programming, robotic process automation technology enables non-technical professionals to self-serve and configure robots for themselves to solve their own automation challenges.

RPA is great at automating manual tasks and stream lining some parts of an overall process. RPA today is focused on tasks and operates with the boundaries of an existing process. As processes flex, this relationship may change. The scope of RPA today are much more focused and limited to single tasks. Though there may be a large number of specialized bots, their power is leveraged by the sequencing that process gives them today. This may change over time. Robotic Process Automation can act as an Application Program Interface (API) for legacy applications for the cases where there are no easy ways to integrate with an application, primarily because either an API doesn't exist or the app doesn't support web services.

5.1.3. Main Differences

Some very clear differences between BPM and RPA are shown below:

Primary Focus

- BPM is a deeper insight to process management which helps optimize the process itself.
- RPA is a surface level fix, which does not optimize the process, but tries to make it faster by replacing the human manual effort.

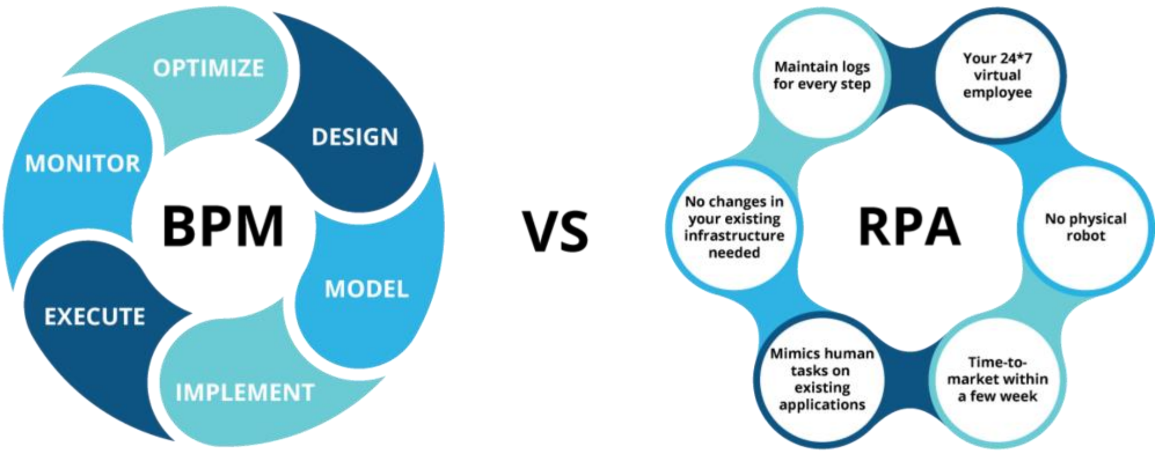


Figure 24 – BPM vs RPA

Technology

- BPM is an approach to management. More specific, BPM is an approach to process operations management which focuses on improving processes performance by streamlining business processes, removing bottlenecks and adding values. BPM uses holistic technology as it encompasses a wide range of software technology components including business analytics, workflow engine in order to optimize business process for maximum value, flexibility and efficiency.
- RPA is a software technology concept. RPA uses software robots or cognitive/AI robots that are configured to complete routine, monotonous tasks that an employee would normally have to do.

Automation Focus

- BPM targets to end-to-end automation by re-engineering process flows to eliminate bottlenecks, connect systems and increase productivity enterprise-wide.
- RPA targets to minimize manual, repetitive and rule-based tasks that do not require complex decision making.

Deployment Effort

- BPM requires a long-term effort which could require dedicated technical resources, depending on process complexity and depth of integrations.
- RPA is a quick and less expensive fix compared to BPM. It requires non-disruptively work across an organization's existing processes and applications without requiring coding or extensive training. Additionally it does not require invasive integration.

Business Impact

- BPM returns significant and transformational impact as wide gains can be achieved in overall productivity, agility, cost reduction, efficiency and compliance.
- RPA returns quick and immediate impacts. Its results can be realized quickly and cost-effectively, but implementations may not always address underlying process inefficiencies.

BPM is better designed for approvals. There are certain aspects of a business that will always require a human eye and human decision-making capabilities. Approvals are one such area and without automation, the approval process is often riddled with inconsistencies, obstructions, and the inevitable human error and oversight. With BPM, the overall approval process along with some of its decisions can be automated and logged for compliance requirements.

RPA can act as an API for legacy applications. In cases where there is no easy way to integrate with an application, either because an API does not exist or the application does not support web services (often because it's an old application or built in-house), BPM can leverage RPA to have a bot perform that task in the same manner that a human would. Sometimes, the cost of building integration is prohibitive and in other cases, an application maybe sunset in the next 1-2 years and it's not worth investing in building a more robust integration with that application. An RPA-based integration can be built and tested in a matter of days/weeks.

5.2. BPM and RPA as a Combined Approach

Why not build everything with RPA? True enterprise BPM comes with a rich set of capabilities not available in RPA but that many process automation initiatives require, such as no-code workflow engines, capacity and work queue/workload management, event management, easy-to-design business rules, collaboration tools and more.

Considering their similar goals of increasing productivity and efficiency, BPM and RPA are not competing approaches and could easily work together in harmony. RPA can be a valuable tool in boosting gains achieved with a traditional BPM system. In many cases, an organization may not always have the resources and time to fully implement a completely integrated and automated process or have a process that does not require any human involvement. Implementing BPM and RPA together can bring about much greater process automation and value that one technology approach alone may not be as positioned to achieve.

They both help establish processes for better efficiency and cost savings. They both support rapid deployment and ability to implement change in an incremental fashion. They both can start out with a low cost approach and grow to value over time. They share many of the operational improvement benefits. Over time as processes and bots increase in intelligence through AI they will both increase the customer, employee and partner experiences to create better journeys.

5.2.1. Example of BPM and RPA in Action

Members of IT departments are usually involved with a number of critical responsibilities for the organizations but may be frustrated by a number of repetitive, manual tasks that do not require complex decision making. A simplified version of an automated network access

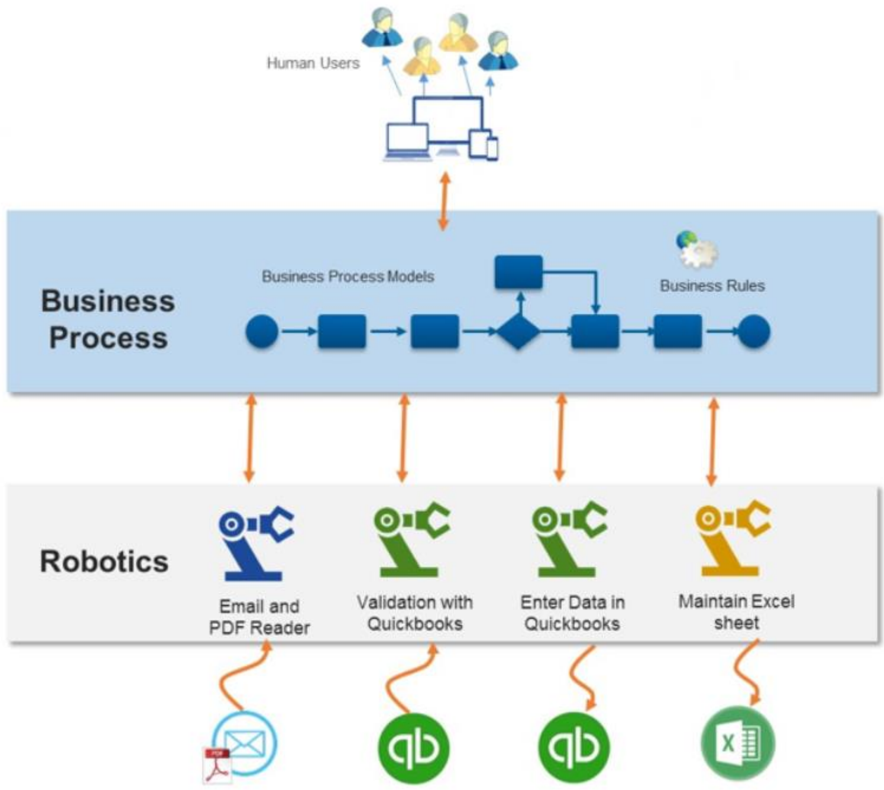


Figure 25 – BPM and RPA combined approach

request process, where an employee submits a request to be granted access to or be removed from a certain software application, is described below. After being approved by the supervisor, IT can then review the request and complete the request as applicable.

In such situation, the process that has been automated with a BPM system still involves some manual work by IT. Completing the request could involve logging into multiple applications, opening up the appropriate pages to grant access rights, applying the appropriate settings, logging out of the applications, and marking the request as completed. As an individual request, performing these tasks may not take a significant amount of time, but if it is happening multiple times a day, it can distract from other valuable actions that a skilled IT professional will need to complete.

