UNIVERSIDAD DEL ROSARIO

From digitalization and automation to the revolution of the digital workers: An analysis of RPA technology.

Trabajo de Grado.

Autor:
Matthieu Ribaucourt.

Bogotá

2019

UNIVERSIDAD DEL ROSARIO

From digitalization and automation to the revolution of the digital workers: An analysis of RPA technology.

Trabajo de Grado

Autor:

Matthieu Ribaucourt

Tutor:

David Enrique Anzola Pinzón

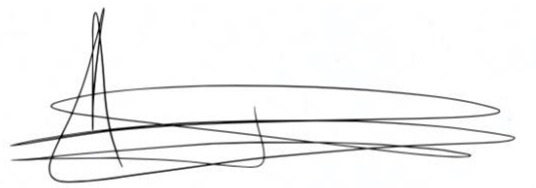
Maestría en dirección

Bogotá

2019

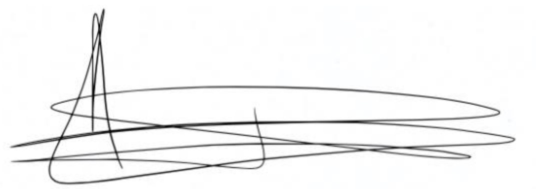
Declaración

Declaración de autonomía: "Declaro bajo gravedad de juramento, que he escrito el presente trabajo de grado de maestría por mi propia cuenta, y que, por lo tanto, su contenido es original. Declaro que he indicado clara y precisamente todas las fuentes directas e indirectas de información, y que este trabajo de grado de maestría no ha sido entregado a ninguna otra institución con fines de calificación o publicación".



Matthieu Pierre Graziano Ribaucourt
13/12/2019

Declaración de exoneración de responsabilidad: "Declaro que la responsabilidad intelectual del presente trabajo es exclusivamente de su autor. La Universidad del Rosario no se hace responsable de contenidos, opiniones o ideologías expresadas total o parcialmente en él".



Matthieu Pierre Graziano Ribaucourt
13/12/2019

Table of contents

Table of figures

Abstract

Digitalization and automation in the revolution of digital workers. Nowadays many new technologies are emerging to help simplifying our work and improve a company's efficiency and profitability. The robotic process automation (RPA) is one of them. There are various papers treating RPA. They analyze its scope of action, the saving that it can bring, the effect on services improvement, etc. But fewer are trying to understand where these technologies come from and what is the best way to implement and use them. This paper tries to analyze those two aspects. To do so, we used, on one hand, a corpus of specialized articles and, on the other hand, knowledge retrieved from a consulting firm working on RPA implementations in various countries. We will also use a Colombian business case of implementation to illustrate our research.

Introduction

“The relationship between technology and people has to change in the future for the better, and I think RPA is one of the great tools to enable that change”. Leslie Willcocks, professor of technology, work, and globalization at the London School of Economics.

In a context of globalization, intensified economic competition and constant technological change, companies more than ever are seeking to improve efficiency, lower costs, and provide a better level of services (UNDESA, 2007). To do so, organization are using various combinations of technological and methodological innovations. This work will focus on a tool that combines two domains, technology and process improvement: Robotic Process Automation (RPA). RPA allows the creation of virtual robots programed to automatically perform specifics tasks in companies. The main purpose of this technology is to automate repetitive tasks that previously required a human to perform and, therefore, improve efficiency, rapidity, precision, and, of course, profitability. But the technology also represents a real challenge for workforce organization.

Today we notice a great interest in new technologies and the benefits they can bring about, but also a lack of information about how to implement them correctly and successfully in an organization. Many directors are directly speaking of FTE (full time employees) reduction, costs savings, and automation, but few are talking about reorienting employees’ tasks related to added values work, error reduction, higher activity for employees or governance model. Since this type of technological implementation is often outsourced, few companies have the internal capacity to evaluate and plan such a change. Since RPA is developing quickly in many countries (Deloitte, 2017), it seems interesting to analyze an implementation methodology.

Technological innovation such as RPA will brings many changes in the way people work while also having a significant impact on job location, destroying jobs that are common and accelerating the movement of business process outsourcing (Sethi & Gott, 2017). Colombia is a good example of this change because, between 2011 and 2015, it won 12% of new business process outsourcing and shared services in Latin America (Sethi & Gott, 2017). These changes are now becoming a reality and criticizing them or denying them will not change the facts that society has to prepare for them (Arogyaswamy & Hunter, 2018). To do so, it is important first to understand the origins of RPA and how to implement a digital workforce that will help and support real human workers.

To try to respond to this problematic, we will try to contextualize the emergence and development of RPA and propose a methodology and best practices to implement this technology successfully with the consideration of business and workforce interests. To do so, we will use a theoretical approach based on secondary analysis of scientific articles, books, and business studies, combined with practical knowledge and documents gained from consulting firm experience.

In the first section we will focus on the evolution of computer science and processes automation that led to the creation of RPA. The second section will be dedicated to defining RPA, its actors, fields of actions, and benefits for companies. The last part will propose a methodology of implementation and an analysis of a real-world case of RPA implementation in Colombia.

From digitalization to automation: History and concepts

The first section of this work is dedicated to describing the evolution of computer science and the automation concept and techniques. The aim is to understand how those two fields are combining in the RPA technology.

History: From ENIAC to RPA

The pioneers

The beginning of what we call now computer science was closely related to metamathematical theorical discover, as it’s based on computing and algorithms (Ralston, 1981). Many of the pioneers of computing were mathematicians, like Alan Turing.

The first computers were born from a necessity to perform complex computation in a short time period. The word “informatic” is a combination of “information” and “automatic” and was first used by German scientist Karls Steinbuch in an article from 1957 “Informatik: Automatische Informationsverarbeitung” ("Informatics: Automatic Information Processing").The creation of computing and its reprogramming capabilities had a huge impact on humanity in terms of productivity, work, entertainment, and education (Olsen, 2013).

In 1936, the publication of “On Computable Numbers, with an Application to the Entscheidungsproblem” by Alan Turing (1937) and fundamental research led by A. Church and K. Gödel constituted the theoretical basis of computer science. Alan Turing, historically known for helping the Allies during the WW2 to decipher German codes, was the inventor of the theoretical machine known as the “Turing Machine”. Even if this theoretical machine was never meant to be materialized, it inspired the future creators of real computers (Cooper & van Leeuwen, 2013).

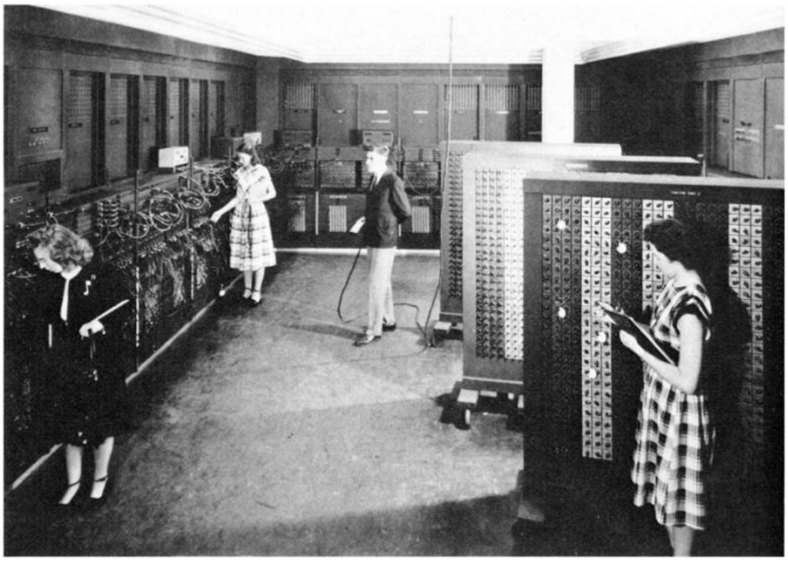


Figure 1 Electronic Numerical Integrator and Computer (ENIAC), 7 July 1948. Ballistic Research Laboratory, Aberdeen Proving Ground, Aberdeen, Maryland. Reprinted from Platzman (1979).

The change from mechanical to electronic technology in computer science provided significant improvements in speed (Allan, 2001). In 1945, the first entirely electronic computer, the ENIAC[1] (Figure 1) was created in the United States and was able to solve numerical problems through reprogramming. ENIAC contained 18.000 vacuum tubes and was able to process 5000 arhythmical operations per second. It was used by the US military to calculate artillery firing tables (Light, 1999). In 1947, the invention of the transistor by the Bell Telephone Laboratories led to the second generation of computers by replacing vacuum tubes. This smaller and more efficient component allowed companies like IBM to create computers more suitable for the public use, such as the first hard drive computer, the RAMAC 305, or the IBM 1401, the first computer that, thanks to its affordable price, sold over 10.000 units (The Irish Times, 2009). In this period, IBM became the world leader in computers.

[1] ENIAC: Electronic Numerical Integrator And Calculator – First computer built by J. Mauchly & J. Presper Eckert from the University of Pennsylvania.