As IT may prefer to closely monitor the requests to see who is gaining access to what, the actual actions involved with granting access are not always that important. Adding an RPA bot to perform the manual tasks that will likely need to be repeated multiple times as employees change roles, join the organization, etc., will further optimize the overall process flow and free up the IT staff to focus time on other priority work. It will benefit the organization to have IT professionals focus their energy on tasks that actually require human decision-making and nuanced consideration.

For professionals, moving between applications to perform specific actions is a classic activity. With this so-called "swivel chair" work, employees must constantly switch between multiple systems to complete a particular task in an automated process. RPA technology helps fill in these types of gaps in a BPM process, allowing organizations to achieve an even higher level of efficiency that may not have been as possible before. Existing systems remain as-is, whereas bots would perform the manual actions a person would typically have to perform. Once the bot has completed its task, BPM can take over, pushing follow-up actions and results to the employee to complete or review. Offloading time-consuming, repetitive tasks to bots as part of a BPM solution will help enable employees better focus their talents on more productive work only they can do.

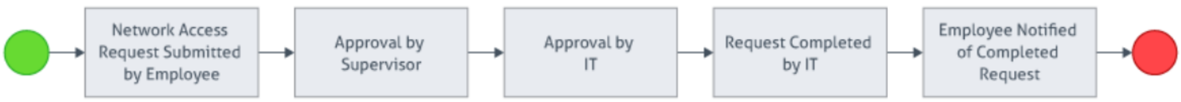


Figure 26 – Network access request process

5.3. Orchestration of independent RPA activities using BPM

Typically, each bot in an RPA solution is focused on a specific activity within a larger end-to-end process flow. Unlike BPM activities, bots are designed to execute activities independently from other activities within the process, where tasks from multiple processes are executed in batches of many hundreds or thousands. If there are several independent RPA activities implemented as bots, BPM can be used to sequence the RPA activities and connect them to the other system and human activities that make up an end-to-end BPM process flow. It is good practice for business analysts to capture enterprise process models using collaborative modeling tools to determine which RPA and BPM automation projects would most benefit each organization.

Several different techniques can be used to integrate RPA activities into a BPM process, depending on whether it is the first activity in a process flow or an activity in the middle of a process flow. If an existing RPA activity is the first step in an end-to-end process, then on successful completion of each bot you can launch a BPM process to orchestrate the rest of the process. Else if an existing RPA bot implementation that belongs in the middle of an end-to-end process, then after the successful completion of each bot activity it can send an event to BPM to trigger the next activity in the process.

5.4. Digital Transformation Driven by BPM and RPA

Even if RPA and BPM technologies can be deployed separately in digital transformation initiatives, it is when they are strategically implemented together that their individual benefits are compounded. BPM and RPA complement each other, forming a powerful duo that can help organizations further deliver on their process automation goals. In the near future, RPA will become even more of an integrated part of traditional BPM systems and organizations' overall digital transformation toolkit.

There are a lot of providers of powerful BPM tools including workflow, web forms, business reporting and analytics, and capture solutions to streamline and transform business processes. By including RPA in its process automation feature set, organizations are further enabled to develop optimized business processes that increase productivity, reduce costs, and make employees' lives easier.

In the following diagram there is a high level summary describing how RPA and BPM can complement each other and how they can be used combined.

Already using BPM?	Already using RPA?	You need both!
Add RPA to BPM	**Add BPM to RPA**	**Leverage BPM and RPA**
Let bots handle repetitive and mundane tasks or scale human tasks	Manage customer interactions and robotic exceptions via BPM	End-to-end process orchestration/ process application
Automate integrations not easily accessible via API	Orchestrate manual approvals, business rules and integrations with systems	Humans, robots and systems working together in a seamless process
Higher efficiency and accuracy	**Better visibility & exception handling**	**End-to-end digital transformation**

Figure 27 – BPM and RPA complementarity

5.5. RPA in Banking

Retail and commercials banks alike are facing increased pressure from management, shareholders, and external competition (such as Fintech companies) to reduce costs, increase product quality, and accelerate the processing of back-office work. When paired with the right type of process analysis, robotics can help banking operations management tackle most large-scale and routine data-movement tasks. They can also implement it with unprecedented speed on the order of weeks, not months or years. The financial benefits of robotics in banking are matched by the improvement it yields in both back-office processes and the customer experience. In short, banks can save money on labor (while doing more with less) with RPA.

Consider the top seven benefits of robotics in banking, especially when compared to traditional automation:

- Banking RPA does not require new core IT infrastructure change or upgrades. To the contrary, it is a low-cost layer that sits on top and across all currently-installed banking applications.
- There is no coding requirement. Robotics in banking does not require coding experience.
- Implementation is fast. RPA for the banking industry is nimble; robots can be tested in short cycle iterations.
- It is easy to change. A banking robot can be installed or updated in less than a week when banking processes change.
- Minimal IT intervention is required. Front-line employees can be trained to maintain and "manage" their own banking robots.
- RPA boosts morale. Contrary to popular opinion, banking robotics can actually increase (and not decrease) the morale of human workers by reducing the burden of boring data-entry work.
- Robots do not need breaks. Banking robots can work 24/7—365 days per year. Banks do not have to pay robots overtime or health insurance, or worry about them quitting.

Banking RPA use cases are used as process "blueprints" by IT to implement automated scripts that run across multiple data-processing IT systems simultaneously. The steps of the processes that are need to develop RPA use cases are described below:

- RPA Banking Use Case Step 1: Identify sub-processes on process maps where banking robots can be implemented.
- RPA Banking Use Case Step 2: Prioritize and evaluate all of the banking sub-processes, targeting those candidates which will yield the most benefits.
- RPA Banking Use Case Step 3: Develop and document the use-case requirements, rules, and keystrokes that the banking robot must perform.

5.5.1. Detailed RPA Use Cases in Banking

In this robotics-in-banking use-case example, we can follow a consumer loan processor who is getting ready to do his daily job: handling the application from a prospective borrower. Normally, this takes at least 20 minutes, per customer, per loan application. That is because 80 percent of the work he does is manual: He needs to copy and paste information between email, multiple loan-processing systems, credit bureaus, and several government websites. It is difficult, demanding, time-consuming, and tedious work. Consider the pre-RPA banking use case process:

- When a customer requests a new consumer loan or line of credit, a call center representative, branch employee, or website captures the data into Loan Processing System 1.
- Once the loan processor receives the information, he runs a manual credit check. He does this by transcribing data from the loan-processing system into an external website to pull the credit report.
- Then the loan processor saves the credit report as a PDF and attaches it to Loan Processing System 1.
- Then he copies and pastes the credit score into a field in Loan Processing System 1.
- Once the credit check is complete, he transcribes the data from Loan Processing System 1 into two other core banking systems.
- The employee then logs into a government website to the validate customer address and appraisal from supplied documents. He does this, not surprisingly, by copying all of the information from Loan Processing System 1 and pasting it into the website to validate the address of the customer requesting the credit.
- Once the information is confirmed, he prints it as a PDF, attaches it to Loan Processing System 1.

Again, all of this is done by hand. The employee runs through these exact same steps about 20 times a day: assuming that this is his maximum capacity. Of course, 80 percent of his capacity is spent on manual copying-and-pasting. Now consider the exact same scenario, upgraded through the implementation of banking robotics. The banking RPA use case is transformed, almost magically, for a diligent worker:

- Employee receives the loan package in the system just as he did before.
- He launches his UiPath robot. It then logs into Loan Processing System 1 and automatically pulls all the information needed to process the credit check.
- The robot opens the credit-reporting website. It runs the credit check by pulling the information out of Loan Processing System 1.
- The robot creates a PDF copy of the credit report, attaches it to Loan Processing System 1, and copies the credit score into the “Credit Score” field in the system.
- The robot then pulls the loan data received in Loan Processing System 1 and transcribes it into the other two core banking systems.
- The robot logs into the government website, enters the necessary data to run the address check, and validates the property appraisal and customer address.
- Finally, the RPA bot saves the address check and appraisal PDF to Loan Processing System 1.

What used to take employee 80 steps to complete now requires a single mouse-click. What used to eat a full 20 minutes of his day now takes just five. Importantly, he is not only faster, he is now free to focus on delivering an exceptional banking customer experience, instead of just moving data around. It is little wonder that loan processors like this example consider robotics in banking to be such a boon to their productivity, and a morale booster, too.

5.5.2. Predictions for global RPA market

According to P&S Market Research, the global robotic process automation market is projected to reach $8.6 billion by 2023. In the banking industry, robotics process automation (RPA) is gaining traction, with adoption rates increasing pace since mid-2016. And while implementation of this technology is still relatively new in the financial-services sector, there are many processes, operations, transactions, and work tasks which can benefit from RPA. To help you understand the way RPA is being implemented in the banking industry, consider the following case studies, all involving U.S. and European banks that are adopting the technology.