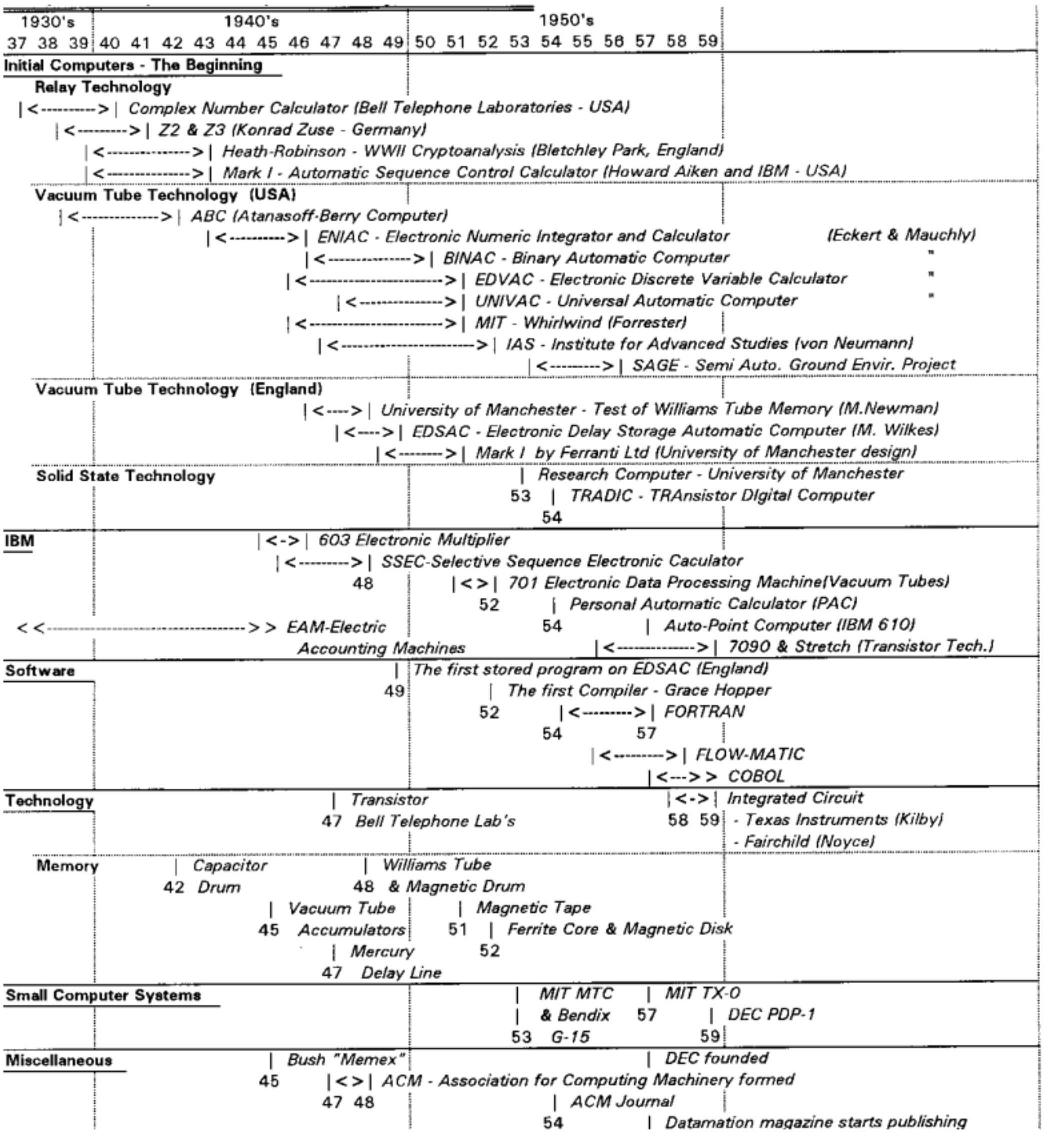


Figure 2 Graphical history of early computer technology (1937-1959). Reprinted from Allan (2001).

In Figure 2, Allan (2001) graphically represents the evolution of early computing. This is a good summary of what we developed in this section and what will be the basis of the technology's democratization.

Democratization of computers

The 60's were a decade of great improvement in informatics, one of which was due to an invention by Jack St. Clair Kilby in 1958: integrated circuit (Bhat, 2012). It was in 1963 that the first computer using this technology appeared, allowing the creation of much more compact and efficient computers. The MIT LINC, created by Wesley A. Clark in 1962 (prototype), is considered by many as the first personal computer, even though it was about the size of a refrigerator (Allan, 2001). But the 60's were also the beginning of user experience improvement. Whereas in the 50's computers were only used for computing tasks, in the decade that followed came the first user interface and "mouse". We can also note that these inventions were mainly the result of US government research investment in organizations like the Massachusetts Institute of Technology (MIT) and the Advanced Research Projects Agency (ARPA), part of the US department of Defense. These technological evolutions allowed the great innovation in the manufacturing of computers. Companies like IBM, Hewlett-Packard, and Data General led the market. At the end of this decade, computer size had significantly reduced and user interaction was greatly improved. However, the complexity of their construction still meant computers were very expensive and inaccessible to the public.

The 70's marked a turning point in the evolution of computer science with the invention of the microprocessor by engineers at Intel. A microprocessor is a computer processor that incorporates all the elements of a central processing unit in a single integrated circuit (Osborne, 1976). This invention led to a phenomenal improvement in computer calculation capacity and size. The increased number of components integrated in a microprocessor, which was determinant in improving these two factors, is known as the Moore's Law (Moore, 1965). This law states that the number of transistors in a semiconductor chip would double every year, a period of time that would later become 18 to 24 months. This statement effectively described the evolution of transistors in integrated circuits (Figure 3) and had a great impact on computer science.

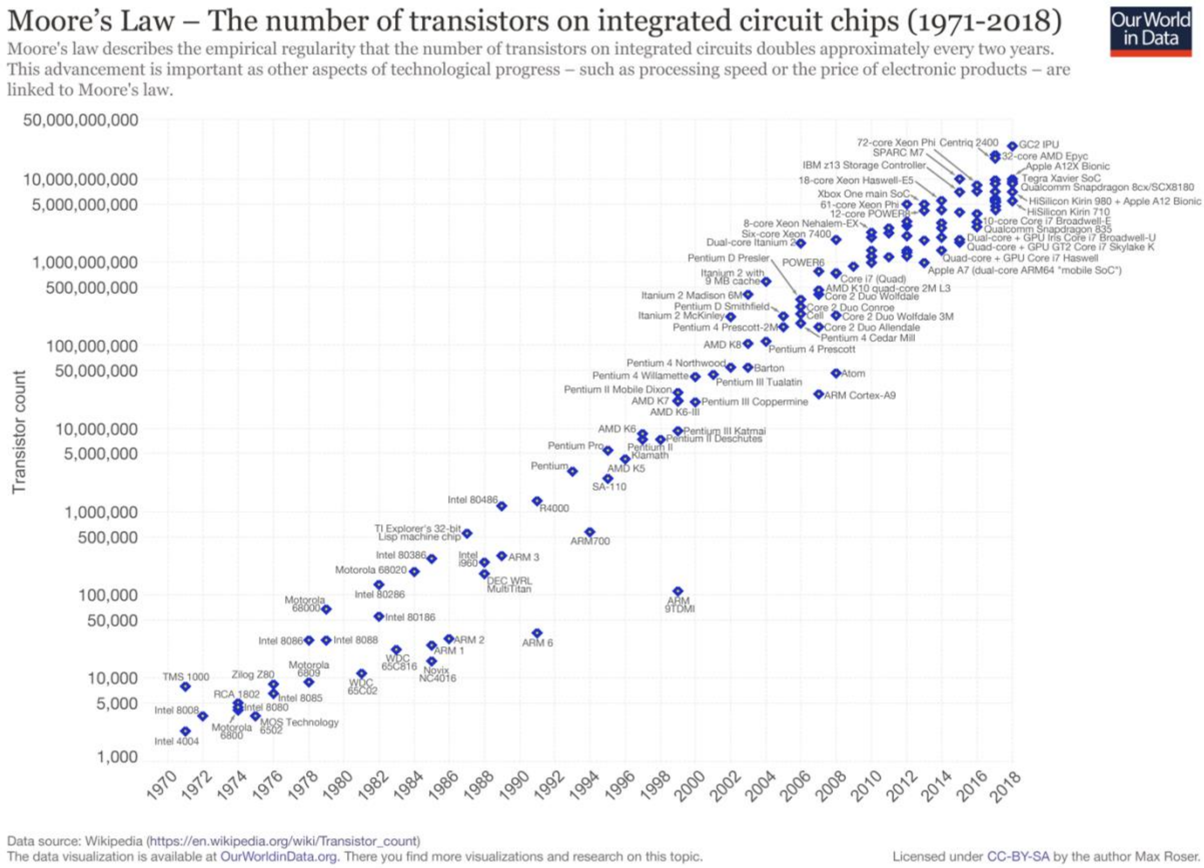


Figure 3 he number of transistors on integrated circuit chips (1971-2018).Reprinted https://ourworldindata.org/uploads/2019/05/Transistor-Count-over-time-to-2018.png

These technological changes considerably reduced the complexity and costs of computers in that decade. This fact, combined with considerable change in user interface, led to the creation of personal computers accessible to a larger part of the population (Figure 4).

From this period on, the real change was in software rather than hardware. Even if the design and the capacity increased during the 80's and the 90's, the most relevant change occurred in interface, new software, and coding languages. The 80's are considered the golden age of personal informatics and the beginning of office automation. This process was facilitated by the creation of exploitation systems that incorporated graphic interface, making the use of computers possible for the general public (Myers, 1998).

Figure 4 The three computers Byte magazine referred to as the "1977 Trinity." From left to right: The Commodore PET 2001, the Apple II, and the TRS-80 Model. (2001). Retrieved from https://en.wikipedia. org/wiki/ File:Trinity77.jpg

In 1984 and 1985, the release of Macintosh and Microsoft exploitation systems that integrated the use of mouse and keyboard with icon interaction democratized informatics and allowed the creation of numerous software programs, which facilitated office work around the world.

From this period on came numerous other innovations that led to the computers we now know in terms of size, performances, and price. We will skip these evolutions—since everybody is now familiar with these machines—and focus on two lesser known breakthroughs, the internet and cloud computing.

The revolution of cloud computing

The revolution of cloud computing is directly linked to the creation, improvement and democratization of the internet. The internet was born from US military research, led by the ARPA[2] during the 60's, which was intended to create the "Galactic Network" described by J.C.R Licklider in a 1962 memo (Leiner et al., 2009). This communication method is based on a packet-switched network[3] that allows computers to interconnect and quickly access data and programs from one another. It was originally designed to work in "closed network", which means that computers are allowed to communicate only with specifics users determined by

[2] Advanced Research Projects Agency.
[3] Packet switching is a method of grouping data that is transmitted over a digital network into packets. Packets are made of a header and a payload.

permission or geographical position. But when the idea of open-architecture networking was introduced, it evolved to become the internet we know today. It was during the 90's, with the creation of the first browser called WorldWildWeb by Sir Tim Berners-Lee (Myers, 1998), that the Internet started to became popular and spread throughout the world. In 1998, 3 out of every 100 people worldwide were using the internet, By 2018, the number had reached 48 (Figure 5).