5.5.3. BNY Mellon Case Study

BNY Mellon is among the more outspoken proponents of robotic process automation in the banking industry. The bank began adopting RPA in 2016. As of 2017, it reportedly had 250 bots in production. BNY bots are being used, for example, to streamline the firm's trade-settlement procedures. Tasks include clearing trades, conducting order research, and resolving discrepancies. While human staff requires five to ten minutes to reconcile a failed trade, the BNY bot can perform the same procedure in a quarter of a second.

Other RPA benefits realized by the bank include an 88-percent improvement in transaction-processing times and account-closure validations across five different systems, with an impeccable accuracy rate of 100 percent.

The deployment of the RPA bots at BNY Mellon has allowed banking employees to devote more time to operational quality control and outliers; consider this quote from the bank's 2017 annual report:

"We have been improving our processes and applying automation tools, such as robotics for routine processing… these tools are increasing efficiency, reducing costs and improving speed and accuracy, which benefit us and our clients. And, our work progresses as we continue to invest in our technology platform and capabilities to advance and enhance our client service."

5.5.4. Deutsche Bank Case Study

German-based Deutsche Bank is deploying RPA to more efficiently manage repetitive tasks. It has reported 30-70 percent automation in areas where the software is integrated and noted a decrease in the time required for employee training. In its 2017 annual report, Deutsche Bank highlights some specific examples of automation:

"We are modernizing our IT and pursuing the digitalization of our business. Today, our private clients can open an account online in a matter of minutes – and not seven days as before…We have launched robo-advisers (WISE) in the asset management business and in the Private & Commercial Bank (ROBIN). WISE and ROBIN use algorithms to compile a suitable portfolio for our clients. In our other businesses, too, we are utilizing robotics and artificial intelligence to automate what were previously manual processes – this will minimize errors and lower costs."

While some 2017 reports suggest that Deutsche Bank will replace a significant number of jobs with robots, the bank itself has projected that robots are more likely to complement human employees than replace them outright. With a new CEO on board as of April 2018, evidence suggests that the bank is attempting to push into a new era—and automation is a priority in its strategy.

5.6. Summary

BPM and RPA are for sure better in combination as they will both get better as they add smarts. As control moves to the edge, those tasks sequences will likely be short running and smaller in scope putting the advantage to RPA over time. Task sequencing is important in a great number of cases, so process will be there, but not as the BPM of old that many know today. In the future as the bots become more intelligent and are able to anticipate and negotiate, then maybe there will be less pre-built processes.

6. Application of RPA to Selected Business Processes

Until now we have discussed about some fields that are not absolutely relevant to each other. More specific we discussed about business processes, integration models, banking sector, business process management and robotic software automation. At this chapter we are going to study some cases that combine all of the above. At this chapter we are going to analyze the models of some complex banking processes that integrate different departments and organizations. Afterwards, we are going to find examples that RPA implementation could give positive impact to the processes. We used Bizagi Modeler 3.4.1 for process modeling and UiPath 19.5.0 for RPA implementation. Additionally we used Microsoft SQL Server 14.0 Databases and SQL Data Tools 15.0 along with SSIS software to support our implementation.

6.1. Case Study: Withdrawal

6.1.1. Process Model

The first case we are going to discuss is a common online withdrawal process through ATM. This use case starts with the user inserting a debit card into an ATM and requesting a withdrawal. As a result Customer should be considered as an independent role and will be designed as an autonomous pool and the first activities of the process can be described as apart. Customer's 'Create Request' subprocess contains the following activities:

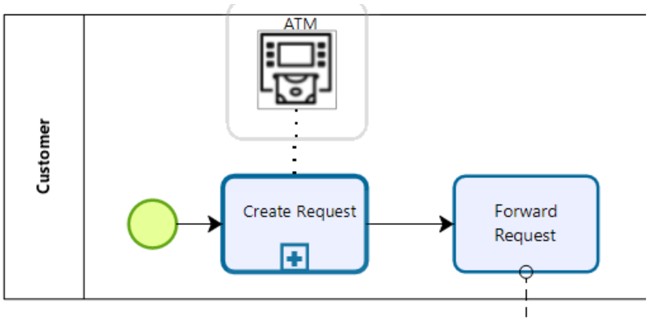
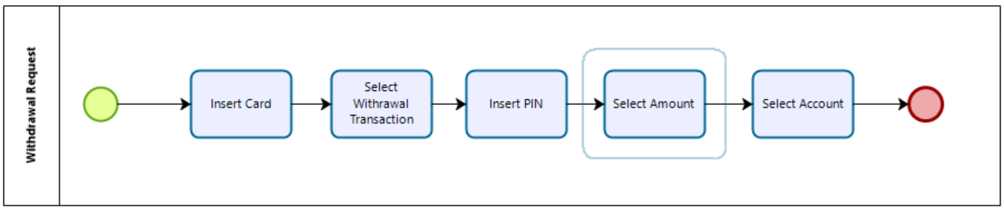


Figure 28 – Customer pool: start of process



After customer's actions the request is forwarded to the bank. At this case there is not any integration hub to coordinate the tasks and the request is forwarded straight from one department to another as described at Point-to-Point Integration section. We assume that a bank's structure could be described by the following departments that are being evolved to serve this transaction:

- Terminals Department
- Switching Department
- Cards Department
- Commissions Department
- Accounts Department

A new pool will be designed to frame bank's organization, while a lane will be designed for each of the departments.

Obviously the first department that is going to receive the message is the terminal department. At a rainy day scenario that the terminal is not available is will compose a rejection message to the customer and the process will be aborted. Assuming that the terminal will face no problem at its validations it will immediately forward the message to switching system. Switching system needs to parse the message and forward it to the proper system. In our case the upcoming department is the card department. In order to forward the message to card department, switching system first needs to establish a connection. It may be unable to establish the connection and that is the purpose of the exclusive gateway, as even if the switching system is not the proper one to authorize the transaction, it will try to serve the client's request in order. This action contains a risk but it the process was designed this way in order to maximize the positive outcome of the organization's clients.

Considering that withdrawal is a card transaction, the responsible department to authorize this transaction is Card's department. At first, it will check card's BIN number to identify issuing organization. If the card belongs to another bank of the same country to the terminal's acquiring organization, then the transaction will be forward to the respective national interbanking system. Similarly, if the card belongs to a card of another country, the transaction will be forwarded to the respective payment scheme such as Visa or MasterCard. Both of those cases are moving outside of the organization to another pool.

On the contrary, if the issuer and the acquirer is the same organization the transaction will be served internally. Card department will perform some internal validations such as PIN correctness, valid card status and later expiration date. Although, still card's department does not always have all the required information in order to authorize a withdrawal. That is because debit card does not actually have any ledger balance. Instead, debit card is linked with the deposit account that is stored at the accounts department. For that reason the message should be forwarded even further.

Once again, a connection with the next system should be established. But it would help if

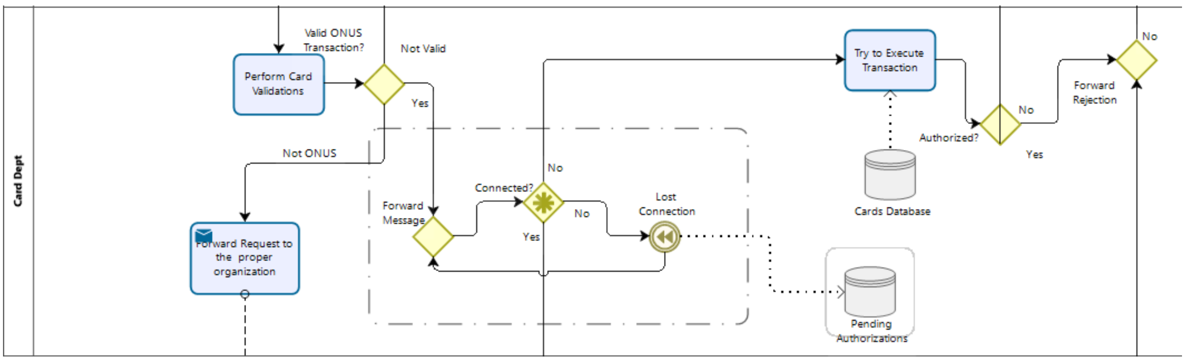
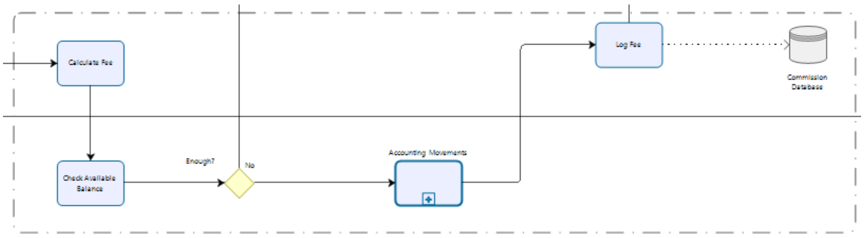


Figure 30 – Card Dept. message exchange

describe a case with greater complexity than before. Assuming that asynchronous message queues are used to serve the communication, if the connection with the next department is lost, card's system will try to authorize the transaction but at the same time it will try to repost the message for a specified number of attempts. For that purpose, the undelivered



message should be stored at a queue. Once more this decision includes risks, but it was decided as it maximizes customer's outcome.

Between cards' and accounts' department there could exist some intermediate departments such as a central commission department, which would calculate the fee, if any, and update the total amount that should be debited to customer's deposit account. The Accounting Subprocess that is being invoked if deposit account's balance is greater than transaction's total amount includes the following activities.

Figure 31 – Core Banking System Activities

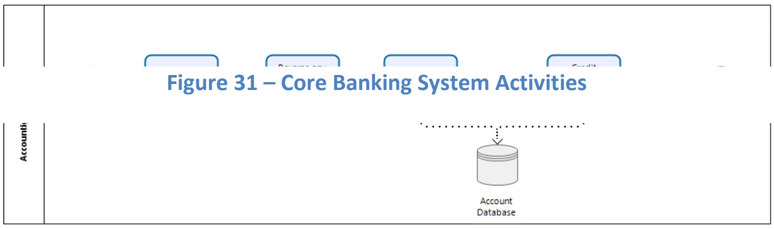
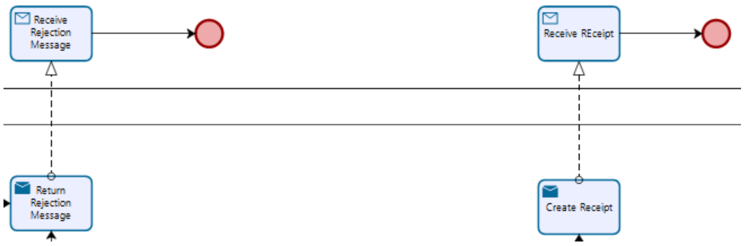


Figure 32 – Accounting subprocess

The final message should pass through all corresponding systems that were already invoked so that the process will be completed. Regardless if the transaction was authorized or rejected a message should be delivered to the customer to inform him about the result. As a



result the ending of the process will be at the starting pool. This phenomenon is not requisite, although it is very common while analyzing customer services processes.

Figure 33 – End of Process

The model of the whole process can be found below:

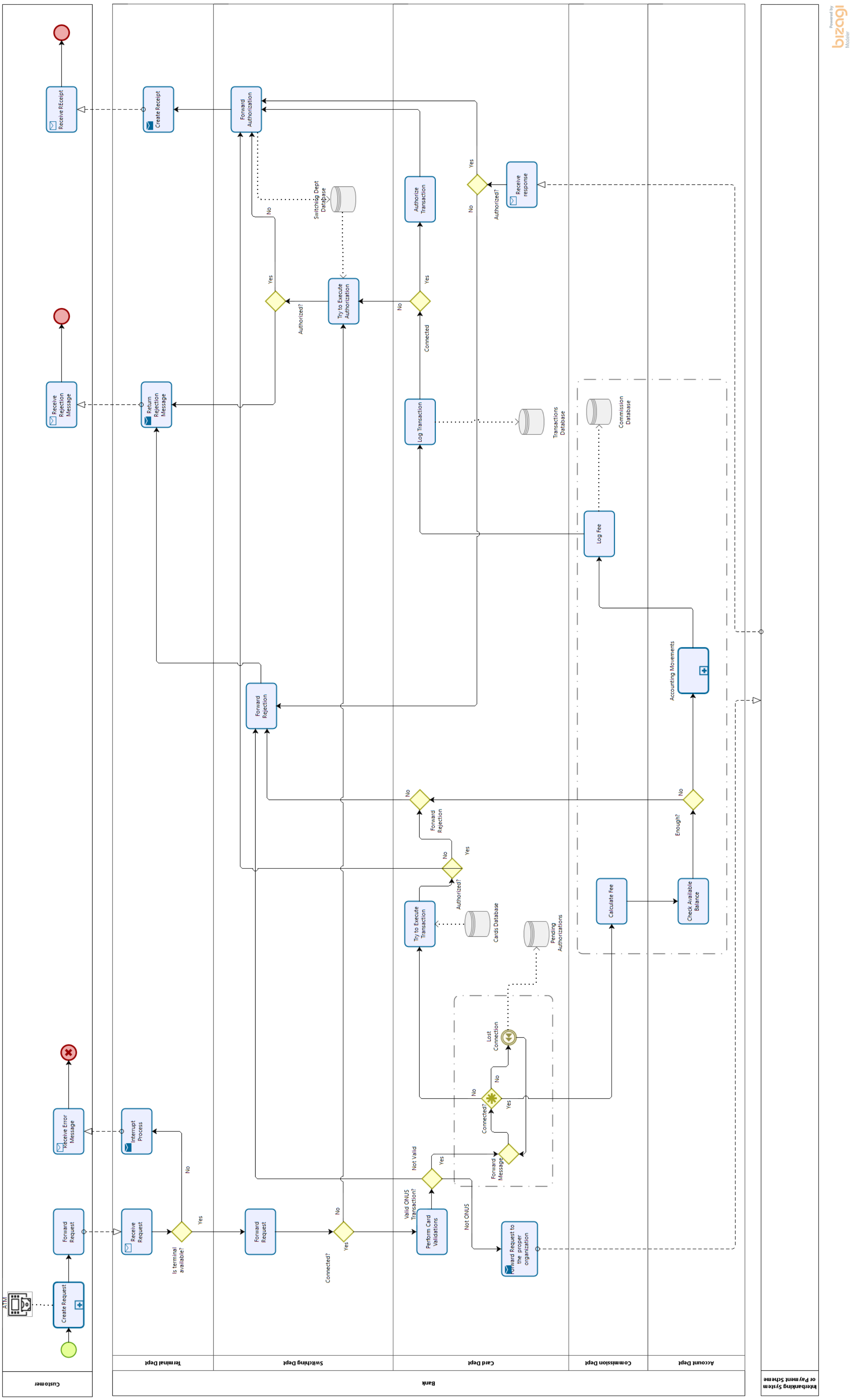


Figure 34 – Withdrawal Process

6.1.2. RPA Application

Often, the needs of implementing RPA to an existing process are something that emerges during the time and they were not described at initial requirement and solution design documents. For example, if it was not designed a way to perform the accounting movements for all the withdrawals that the customers took their money but the corresponding messages were never received from the account department the bank would face great problem at accounting balance and would definitely have to redesign the process. Additionally, when the connection between two departments is dropped is a high priority problem that should be solved immediately and the first action that should be taken is to communicate it with all involved participants. Those participants usually perform some standard troubleshooting actions and provide a workaround. The total time that is needed is the sum of the following actions:

- Organization's 1st level support identifies the problem and transmits the problem to the 2nd level support of the proper department
- Department's 2nd level support performs some standard troubleshooting actions to identify the reason of the problem
- Department's 2nd level support performs some actions to solve the problem
- Organization's 1st level support informs 2nd level support for the progress

All those steps involve great level of human interaction. The fact that sometimes 1st level support could not be able to reach 2nd level support or that 2nd level support may need respectable time to connect to the network/database/informational system can cause great delays and will create very poor outcome. Plus that, as described above all the transactions that were served peremptorily should be manually handled after the resolution. Redesigning such complex processes requests great time and sometimes may be very risky. Instead of that, it would be very efficient to let a robot do all this standard work.

To implement this application, we first created a database at Microsoft SQL Management Studio. Then we created two tables [dbo].[pending_authorizations] and [dbo].[problematic_authorizations] with the same structure and inserted some random transactions to the first one.

Column Name	Data Type	Allow Nulls
id	int	☐
transaction_type	nvarchar(10)	☑
amount	numeric(15, 2)	☑
transaction_timestamp	datetime	☑
completion_status	nvarchar(2)	☑
message_status	nvarchar(2)	☑
record_id	nvarchar(10)	☑

Figure 35 – Tables' structure

A UiPath RPA process only needs the Data Source and the Connection String to be provided and then it can easily connect to the Database. Assuming that for example we want this implementation to be reused for different types of transactions we can add some input dialogs so that we will handle the input parameters. Afterwards, by adding "Execute Non Query" tool, we can easily execute SQL statements that are not expected to return any results. For instance, by doing that we can move all the records that matches some statements from dbo].[pending_authorizations] to [dbo].[problematic_authorizations] and then can automatically extract them to move them to accounts department through an online or even a batch process. A possible query that can be executed is:

```
"insert Into [dbo].[problematic_authorizations]
Select      [transaction_type]
      ,[amount]
      ,[transaction_timestamp]
      ,[completion_status]
      ,[message_status]
            ,[record_id] From [dbo].[pending_authorizations]
Where completion_status = 'Y'
And transaction_type = @TranTypeVariable
And message_status = 'N'

delete  [dbo].[pending_authorizations]
where record_id in (select record_id from [dbo].[problematic_authorizations])"
```

Adding new queries below, we can select all the records from the two tables and store the results at DataTable variables (ProblematicResults, NormalResults). Afterwards, we can add an if condition through an (.NET) expression in order to check the level of the problem, such as: `ProblematicResults.Rows.Count/NormalResults.Rows.Count > 0.2`

In this example, if the rate of the problematic transactions is high then then RPA software will send an email to the recipients. There is no need for the recipients to be predefined. For example, if the RPA identifies that the problem is for a specific product (e.g. prepaid cards) then it simply needs access a source where the calendar of the support engineers of its department is being stored. That source could be an excel document, a website, a DataTable etc.