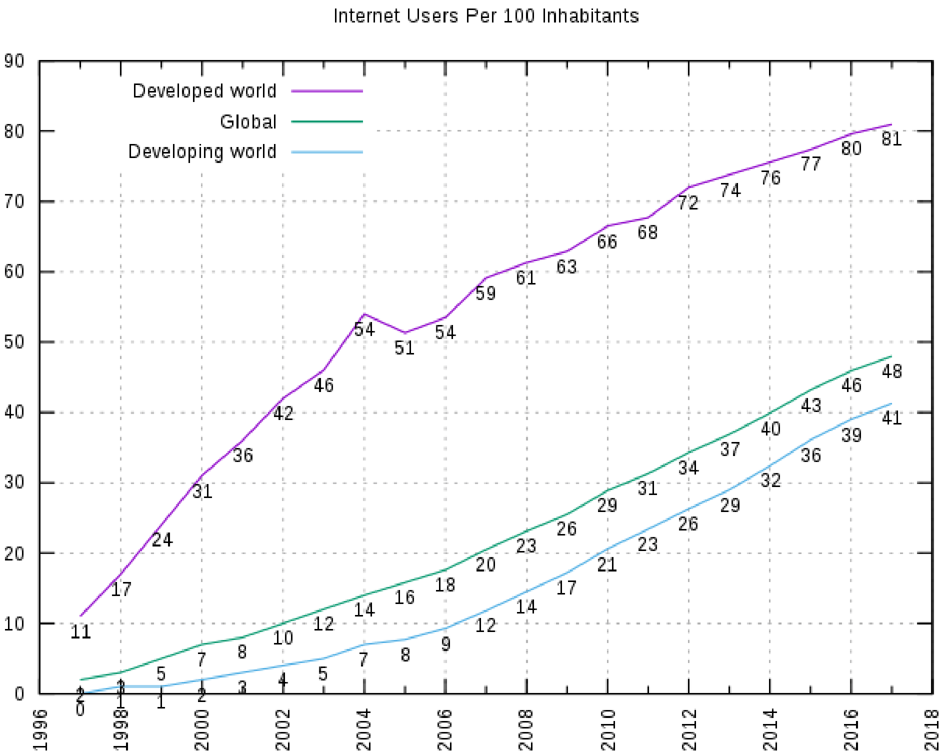


Figure 5 "Internet users per 100 inhabitants 1997 to 2017" years on the x axis, number of users on the y axis, according to the International Telecommunication Union (ITU).Reprinted from https://en.wikipedia.org/wiki/Global_Internet_usage#/media/File:Internet_users_per_100_inhabitants_ITU.svg

The evolution and democratization of the internet led to huge increase in computers, from about 2 million in 1994 to over 200 million in 2004 (Cave, Majumdar, & Vogelsang, 2005). This automatically generated the need for strong, reliable infrastructure that could provide the required connectivity speed and uninterrupted operation.

The improvement of shared internet infrastructures, like data center, available simultaneously to a great number of users, allowed for the creation of a new way of managing IT resources: cloud computing. Said IT resources can be used "on demand" and offer both hardware and software solutions. In 2006, Amazon was the first major cloud provider, rapidly followed by Microsoft and Google (Ruparelia, 2016).

This new paradigm considerably reduces the cost of hosting and running any type of application. Before this technological change, all applications were “on premise”, which mean they were entirely hosted and managed in the client infrastructure. This required a great deal of material and maintenance. With cloud infrastructure, the client can outsource a portion of or the entire application within the provider facilities (Buyya, 2010). We can note 3 major architectures: Infrastructure as a service (IaaS), Platform as a service (PaaS), and Software as a service (SaaS).

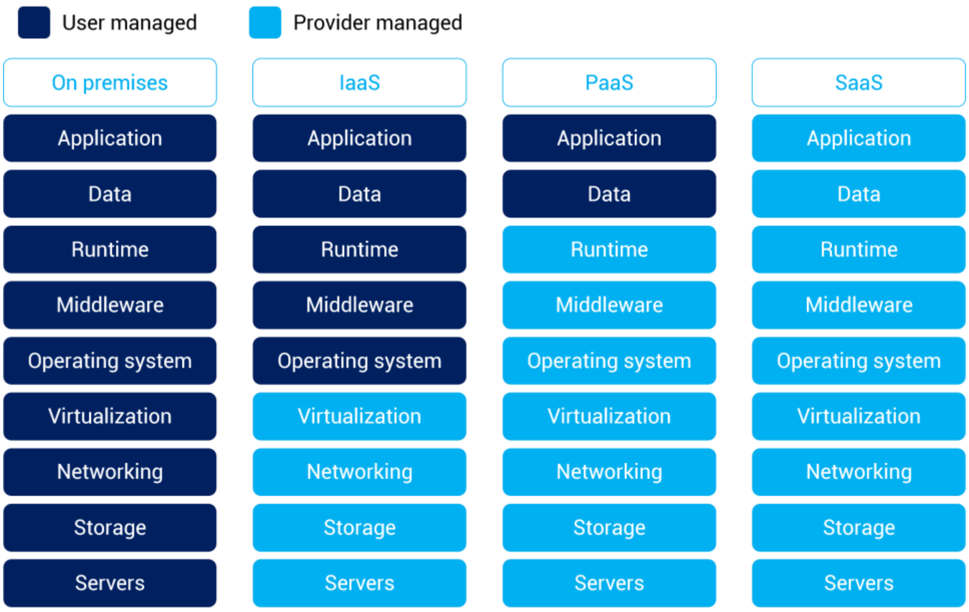


Figure 6 Cloud computing infrastructure models. Reprinted from Alibalcloud, Retrieved from https://www.alibabacloud.com/knowledge/what-is-iaas

Figure 6 shows the different abstraction levels that cloud computing can create. On the Infrastructure as a service model (Iaas), only the hardware infrastructure is outsourced (servers, storage, etc.). The platform as a service model (Paas) includes the operating system and enables the client to install and run software from the platform. The Software as a service (SaaS) model includes hosted applications. The client simply uses the applications when needed, avoiding the work and cost to install and maintain it (Buyya, 2010). Companies will choose their level of abstraction based on their number of users, financial capacity, IT needs, and maturity. These infrastructural changes allowed by the communication facilitated by the internet has modified the way that companies use IT. It creates scalability, agility, enhanced performance, and democratization of the connected applications (Ruparelia, 2016). Companies can have access to effective IT, reduce the time required to go to market, and align IT resources with business environments without investing in expensive hardware installation (Marks & Lozano, 2010).

All these technological breakthroughs have allowed us to digitalize, facilitate, and automate numerous processes and manual tasks, such as communication, accountancy, redaction, graphic design, etc. These digitals tools are now part of every aspect of our life as productivity, social, and entertainment tools.

The RPA (Robotic Process Automation) is a direct application of this modern technology combined with the much older process of automation. Simple automation applies to mechanical processes like manufacturing, whereas RPA applies to digital processes within companies. It uses the very same methodology and has the same goals, such as increasing efficiency, reduction of tedious tasks or control of production. Because RPA is an adaptation of the historical concept of automation, it is important for understanding automation's history and the concepts related to it.

The evolution of automatization

First, we can define automation as the technology by which a process or procedure is performed with minimal human assistance (Groover, 2014). We can divide the process of work automation into two main areas, operational processes and administrative processes. They both revolutionized the way we work and drastically improved productivity. In this section, we will describe some applications and effects of operational automation. The administrative automation will be described in the RPA section.

History

Many inventors and engineers have worked to improve and facilitate human labor. Without entering into the details of the various technical evolutions, we can mention some big turning points, such as the First Industrial Revolution, which took place around 1750 with the invention of the steam machine. This invention changed production systems entirely and in 1759, James Watt invented a performant steam machine (Russell, 2014).

These technological changes led to the creation of numerous machine that led to productivity improvement. Whereas global production took 120 years to double between 1700 and 1820, these technical changes allowed it to double between 1820 and 1870, a period of just 50 years (Graff, Kenwood, & Lougheed, 2014).

Global production increased again thanks to the Second Industrial Revolution. This industrial revolution is characterized by new energy sources likes electricity, petrol, and the evolution of chemistry, as well as by new organizational working methodologies.

Figure 7 Daimler Schroedter-Wagen in the Mercedes-Benz museum of Stuttgart (2012). Retrieved from [https://commons.wikimedia.org/wiki/File:Das_erste_Auto_ der_Welt.jpg?uselang=fr](https://commons.wikimedia.org/wiki/File:Das_erste_Auto_der_Welt.jpg?uselang=fr)

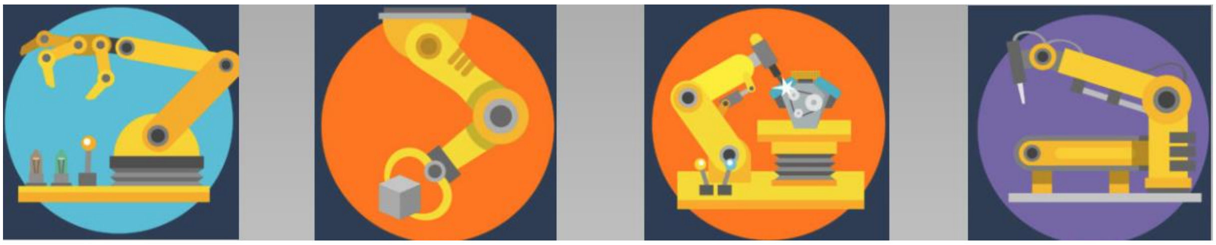
The first cars emerged during this period. Eugenio Barsanti and Felice Matteucci, two Italian engineers, invented the first internal combustion engine, which was later perfected. The automotive industry was one of the most affected by these changes in production and technology (Zmolek, 2013). Figure 7 shows the first mass production car model, invented by Daimler Schroedter-Wagen in 1892.