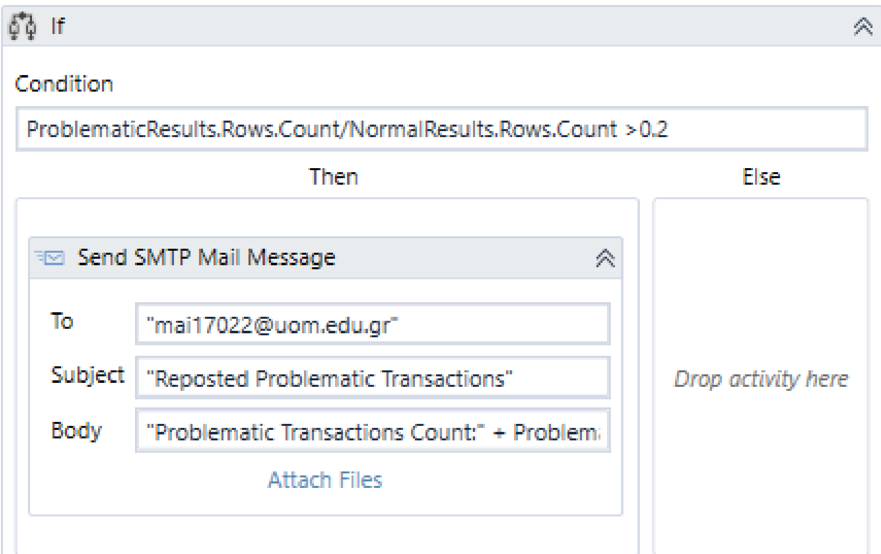


Figure 36 – Send email step

This software has the capability to wait for a reply or automatically take some actions such as restarting a transaction switch application through console management or recycling whole application pool. Those actions can be easily learned from the robot as it is not mandatory to execute any commands or calling any executable files. By using Recording Wizard the robot can mimic one-by-one every action that is at first taken by the user and repeat it when it is needed. A possible sequence would that would serve some of the above functionality would look like:

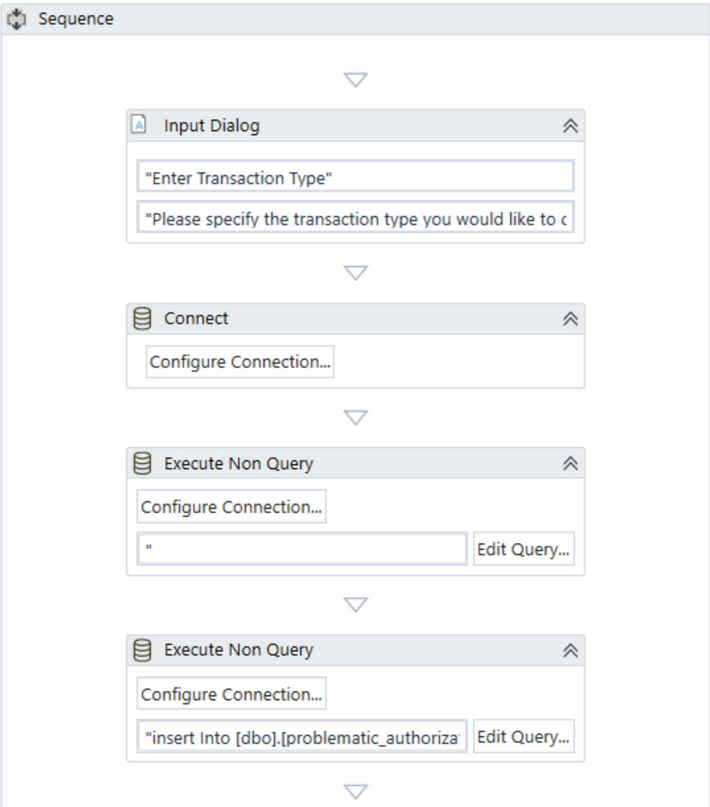


Figure 38 – Sequence part 1

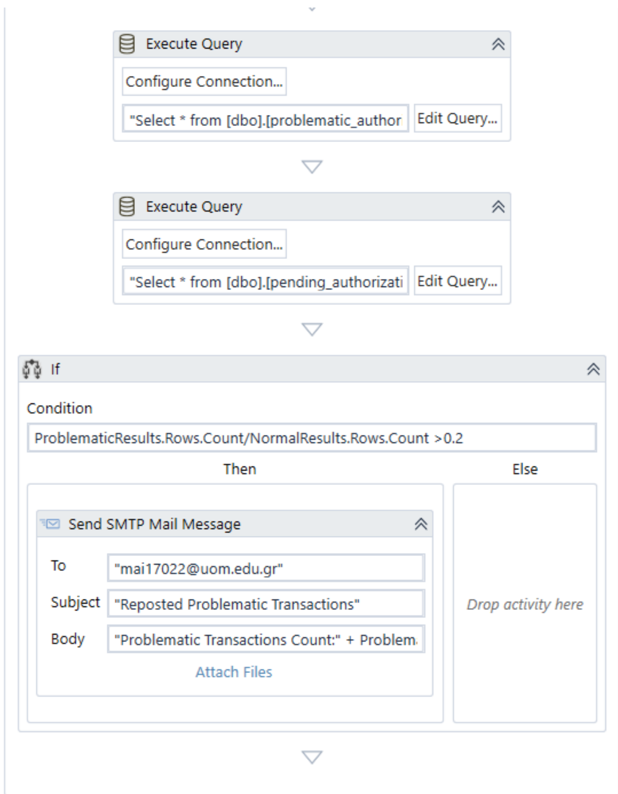


Figure 37 – Sequence part 2

RPA is definitely not going to solve all the support needs as not all the cases are not known and not all the cases are often repeated. Instead, it may save a lot of time to from daily repetitive tasks and minimize response times to known issues.An exemplary execution of this process would have the results that are available at the upcoming screenshots:

1) At first, a pop-up window requires the transaction type that needs to be checked. At our case, we type “Withdrawal” at the textfield and then we press OK button.

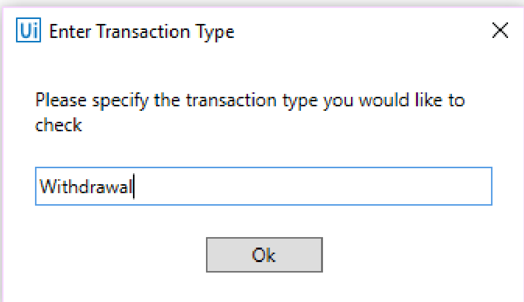


Figure 39 - Inserting Parameter

2) Afterwards, we check at the database that the queries where executed successfully and the records were moved from pending_authorizations table to problematic_authorizations.

SQLQuery1.sql - DE...3M73V7\plzdo (53))*

```
select * from pending_authorizations
select * from problematic_authorizations
```

100 %

Results | Messages

	id	transaction_type	amount	transaction_timestamp	completion_status	message_status	record_id
1	3	Withdrawal	80.00	2019-06-09 11:05:00.000	N	N	100003
2	4	Withdrawal	100.00	2019-06-09 11:00:00.000	N	N	100004
3	5	Purchase	100.00	2019-06-09 11:00:00.000	N	N	100005
4	6	Purchase	100.00	2019-06-09 11:00:00.000	Y	N	100006
5	7	Purchase	100.00	2019-06-09 10:00:00.000	Y	N	100007
6	8	Purchase	120.00	2019-06-09 10:00:00.000	Y	N	100008
7	9	Purchase	5.00	2019-06-09 10:00:00.000	Y	N	100009
8	10	Purchase	1.00	2019-06-09 10:00:00.000	Y	Y	100010
9	11	Purchase	1.30	2019-06-09 10:00:00.000	Y	Y	100011
10	12	Purchase	1.30	2019-06-09 17:00:00.000	Y	Y	100012
11	13	Purchase	1.80	2019-06-09 17:00:00.000	Y	Y	100013
12	14	Purchase	1.80	2019-06-09 19:00:00.000	Y	Y	100014
13	15	Purchase	18.00	2019-06-09 19:00:00.000	Y	Y	100015
14	16	Purchase	12.00	2019-06-09 20:00:00.000	Y	Y	100016
15	17	Return	10.00	2019-06-09 20:00:00.000	Y	Y	100017
16	18	Return	20.00	2019-06-09 20:00:00.000	Y	Y	100018
17	19	Inquiry	NULL	2019-06-09 20:00:00.000	Y	Y	100019
18	20	Inquiry	NULL	2019-06-09 21:00:00.000	Y	Y	100020
19	21	Inquiry	NULL	2019-06-09 21:00:00.000	N	N	100021
20	22	Inquiry	NULL	2019-06-09 21:00:00.000	N	N	100022
21	23	Inquiry	NULL	2019-06-09 21:00:00.000	N	N	100023
22	24	Inquiry	NULL	2019-06-09 23:00:00.000	N	N	100024

	id	transaction_type	amount	transaction_timestamp	completion_status	message_status	record_id
1	1	Withdrawal	20.00	2019-06-09 11:50:00.000	Y	N	100001
2	2	Withdrawal	40.00	2019-06-09 11:55:00.000	Y	N	100002
3	3	Withdrawal	100.00	2019-06-10 20:00:00.000	Y	N	100026
4	4	Withdrawal	100.00	2019-06-10 20:01:00.000	Y	N	100027
5	5	Withdrawal	100.00	2019-06-10 20:02:00.000	Y	N	100028
6	6	Withdrawal	100.00	2019-06-10 20:03:00.000	Y	N	100029
7	7	Withdrawal	100.00	2019-06-10 20:04:00.000	Y	N	100030
8	8	Withdrawal	100.00	2019-06-10 20:05:00.000	Y	N	100031
9	9	Withdrawal	140.00	2019-06-10 20:05:00.000	Y	N	100032
10	10	Withdrawal	140.00	2019-06-10 20:03:00.000	Y	N	100033
11	11	Withdrawal	140.00	2019-06-10 20:01:00.000	Y	N	100034
12	12	Withdrawal	140.00	2019-06-10 20:02:00.000	Y	N	100035
13	13	Withdrawal	200.00	2019-06-10 20:02:00.000	Y	N	100036
14	14	Withdrawal	200.00	2019-06-10 20:08:00.000	Y	N	100037
15	15	Withdrawal	200.00	2019-06-10 20:11:00.000	Y	N	100038
16	16	Withdrawal	400.00	2019-06-10 20:11:00.000	Y	N	100039

Query executed successfully.

Figure 40 - Tables' Data

3) The fact that the number of problematic transactions in this dataset was almost the half of total transaction leads the RPA to send an email as wished.

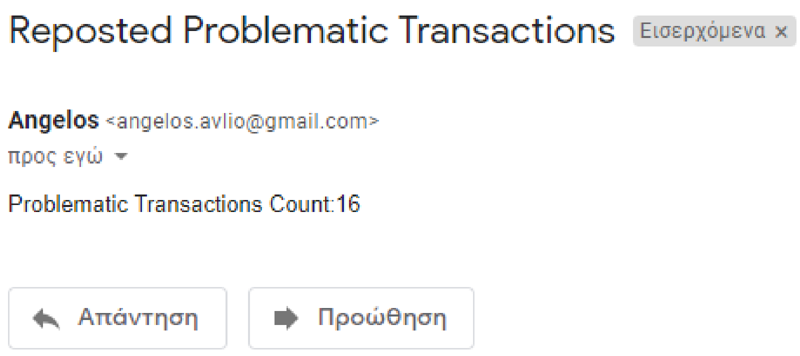


Figure 41 - Received e-mail

6.2. Case Study: Embossing

6.2.1. Process Model

The second case that we are going to study is batch process that includes all the required activities to create card's plastic entity. As opposed to the previous case study, now there exists an integration hub to coordinate the tasks and the request is forwarded through this hub as described at Hub-and-Spoke Integration section.

Customer, who is once more considered as an autonomous pool, requests a plastic issuance or reissuance through a bank's application such as Internet Banking website and CRM. Though, the process will not start immediately as it is a batch process it may be executed only one or a few times per day. As a result, a timer start would be needed to describe the start of its execution.

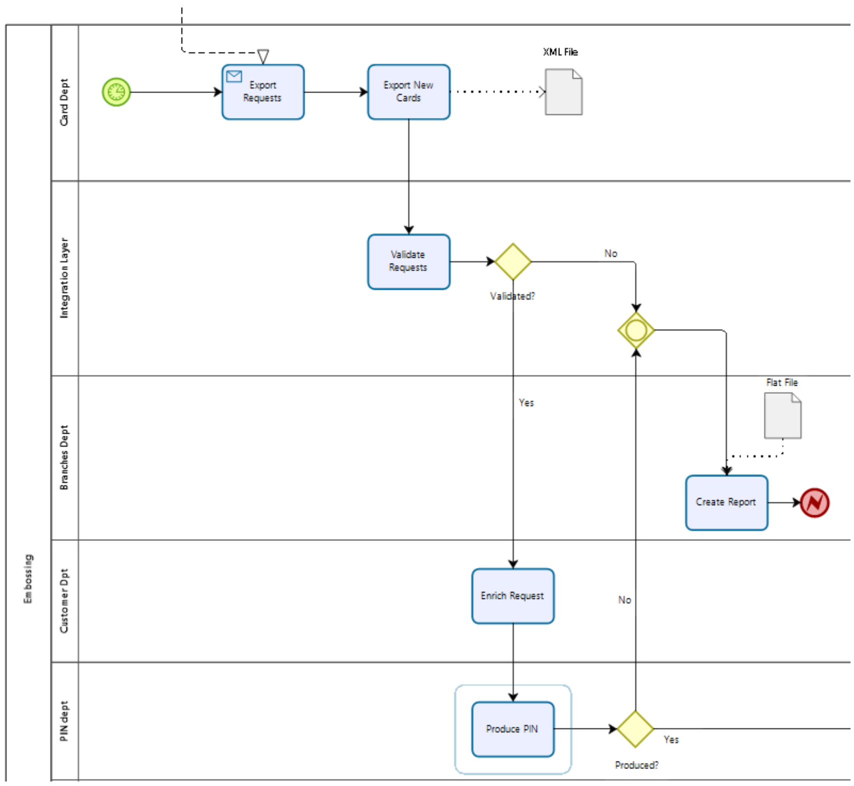


Figure 42 – Start of Process

Once the timer is enabled and the process has started, card department will export a file that contains all the requests that were not served till then. Integration Layer will receive the file and validate that its format. If the format is valid, then the integration layer forwards the message to Customer's department and PIN department in order to enrich the request and produce new PIN. If any of these actions fail, then a report should be created for branches department that will inform all the tellers for the process' abnormal end.

After a successful execution of the previous steps, Integration Layer will receive the enriched request transform the data to the suitable format that is provided from the printing company and forward the file outside the organization. Obviously, a new pool needs to be created for this 3rd party company that is responsible for the printing.

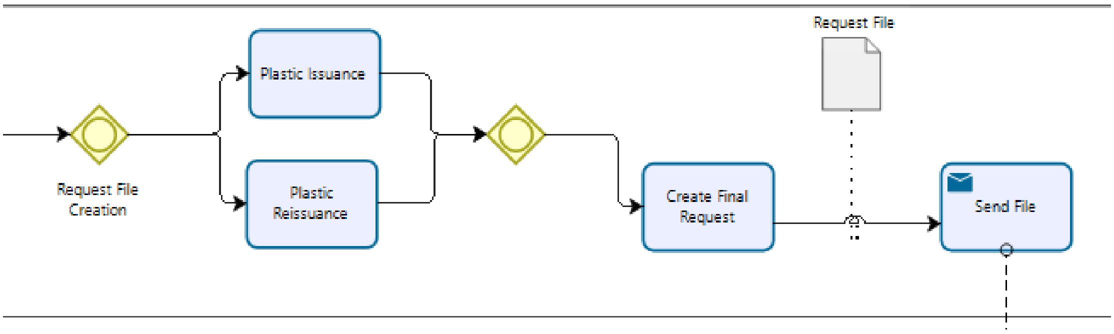


Figure 43 - Integration Layer Transformations

At this case, Integration Layer will wait for the external system's response and once it receives it, it performs again the needed file transformations. IL will forward the message at parallel to the next departments and once it will receive reply from all of the will deliver the card to the customer and that will be the closing activity of the process.