These changes turned an agricultural and artisanal society into a technical and industrial one. Production was now organized in a scientific way to maximize productivity. This change was fundamental to what we now call automatization. To illustrate the new production paradigm, we can look at Figure 8, a picture of Ford Factories in the 20th XX century, a pioneer organization of mass production (Zmolek, 2013).

Figure 8 Ford factories in 1904. Retrieved from https://auto.lapresse.ca/actualites /ford/201310/06/01-4697008-ford-la-chaine-de-montage-a-100-ans.php

Modern automatization

These industrials revolutions coupled with informatic development (also called the Third Industrial Revolution) led to an increase in the amount of machinery in all industries (Yin, Stecke, & Li, 2018). The technical progress in computer science allowed the creation of autonomous computer-guided machines. Robotization is used in production in 4 main areas illustrated in figure 9.



Manipulation at high velocity	Conditioning products	The assembly of product	End of production line (wrapping, Palletization…)

Figure 9: Role of automation in production. Reprinted from Seram-industrie, 2019, Retrieved from https://seram-industrie.fr/competence/robotique

A good example is the Tesla factory in Fremont, California, illustrated in Figure 10. The factory, with more than 160 car-constructing robots, is known as being one of the most robotized in the world. The creation of an automated production line eliminated non-ergonomic work for humans and sped up the construction process (Field, 2019).

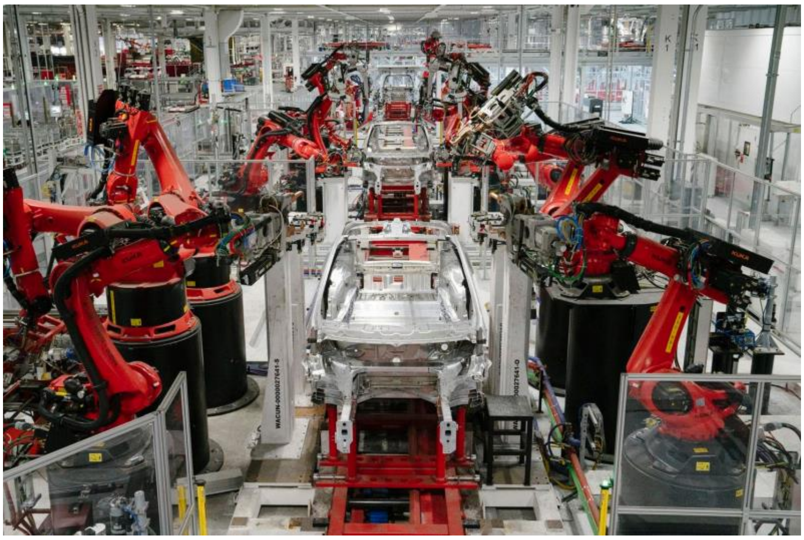


Figure 10 Tesla factory, California. Retrieved from.https://cleantechnica.com/2019/03/31/a-look-inside-teslas-fremont-automotive-factory-cleantechnica-exclusive/

The robotization of the production industry has increased the level of productivity in every industry —no human can compete with the velocity and accuracy of the machines. There is no turning back from this movement of mechanization of work. The Tesla factory is a good example of this increased productivity, as can be seen in Figure 11.

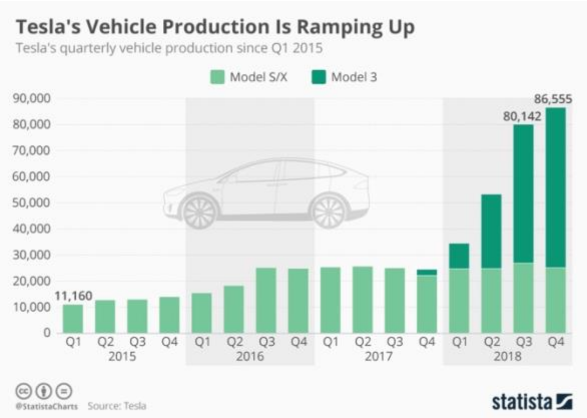


Figure 11 Tesla's vehicle production is ramping up. Reprinted from https://www.statista.com/chart/13435/tesla-vehicle-production/

This evolution is a combination of mechanical robots and computer science. The robots are using complex software to act as effectively as possible while generating data to analyze and improve their work. This will lead us to the Fourth Industrial Revolution, where the entire system involved in the production process is interconnected, analyzes production data and takes actions independently to correct and improve itself. This new paradigm is based on technologies such as IoT, Big Data, cloud computing, and artificial intelligence (Figure 12).

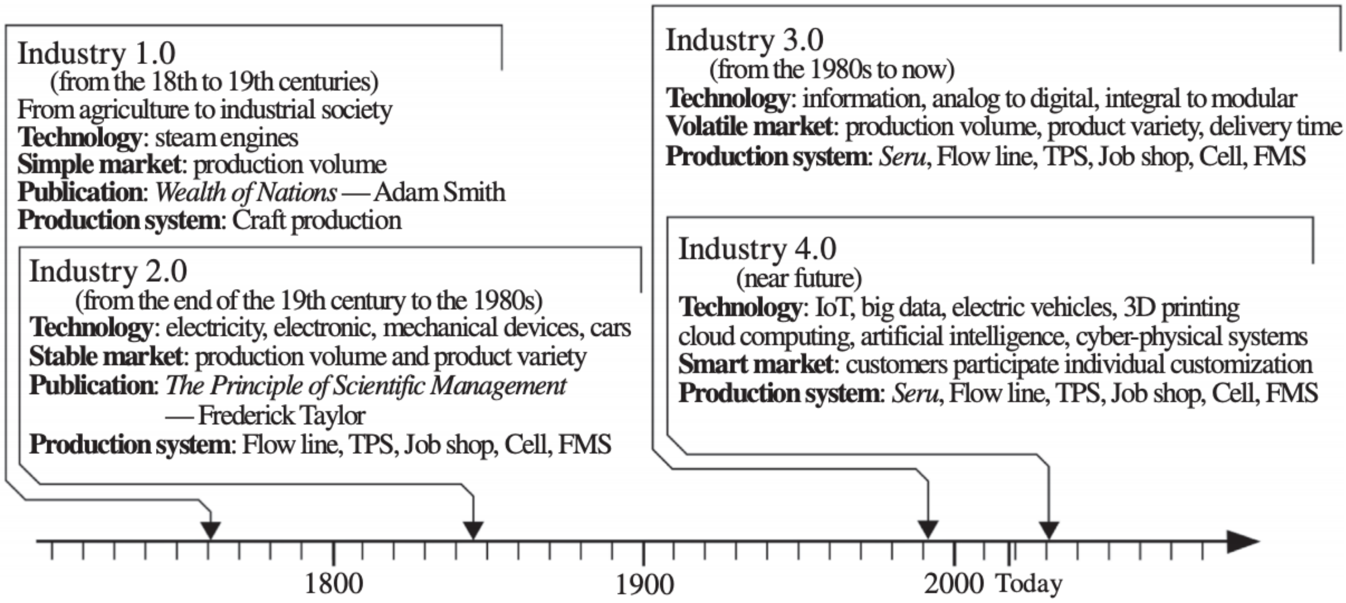


Figure 12 Timeline of Industry 1.0-4.0. Reprinted from Yin, Stecke & Li (2017).

As we have seen in the last two centuries, there has been a technological revolution in energy, production, and management of information. This has allowed us to increase production of goods in every industry. The help of informatics combined with mechanical engineering and now AI[4] has become a powerful tool for production throughout the economy. This process allows for the reduction of repetitive and non-ergonomic work, while at the same time reducing costs and production time.

Informatics, meanwhile, have helped us in many administrative processes, but even if it is now possible to create software that automatizes a large part of this type of work, there still remain many manual and repetitive administrative tasks to be done within companies. This is where RPA comes in as a digital process automation tool. Just like Tesla’s robots automatized their production lines, RPA-style robots will automatize our digital work with the similar improvements in velocity, precision, and scalability.

4 Artificial Intelligence.

RPA: Definition, actors and benefits

In this section, we will define RPA and the concept of the digital worker. We will focus on actors in the market and the functions of these robots (or bots). We will then look at what type of work they can perform, and what benefits they can provide to companies and their employees.

What is a digital worker?

Theory

RPA (robotic process automation) is a technology that uses business logic[5] and structured input to automatize business processes. Thanks to the technology, companies can configure robots (also known as bots) to capture, interpret, and transfer data from different sources while interacting with all the applications used by a company. The bot can easily create an automatic response to an email or perform complex actions involving, for example, the company's ERP[6] system.

The best way to think of a robot created with RPA technology is as a digital worker who can work 24/7. The robot can be hosted on a physical machine within the company (a computer) or in the cloud with the different cloud computing providers.

RPA can be attended or unattended. The attended robot is like an assistant in your computer that can execute a task when activated, like sending a report by mail or registering a bill in your accounting system. The unattended one is an autonomous robot trained to execute

[5] Business logic is understood is this context as a series of rules that define a process.
[6] Enterprise Resource Planning is an information system allowing management and monitoring of all the information and operational services of a company.

one or multiple processes without human intervention, such as receiving a purchase order by mail and treating it from registration in your internal system to the sending of the delivery order.

Actors

It requires specifics programs to create these robots, and although there are many RPA providers, we will focus on the top three according to the Gartner Magic Quadrant[7] (Annex 1), which are Automation Anywhere, UiPath, and Blue Prism. In this text we won't enter into an exhaustive comparison of the three types of software. It suffices to say that these three actors provide solutions to create, run, and monitor a digital workforce[8]. They manage an annual subscription (Annex 2) depending of the number and the types of bots required by a company.

Functions

When describing the functions of an RPA robot, the analogy of a human worker can help to make the explanation clearer. The analogy can be divided into three main categories: the basic functions that can be described as the hands, the OCR[9] that can be thought of as the eyes, and the machine learning process, which is equivalent to the brain.