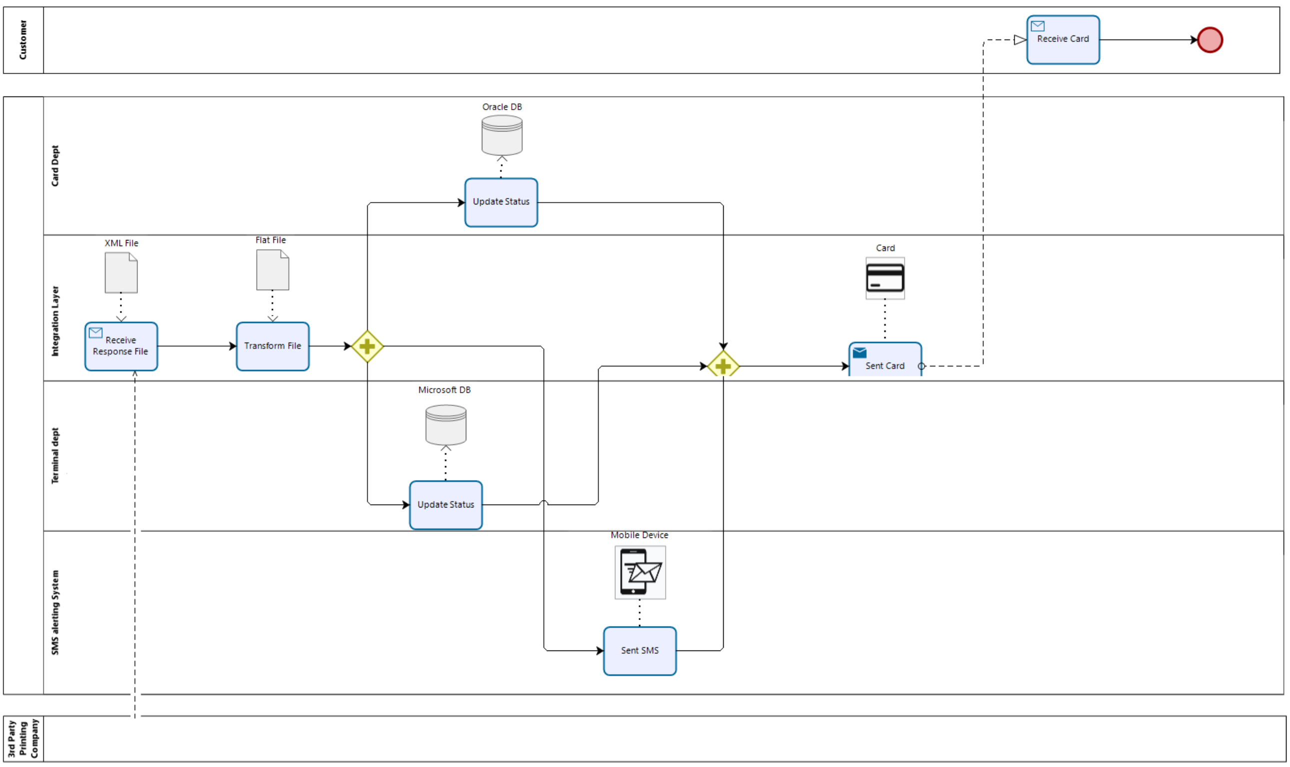


Figure 44 - End of Process

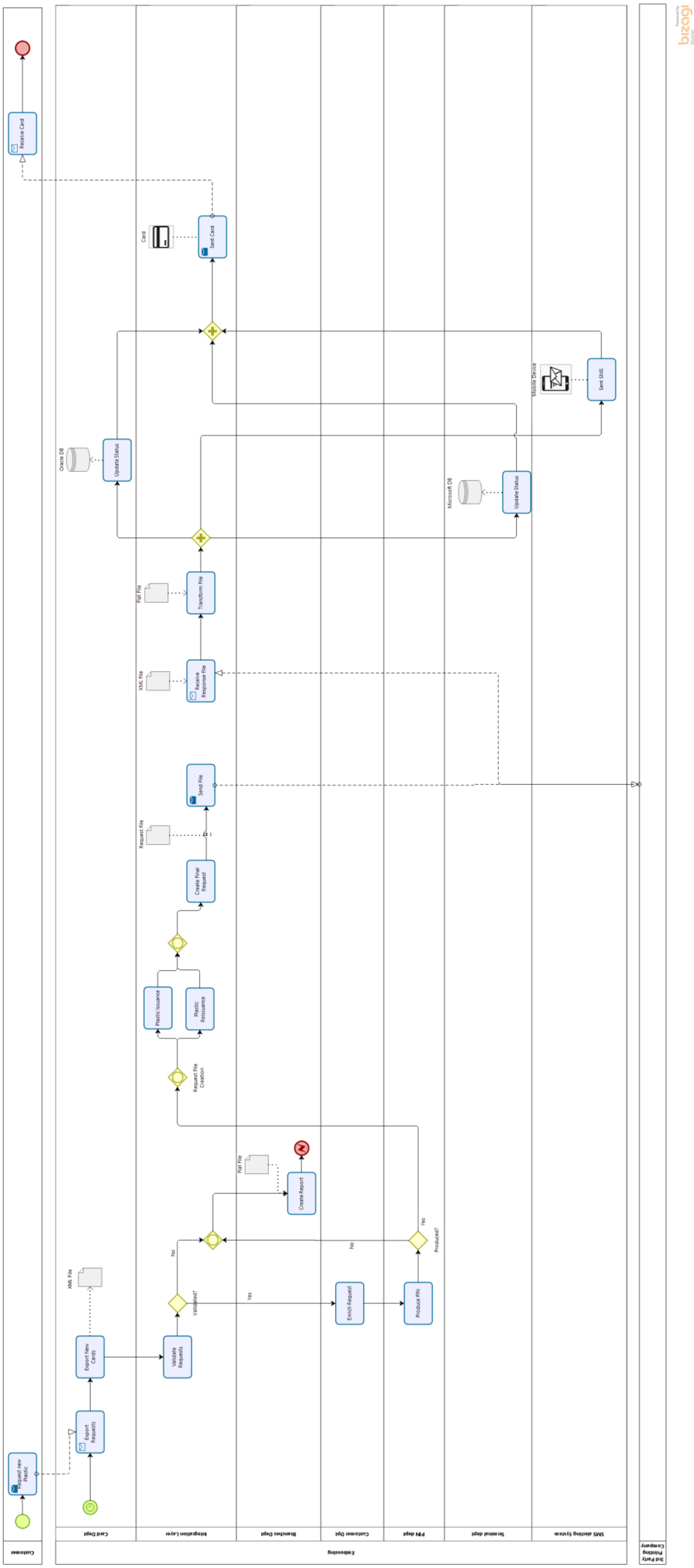


Figure 45 - Embossing Process

6.2.2. RPA Application

At batch processes that commonly use files and databases the integration hub has to do a lot of work in order to accomplish the accurate communication of many different systems. For that reason, many different platforms for building enterprise-level data integration and data transformations solutions, which are largely used in regular and ad-hoc processes. RPA can easily orchestrate the processes that should be executed based on events.

For instance, if we assume that all the processes of an organization are logged on a table.

```sql
select * from process_log;
```

	id	process_name	process_id	execution_timestamp	status
1	1	Import File	3010	2019-06-11 01:47:00.000	S
2	2	Export File	3011	2019-06-11 01:48:00.000	S
3	3	Import File	3012	2019-06-11 01:49:00.000	S
4	4	Import File	3013	2019-06-11 01:52:00.000	S
5	5	Import File	3014	2019-06-11 01:57:00.000	S
6	6	Export File	3015	2019-06-11 02:01:00.000	S
7	7	Export File	3016	2019-06-11 02:18:00.000	S
8	8	Import File	3017	2019-06-11 02:19:00.000	S
9	9	Import File	3018	2019-06-11 02:32:00.000	S
10	1	Export File	3019	2019-06-11 02:37:00.000	S
11	1	Import File	3020	2019-06-11 02:41:00.000	S
12	1	Import File	3021	2019-06-11 02:41:00.000	S
13	1	Import File	3022	2019-06-11 02:48:00.000	S
14	1	Import File	3023	2019-06-11 02:49:00.000	S
15	1	Import File	3024	2019-06-11 02:52:00.000	S
16	1	Export File	3025	2019-06-11 02:57:00.000	S
17	1	Import File	3026	2019-06-11 02:59:00.000	E

Figure 46 - Process_log table

Additionally we can assume that there is also a derived table with more details regarding each process' execution.

```sql
select * from process_details;
```

	id	message	process_id	status
17	17	Process Started	3026	S
18	18	Process Finished	3010	S
19	19	Process Finished	3011	S
20	20	Process Finished	3012	S
21	21	Process Finished	3013	S
22	22	Process Finished	3014	S
23	23	Process Finished	3015	S
24	24	Process Finished	3016	S
25	25	Process Finished	3017	S
26	26	Process Finished	3018	S
27	27	Process Finished	3019	S
28	28	Process Finished	3020	S
29	29	Process Finished	3021	S
30	30	Process Finished	3022	S
31	31	Process Finished	3023	S
32	32	Process Finished	3024	S
33	33	Process Finished	3025	S
34	34	Process Interrupted	3026	X
35	35	Error: 2000	3026	X

Figure 47 - Process_details table

The development team may be already aware of some common cases where some processes returns errors and have implemented the proper solutions in order to protect the total process' abortion. Considering that at huge workflows a process' completion can be a precondition for other processes to start their execution it is really important to avoid blockers of any level.

At this use case for example the Integration Layer may face an error while importing the file that was previously exported from card department. At the case that the error concerns one particular row/record/request and not the whole file the development team along with the business analysts decided to exclude the problematic record from the file and continue the process' execution. Such errors are very common at Integration Layers and can be easily handled by data integration/transformation platforms. At our example, to accomplish the integration we created a very simple SQL Server Integration Services solution provided by SQL Server Data Tools 2015. This package receives a delimited flat file with the following format.

```
Debit;A Avliotis;New;5555555555;1001
Debit;K Papadopoulos;Renewal;4444444444;2000
Debit;S Tsitsipas;New;666666;4546
Debit;A Petretzikis;New;888888888;0004
```

Figure 48 - File's format

As shown at the earliest screenshots that contains data from [dob].[process_log] and [dob].[process_details] tables, an error has occurred while importing the file at the record with unique_id = '2000'. SSIS package simply needs to load the file to a table ([dbo].[resp_table]) and exclude the problematic record from the file. This can be completed by joining process_details and resp_table tables, executing the following SQL statement:

```
"delete [dbo].[resp_table]
where unique_id in (select
SUBSTRING(pd.message,8,4) as
problematic_request from  [dbo].[process_log] as pl
join [dbo].[process_details] as pd
on pl.process_id = pd.process_id
where pl.status = 'E'
and pd.message like '%Error%'
)"
```

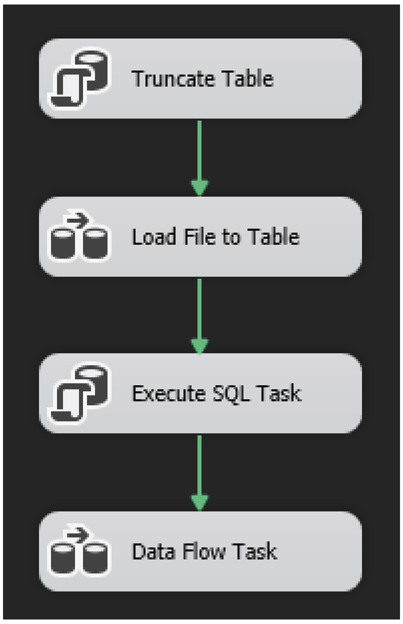


Figure 49 - SSIS Control Flow

There may be too many solutions like the above that are often executed ad-hoc and they are not part of the regular workflow. As long as the decision of which one should be executed is quite obvious despite the number of the times that each are called the process can return pretty good outcome without redesigning.

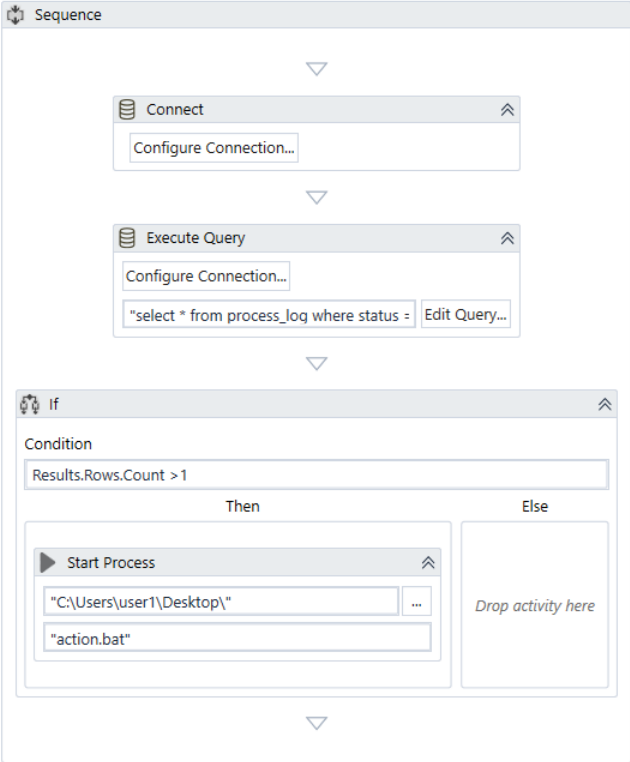


Figure 50 - Sequence that coordinate processes

6.3. Summary

At this chapter some basic RPA implementations where attempted in order to study their affection on business process. Organizations can gain great benefit by RPA software that identifies the error and just calls the prebuilt solution to deal with the problem. In that way the organization can take advantage of the legacy codes that can still give impact without any need to build something from scratch. That literally takes much shorter time than redesigning the process and accomplishes the basic goal of RPA implementation. It takes the robot out of human.

7. Discussion and Conclusions

This chapter concludes this thesis and provides an overview of the main outcomes and the research contributions. In addition, the limitations of this research are discussed along with the issues that could have a potential for future work.

7.1. Thesis Overview

The aim of this thesis is to bridge the gap between Business Process Management and quick improving results of business process execution. The proposed solution was RPA implementation that can assist an organization's the existing business processes and support the future ones.

Industries with organizations that contain complex business processes which involve a lot of participants and include great technical integration challenges were considered the best environment to study. As a result, the analysis of BPM and RPA was based on the banking sector which meets the above criteria.

Marlon Dumas and Mathias Weske have placed the most interesting approaches over Business Process Management, that are considered until today integral parts of every healthy organization. They declared the components of business processes, described integration models, proposed process analysis models and provided all the properties to make a business process model executable. The effective handling of the above properties creates great opportunities to improve business processes by doing them faster, cheaper more qualitative and flexible.

The most famous technique that automates any portable part of procedural work and maximizes the efficiency of business process is called automation. Nowadays a trend way to apply automation is by implementing Robotic Process Automation solutions, which deal with structured data, rule-based processes, and deterministic outcomes and target to take the robot out of the human. Willcocks was the one that attempted to highlight the capabilities of RPA, although some big brands are still cautious about the underlying risk.

Considering that the deployment effort of RPA is said to be minor, we tried to implement some RPA processes In order to find out how effective they are. Our conclusion is that even true enterprise BPM comes with a rich set of capabilities not available at least yet in RPA, this approach could be very valuable for minimizing manual, repetitive and rule-based tasks that do not require complex decision making.

7.2. Research Contribution

As there is a lot of discussion around RPA and whether it replaces BPM, this research concluded that RPA and BPM have a lot of crucial differences and they are not competitors. On the contrary, implementing BPM and RPA together can bring about much greater process automation and value that one technology approach alone may not be as positioned to achieve. The great percentage of RPA projects that are not meeting the deadlines should warn everyone about the underlying risks and the reason why an RPA implementation may fail. Although, the fact that RPA can act as an API for legacy applications, in cases where there is no easy way to integrate with an application, and orchestrate modules concluded that RPA is a great tool at BPM toolbox.

7.3. Research Limitations

The first limitation of this research comes from the fact that all those manual and rule-based tasks, that are going to be minimized, are at first identified correctly. Misconduct will result the negative results of automation and will magnify the business process inefficiency and rather than taking the work out of the human, it might need several man-days to revert the situation.

The second limitation originates from the BPM is considered the most effective discipline that improves operational performance of organizations. As a result, there was not made any attempt to combine RPA with other famous disciplines such as Total Quality Management (TQM), Lean and Six Sigma.

7.4. Future Work

In light of the potential and the advantages of this project identified during the process, there are issues that could be potentially explored. As mentioned the famous Chatbots can gain great assist from RPA. Future research on this area could focus on implementing RPA event-driven solutions where clients' demands could be served online by ad-hoc could return great outcomes. The waiting time will be greatly reduced, the resources will be allocated dynamically and the organization will be able to reduce long batch processes that demand difficult maintenance.

Finally, serious work should be made in the future for enabling RPA to manage more difficult activities. Database administration is a difficult, but very interesting, area that worth studying. Even if this area required a broad spectrum of knowledge, RPA can assist DBAs by automating tasks that concerns backup, memory, recovery and internal operations. Even if they may need to handle a huge amount of data, the way that these data are stored can help their easy development. Cognitive RPA could direct inform developers on how to improve their queries by changing execution plans and tables' indexing, even if the developers are not aware of their existence. Once more, adding RPA to optimize processes to risky areas with great responsibilities will not be easy, but still it worth researching.

7.5. Conclusion

This thesis presented a complete approach of BPM and RPA. The emergence of RPA in complex industries such as Financial Services and Manufacturing creates great potential and will give huge impact reducing human errors, fraud and waiting time in the future. The fact that 47% of tasks can be automated using RPA, reducing time about 40% makes workforce automation one of the biggest trends to disrupt the tech world. Companies should be careful about the underlying risks though. Cybersecurity, governance, platform resiliency and transparency issues are common and this strategic decision needs to be implemented only after assessing the ROI. The results of the whole research were very promising and indicated that BPM and RPA can help each other to build goal driven processes that can adjust to changing business needs.

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