Basic Functions:

The basics functions of a bot are like a person's hands. The bot can receive an email, open it, enter an ERP like SAP[10], and digitize the data. This is the most common use. By basic function we are not saying that it can only execute simple tasks; the business rules can be complex and involve hundreds of parameters. It is during the programming part that we will "teach" the robot how to react in different cases and with specific variables.

[7] Magic Quadrant (MQ) is a series of market research reports published by IT consulting firm Gartner.
[8] Term used to describe a group of robots operating in a company.
[9] Optical Character Recognition or Optical Character Reader (OCR) is the mechanical or electronic conversion of images of typed, handwritten, or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo, etc.
[10] German multinational software corporation that makes enterprise software to manage business operations and customer relations.

By basic functions we mean that the robot will follow a predefined pattern and interact with the internal applications by moving structured data between them. The term structured data is central here. Structured data refers to data that has been organized into a formatted repository—typically a database—so that its elements can be made addressable for more effective processing and analysis.

OCR:

Continuing with the human analogy, we can now discuss the robot's eyes. If you are receiving scanned documents or a PDF[11], we can add an OCR software that enables it to read. In this case, we need to teach the bot where the data that we need are located in the document, allowing it to extract and treat it.

Machine learning[12]:

That is where we add a "brain" to our robot. By brain we are referring to AI[13] and Deep Learning[14]. Those technologies allow the bot to learn from the data it treats. For example, coupled with OCR the bot will start to understand the context of the sentence it is reading, extract the information, and use it according to a programmed schema.

If a specific data changes position or is presented in a different way, the robot will be able to understand it. This type of technology is also used to interact with humans by voice or writing. The robot will be able to understand what you are asking and will be able, for example,

[11] A Portable Document Format (PDF) is a file format developed by Adobe in the 1990s to present documents

[12] Machine learning is an application of artificial intelligence (AI) that gives systems the ability to automatically learn and improve from experience without being explicitly programmed.

[13] The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

[14] Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without using explicit instructions, relying on patterns and inference instead.

to interpret if you are hungry or satisfied with the service or product, prioritizing and adapting his response accordingly.

Chris Nicholson, CEO of Deeplearning4j, summarized it this way: “You might say that the “software robot” of RPA is the arms and legs, and the machine learning component is the ‘brain’ (2019).”

Now that have seen what an RPA robot is, we will focus on the technology’s different fields of application and its benefits for organization and their collaborators.

RPA: Why and where?

This section seeks to explicate the benefits the use of RPA can provide companies and what kind of tasks it can be used for.

Cost

One of the most attractive characteristics of RPA is a reduced time of development, which considerably lowers the cost of implementation while maximizing the ROI[15]. The differences with automation through classical development can be explained with various factors.

In classical workflow automation, a developer has to produce a list of actions to automate a task. Then, he has to interface with the back-end[16] system using internal application programming interfaces (APIs)[17] or dedicated scripting language. This is technically much more complex, and requires a qualified engineer and several months of development, hence the higher cost (McCann, 2016).

15 Return on Investment.
16 The part of a computer system or application that is not directly accessed by the user, typically responsible for storing and manipulating data.
17 A set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service.

With RPA, on the other hand, developers use graphical user interface (GUI) to create the list of action. The robot will repeat the actions by directly using the GUI to perform automation. This allows automation performance in a company's existing IT environment without changing any software. This technology is defined as non-invasive because it uses the front-end[18] and does not require any IT landscape change in the organization.

This is the key factor of RPA's low cost. The development is almost "code free." In Figure 13, we see the development interface of Uiptah using graphical fields. This permits easier adoption, faster development, and simple modification. This is also why RPA is so adaptable—it can literally interact with every application a human can use through the graphical interface.

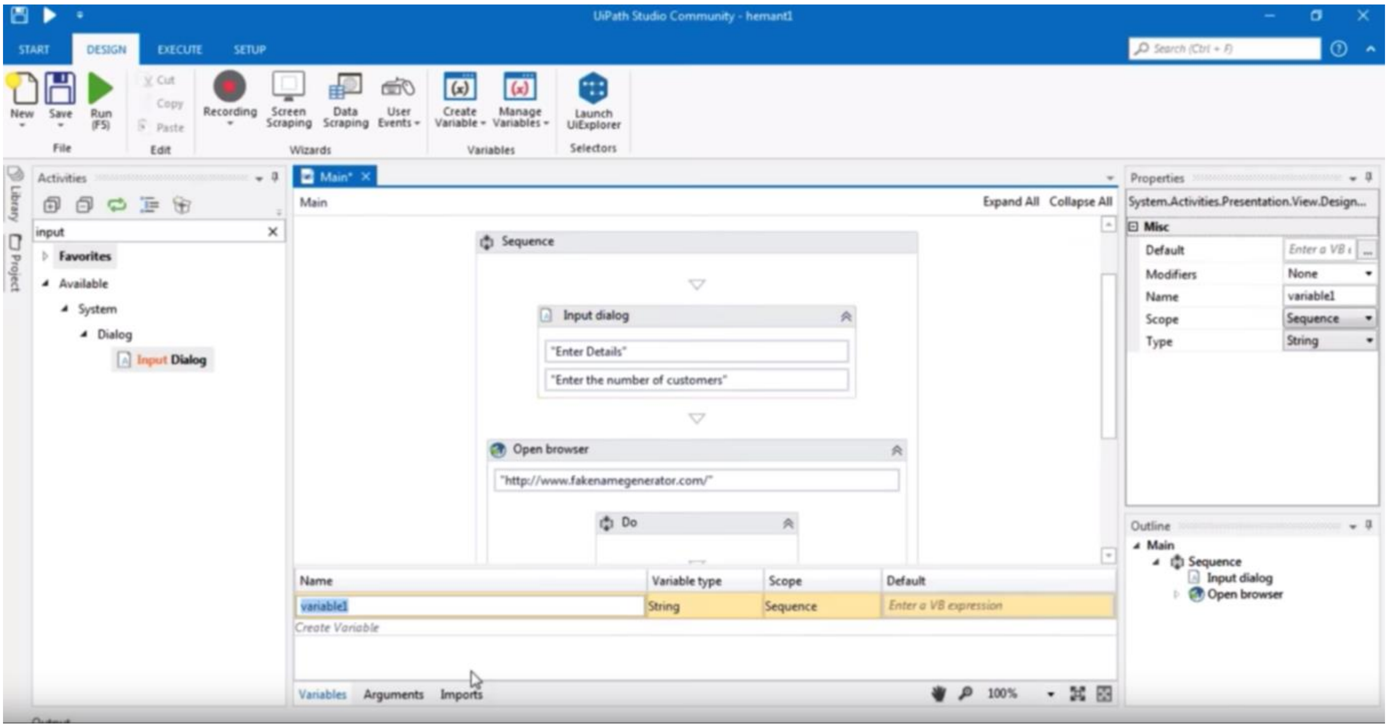


Figure 13 UIpath Studio. Retrieved from https://www.uipath.com/product/studio

18 Relating to or denoting the part of a computer system or application with which the user interacts directly.

While traditional development take months, RPA implementation takes around 4 to 12 weeks[19], depending on the complexity of the process, making RPA highly competitive compared to other technical solutions.

In the cost section, we also need to talk about the rapidity of a bot execution and the possibility of reducing human resources within a company. According to a 2017 survey by Deloitte (2017), companies interviewed expected to reach between 20% to 52 % of their FTE[20] capacity using robots. An increase in productivity and the reduction of FTE combined with faster and cheaper development provided a very good ROI[21] ratio expectation.

From this same survey, we can extract some interesting data. Companies that adopted RPA (53% of respondents) reported an average payback of 12 months and 20% of FTE capacity provided by robots. This can explain why RPA has proven to be a success and will likely spread over the next few years.

Accuracy

The reduction of errors is one of the reasons why companies are adopting RPA. The robot does not make mistakes of reading or typing. It can reach 100% accuracy (depending on the process), but, even if there is a mistake, it will be reported and documented, allowing identification and correction. It will never make the same mistake twice.

Human error is a common problem and can result in great damage for companies. From the simple double billing to the sharing of strategic data, human error can appear in every area of a business. This also affects the company's compliance and result in a huge loss because of a fine or a lost client.

[19] Estimation based on Amaris Consulting internal documents.
[20] Full time employees.
[21] Return on Investment.

Costs from human error in companies is difficult to evaluate accurately. In 2003, David Smith (2003) estimated the cost of lost data in the USA at 18.2 billion dollars, of which 29% was due to human error. To take a more specific example, on March 2017, Amazon Web Services, which represents nearly half of the cloud infrastructure market (Figure 5), went down for approximately 4 hours due to a piece of code that was incorrectly entered during a maintenance process (Kosoff, 2017). A total loss of 150 million dollars was reported by S&P Companies because of the error (Stevens, 2017) . In this context, the error reduction is a key factor to companies' profitability and service compliance.

Automation and, particularly, RPA have shown great results in improving accuracy. 90% of the companies interviewed by Deloitte (2017) in its RPA survey said they've improved accuracy using the technology.

Control and scalability

The use of robots also helps organizations have better control over their operations by creating precise and meaningful reports.

Through sophisticated control panels provided by RPA tools, companies are able to plan and monitor the work of their entire digital workforce in real time, allowing them to have total control and an accurate perspective of the tasks being performed. It is also a powerful source of KPI (key performance indicators), which is a considerable help in a company's decision-making process.

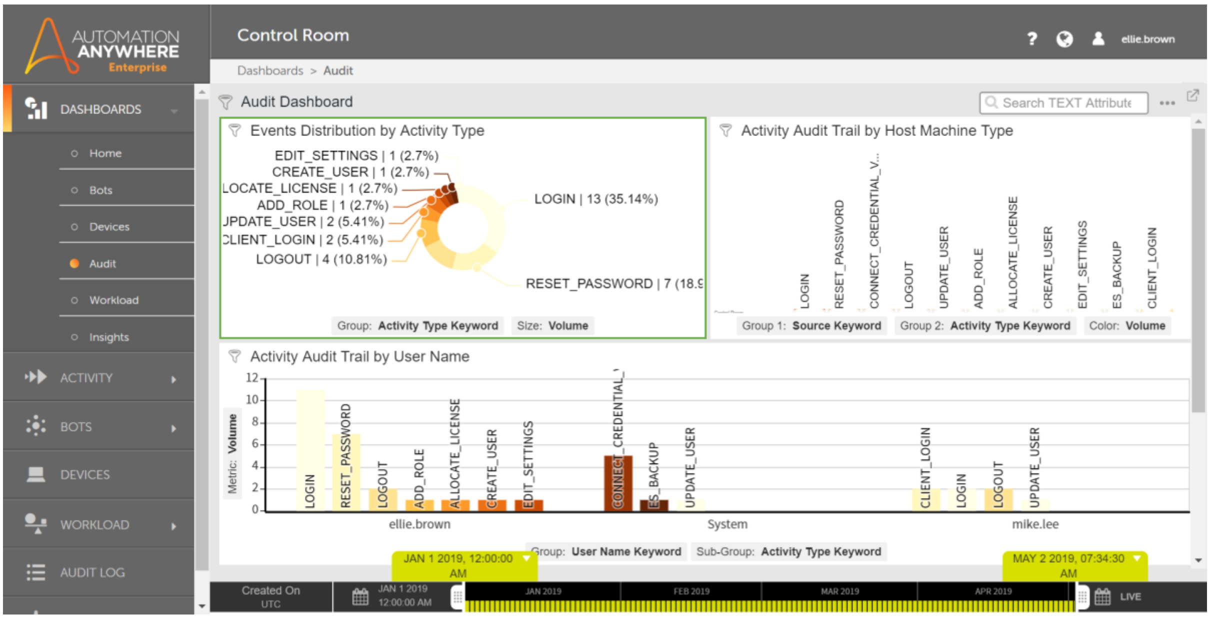


Figure 14 Automation Anywhere control room. (2019) Retrieved from Internal Amaris Consulting Document

In Figure 14, we can see the Automation Anywhere control room. In the menu on the left, there are several categories of report. This tool allows numerous reports on the tasks that have been performed, the time dedicated to each task, the workload of each robot, the devices on which they have been working, etc. From this panel we can monitor every task performed by the bot in a specific time period.

Another great advantage of this technology is its ability to absorb a growing volume of work. With human employees, if a company needs to duplicate its work capacity in a specific area, it has to hire and train new workers. It can take weeks or months before the new employee develops the skills to undertake the task required. RPA only has to duplicate the robot(s) to have double the capacity to perform a task.

Reoriented human work on tasks with added value

RPA also has a positive impact on an employee's work experience and on the companies' abilities to retain human resources and reorient work towards added value tasks. Various studies such as BCG's "Decoding Global Talent" show that the motivation of the employees in their work is less and less driven by fixed salary (Strack, von der Linden, Booker, & Strohmayr, 2014). Work environment and appreciation is becoming a key factor to keeping talent within a company. This is where RPA can be a powerful tool.

First, the disattended robots help reduce manual processes within a company that involve moving and reorganizing data. They are acting on their own, performing entire processes. The attended ones act like a real digital assistant for the repetitive tasks performed by employees; they just have to run the assistant on their desktop.

The code-free character of RPA helps non-technical employees create their own personal bot and maximize the adoption rate of this technology. We can also mention the example of Automation Anywhere, who provides a "bot store"[22] for its customers. Any employee can simply download a pre-trained bot for standard actions like logging and registering a bill in SAP or extracting data from an email or PDF. With this service, it becomes easy for anyone to automate specific and repetitive parts of their jobs.

This helps employees dedicate their time to more stimulating and added value work, where their cognitive decisions and creativity are involved. A study done by the company Forrester Consulting "The Impact Of RPA On Employee Experiences"(2019) shows that 66% of the people interrogated declared that RPAs have helped them restructure their work and have more human interaction (Figure15).

22 https://botstore.automationanywhere.com/

Figure 15 What effect does investments in RPA have on the employee's job? Reprinted from Forrester Consulting (2019).

As a consequence, this has reduced the turnover in companies by 25%, according to the Forrester Consulting studies (even if this is lower than they had expected).

What kind of work for a robot?

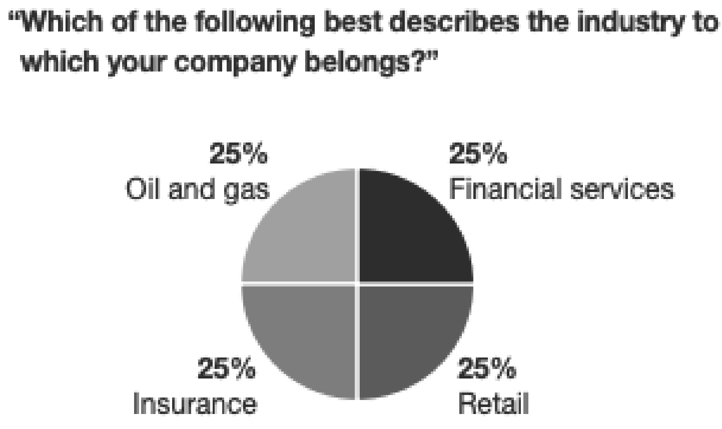


Figure 16 base: 8 manager level and above from operations groups with responsibility, influence or experience using RPA. Reprinted from Forrester Consulting (2019).

This figure (16) shows the diversity of the company's sectors using RPA. This distribution evidences that this technology can apply in many different cases and is not limited to specific uses or sectors.

When focusing on what kind of processes and areas are possible to automate with RPA, we find these include nearly every aspect of a business. AI Multiple (2019) —a blog that aims to democratize and assess business in relation to Artificial Intelligence— based on numerous cases, published a non-exhaustive list of RPA field of action within companies.

In the list, we have common business processes like quote-to-cash, customer onboarding, data update and validation, extraction of data from documents (every kind), generation of emails, and reporting of various kinds. But we also have activities in commercial functions like creation and delivery of invoices or updating CRM, as well as in support functions like software testing in IT or candidate sourcing in HR. There are also many processes automated in finance, logistics, operations, and telecom. We are not going to enter into the details of every process. The aim of this section is to show that RPA can apply in areas we did not at first think possible.

Every time we can define a repetitive, rules-based process, RPA technology can be applied to automate it.

The real challenge with RPA is to create an efficient methodology of implementation to define a governance model involving various areas of the company to analyze, improve, and prioritize the processes selected for automation in order to create an efficient digital workforce and create ROI.

Implementation methodology and success cases

In this section, we will focus on the implementation methodology of RPA. The methodology we will put forward is based on internal knowledge and documents from Amaris Consulting S.A.S, and the result of several years of empirical research. In the section's latter part, we will analyze and comment on a successful case of RPA implementation in the Colombia company Bancolombia with the technology Automation Anywhere.

Best practices and methodology of RPA implementation

"The first rule of 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", Bill Gates.

The success of RPA initiatives in a company depends greatly of the methodology of implementation. The technology to be implemented has a significant cost, which is even higher if we are speaking of a whole digital workforce. To ensure the return on investment, we have to analyze the processes we want to automate (priority and complexity) and above all the impact in the company in terms of number of hours automated, scalability, and error reduction (the economic and legal impact). This will help us to construct a viable business case and have a successful implementation of RPA.

Model of best practice and continuous improvement

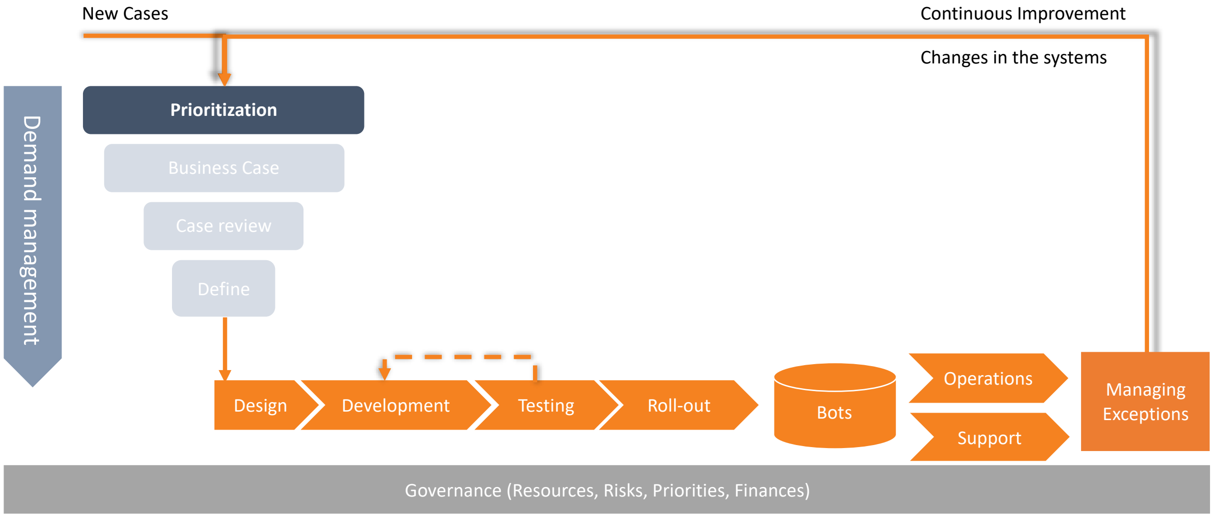


Figure 17 Global model of RPA governance. (2019) Retrieved from Internal Amaris Consulting Document.

In Figure 17, we can see a model of governance from the generation of demand (processes to automate) to the correction and improvement of the system. This diagram starts on the left with the management of demand, which means how we analyze, select, and prioritize the processes to automate within the company. This part will be developed in the second part of the section. When the processes are selected and ordered, we can start the robot's development. This part is represented by the orange process on the bottom of the Figure. It goes from the design of the robot to its operation and support. The process ends with the management of exceptions and improvement and changes in the system.

This model helps us understand the best practices in the governance and management of a digital workforce to achieve efficiency, precision, and return on investment from the selection of processes to the system improvement. It is important to have this model in mind from the start of RPA implementation to align the different stakeholders, maintain an overview of the project, and ensure efficiency. To be able to create this model of governance, it is important to create different roles of management dedicated (not necessarily full-time) to the RPA initiative inside the company, which we can call an RPA board.

RPA board

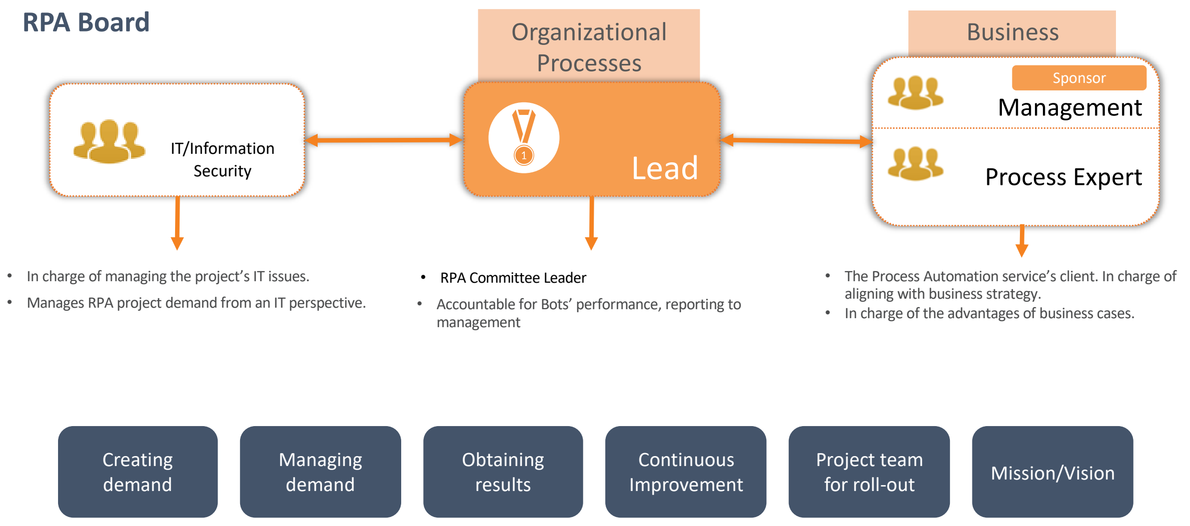


Figure 18 Example of RPA board. (2019) Retrieved from Internal Amaris Consulting Document.

Figure 18 is an example of an RPA board. This example can be adapted to the different structures and strategies of any given company. The principal mission of this board will be to, first, define a mission/vision of the project to create demand of automation in accordance with the company's necessities, manage it, ensure that the results are obtained and then improve and expand the initiative to all areas of the company. In this example, the three main areas needed are represented at the top of the Figure.

The leading committee is represented at the center of the graphic. The committee leader is the origin of the project and will be accountable for its success. He has a central role in the organization since he has to report to management on the evolution of the project, as well as its results to gain and maintain the support of the project by the company's top management. He will also play a role in the involvement of the other areas and actors for the project's success.

The business part is in the top right corner. This group is composed of the company's management team and the process owners. By "process owner", we mean the leaders of each department and the executants. These are the employees with precise knowledge of every process performed in the company. Their mission will be to identify and document the different processes selected for automation. They will also be key to ensuring that the businesses cases are aligned with the company's strategy and that the automation performed is helping in the day to day operation.

IT will play an important role in this board. But, contrary to other technological changes, they will not be central to this board. They will mainly be in charge of the infrastructure of the system (on premise / cloud computing / virtual machine) and its compliance with security policies related to data and authorization. Additionally, there are also process owners in the IT field who can propose their own processes for automation.

When the board is in place, we can start the first phase of the initiative, which is the "demand management," shown in Figure 19. It corresponds to the identification and prioritization of the processes to be automated. The creation of this board and the implementation of this methodology is often called an "excellence center" for RPA.

Managing demand: From identification to selection

Figure 19 shows a methodology to order and select the processes to be automated with RPA. The RPA board will be in charge of this selection. It is divided into 7 main steps.

1) Define the business priorities:

This first step is the base from which all initiatives will start. The question is, "What are the objectives we want to achieve with RPA?". All objectives correspond to KPI's or processes that we want to improve in the company. In Figure 19, the examples are improved quality through error reduction, and improving employee's experiences and customer satisfaction. These can be quite different between companies, which is why it is important to identify them from the beginning. When they are defined, we quantify them by giving a percentage of importance to each objective.

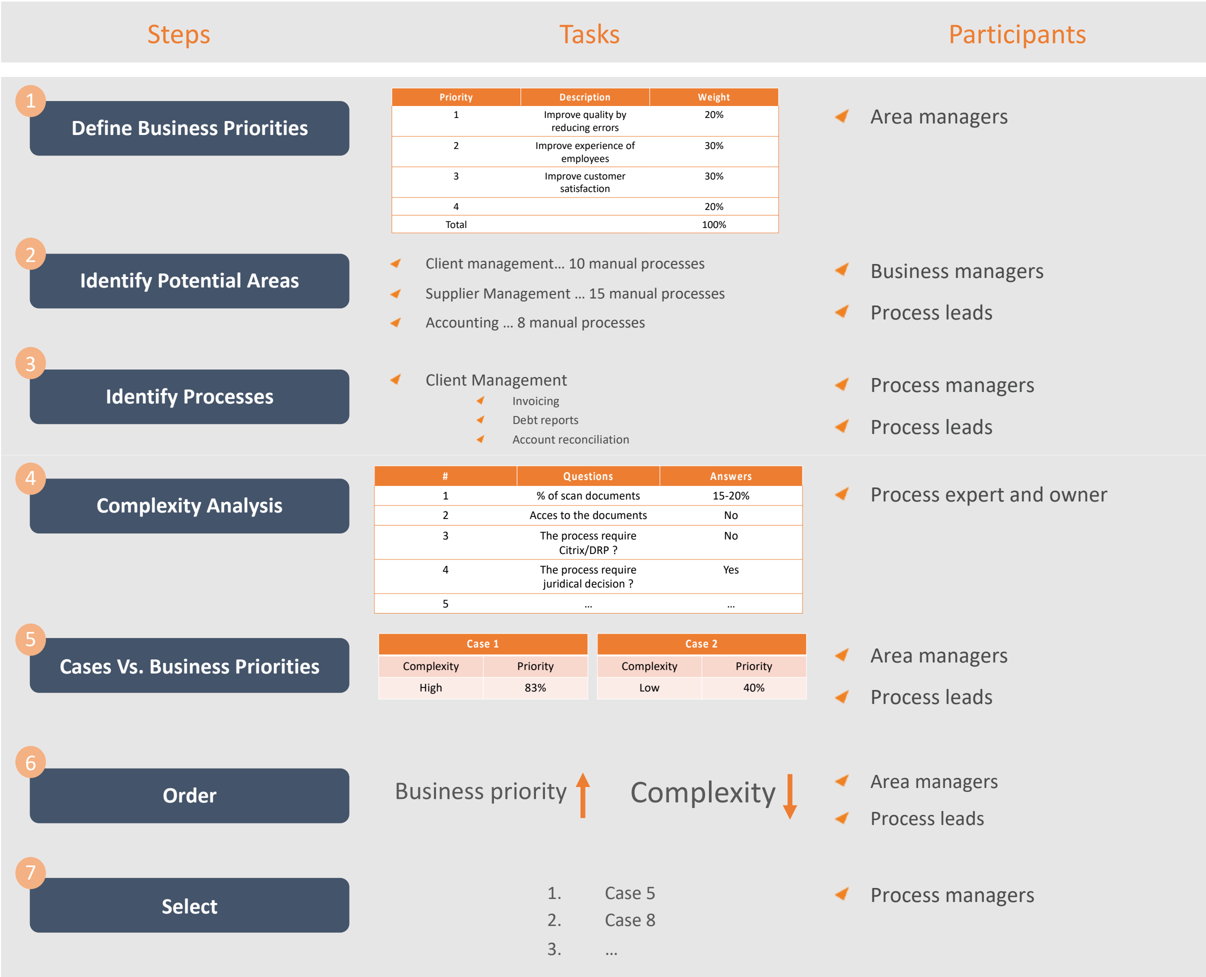


Figure 19 Methodology of processes selection for automation. (2019) Retrieved from Internal Amaris Consulting Document.

2-3) Identify potential areas and processes:

Once the company objectives are defined, we can now select the different areas impacting the KPI’s to achieve the improvements we want. In this example, we chose improvement of service quality through error reduction. Therefore, we will search the different areas affected by errors. When we have defined the involved areas, we will create an exhaustive list of all the processes performed in this area.

4) Complexity analysis:

We have now identified objectives and the areas and processes that impact them. The next step is to analyze the complexity of each process. To measure the complexity, we need to contemplate various aspects, such as the type of documents used, the numbers of areas involved in the process, the application used, the quality of the data, the percentage of case of exception, etc. Even if the questions are generic, the answers can be very specific to each company and may require the help of the IT team, in addition to the business one.

5) Cases vs. business priorities

Now we can build a matrix of each process with the company's priorities in one portion and the complexity in the other. Priority is calculated by multiplying all the objectives achieved by a process. For example, an automated billing process will impact error reduction but also the employee's experience by reducing manual, repetitive tasks, so this would high on my priority list.

6-7) Order and select

Thanks to the matrixes, we are now able to order and select the processes that we will automated with RPA. Here we are seeking the simplest processes with the highest impact in the company, the so-called quick wins. The processes are named this way because, with a quick development, we can make a significant impact on the company's objectives.

That methodology of process selection allows us to create and follow a common objective and generate quick added value. The other important aspect about this way of working is that it will ensure quick results, which helps the company democratize RPA within itself and demonstrate to collaborators that they can benefit from the technology in their daily work. We are generating what is called internal sponsorship, which is used to develop initiatives such as RPA.

Development

	Define	Design	Configure	Test	Deploy	Support
Description	Analyse, define and approve the requirements for each case with the Subject Expert.	Design and approve the solution for each case, bearing the objective agreement in mind.	Configure the solution, carry out comprehensive testing and review compliance with best practices.	Conduct acceptance testing in a homologation environment.	Transfer solution to production environment and prepare for its use at an operational level.	Provide intensive support until the solution meets the objective agreed in the Design stage.
Deliverables	Process Definition Document (or similar document), approved before the testing stage*	Solution Design Document (or similar document), approved before testing stage*	Approved Release Package, and Code Review Checklist (or similar document).	Approved User Acceptance Document (or similar document).	Approved Release Package and Operational Handbook (or similar document).	Approved Stable Solution in Productive Environment and Customer Acceptance (or similar document).

Figure 20 Steps of robot development. (2019) Retrieved from Internal Amaris Consulting Document.

Figure 20 shows the different steps of development to automate a process. First, we will *Define* the process. In this part, the aim is to precisely "map" the process and verify with the stakeholders that every step is described properly. This mapping describes the applications, documents, permissions, and business logic involved in the process. It is built by interviewing the process owners, often recording the computer screen to capture every single movement and interaction. This part is crucial since it will be the base of our automation, and from this comes the efficiency and precision of the robot. This first part results in the production of a document called the *Process Design Definition*[23], which will be presented and validated by the stakeholders.

The second step, the *Design*, will consist of an "improvement" or modification of the existent process to make it more suitable to automation or simply more efficient. Here, we aim to increase the percentage of automation and, by doing so, the return on investment. This part is usually performed by a process analyst or RPA consultant. By making changes in the workflow of a process, there can be great improvements in the company's objectives. At the

[23] Document that precisely describes how a process is being performed by the company, also called the «as is».

end of the analysis, we produce a document called *Solution design definition*[24], once again presented and validated by the process owners in order to ensure complete accuracy in the automation.

The third step, *Configuration*, involves the robot's development. With clear and precise mapping of the process validated by the stakeholders, we know exactly what the robot has to do, when, with what application, and, most importantly, with which rules of business. The development of the bot involves the developer "teaching" it how to react in a specific situation and where to find and interpret information. The time of development depends on the complexity of the process, which is mainly correlated with the complexity of the business rules and the quality of the input data. For this step, best developing practices have to be followed to ensure the availability of the robot and reduce operating errors. It is also recommended to document the way it is coded to allow the support team to correct the code in case of errors.

The fourth step is the *Testing*. At this point, we will run the robot in a test environment to evaluate its reaction in order to correct the bugs and errors that have occurred. This part is mandatory before its deployment in a production environment (the real one) to ensure the continuity of the business, especially when the automated process is central to the company's activities.

The fifth step is *Deployment* to production environment[25]. At this point the bot is truly operative in the company and performing work. This part is more technical, since it will involve informatic infrastructure, security, and permissions. The IT team of the company is deeply involved to ensure that all rules are respected. The code and the behavior of the bot are normally

[24] Document that describes a process after it has been reevaluated and modified to reach a certain objective, also called the «to be».
[25] Term used to describe the setting where software and other products are actually put into operation for end users.

aligned with expectations due to the previous development steps. Nevertheless, it is important to monitor the first “real” executions to avoid errors.

Now that the robot is running and operating as we expected, we will have a “stabilization” process, which is an intense monitoring and correcting process to reach the company’s objectives. Even after this part, it is important to keep monitoring the digital workforce to make it more efficient and running continuously.

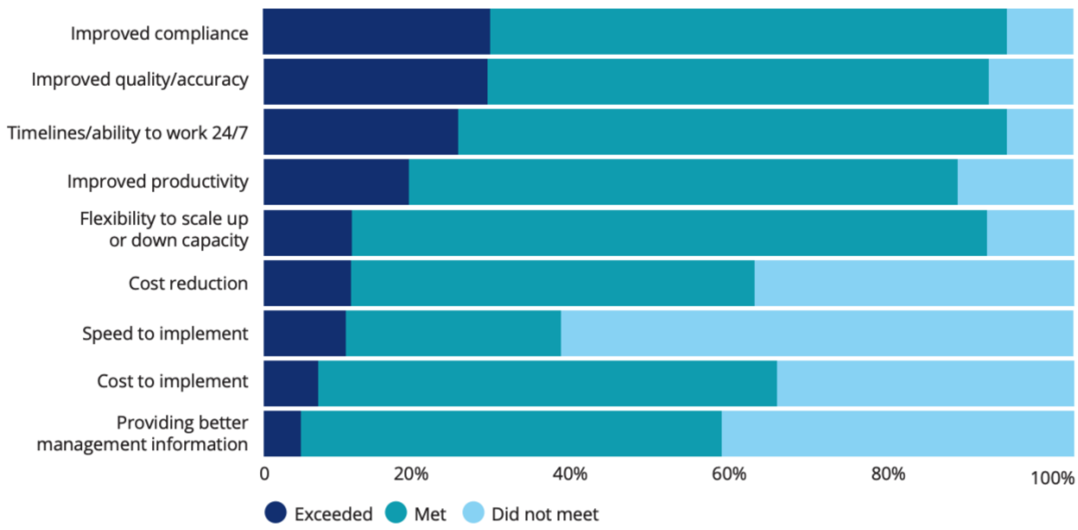


Figure 21 Did the implementation of RPA meet your expectations in terms of (…) ? Reprinted from Deloitte (2017).

By following good development practices, we avoid a considerable percentage of error, which is common in RPA. In Figure 21, we see that 63% of respondents said their expected implementation speed had not been achieved, while 43% found that it had not delivered planned information in management. This is a direct effect of bad methodology of implementation. The errors and delays in development are mainly caused by a bad mapping of the process (Casey, 2019).

Monitoring and support

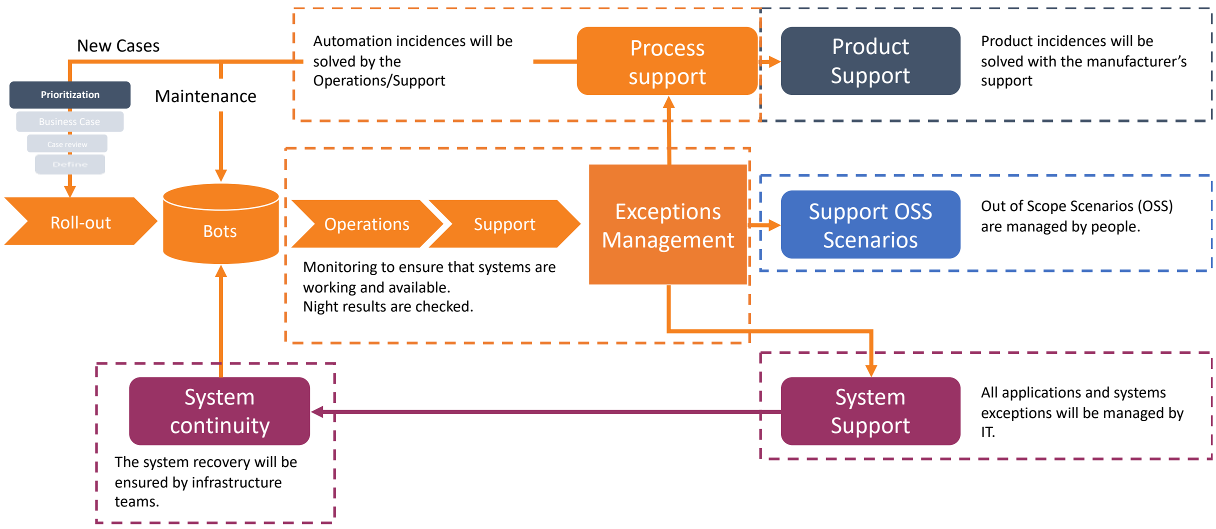


Figure 22 Schema of monitoring and support of digital workforce. (2019) Retrieved from Internal Amaris Consulting Document.

Figure 22 shows an RPA technical support schema, built by Amaris Consulting Group. Without entering into the technical details, we can comment on the aim of such support systems. First of all, it will give us a daily report on how the digital workforce is working, what percent is occupied, which tasks are being performed and how many times, the volume and increase of each task, etc. It also allows faster reaction in case of failure or error and the ability to reach maximum availability of each robot. The other benefit is the identification of "out of scope scenarios," which refers to new situations the robot does not know yet. Identification of such scenarios allows the robot to learn how to react, again with the aim of reaching the highest possible percentage of automation and lowest of human intervention.

To monitor the digital workforce, every RPA provider offers tools like the Automation Anywhere control room (Figure 14). Those tools provide detailed reports and are indispensable for the scalability of the technology to stay in control while continuously improving the system's efficiency.

Colombian case of success: Bancolombia

This section uses a real case to illustrate the different methodologies, uses, and benefits we have been developing throughout this paper. To do so, we have chosen a national banking company case: Bancolombia, which implemented robots with the Automation Anywhere technology.

The Bancolombia case is a good example of a successful RPA implementation in many aspects. Bancolombia is a Colombian financial institution operating in various Latin American countries, as well as the United States. The group was created from the fusion of Banco de Colombia and Banco Industrial Colombiano in 1998.

In 2017, the group launched an initiative to automatize repetitive processes and improve customer service. After a number of studies, POC[26], and evaluation of business cases and providers, they finally chose to adopt (mainly but not exclusively) Automation Anywhere as a partner.

The Bancolombia case is interesting because it used all the methodological points seen in previous chapters. It first began with the identification of priorities and points of possible improvement within the company, in order to focus their efforts in the right direction. These can be summarized as follows:

- Improve customer service
- Reduce manual and non-valuable work from their collaborators
- Reorient the work of their collaborators on added-value work
- Reduce human errors
- Improve efficiency

[26] Proof of concept: procedure which aims to demonstrate that a theory or an idea is viable from a marketing, economic, or technical point of view.

- Avoid reprocesses

Once they had clearly defined the objectives and the technological tools that would be used (in this case, RPA), they began the construction of an “excellence center”, which materialized in a governance model, as seen in the previous section, under the name of RPA board. They naturally adapted it to their own needs, which led to the following model:

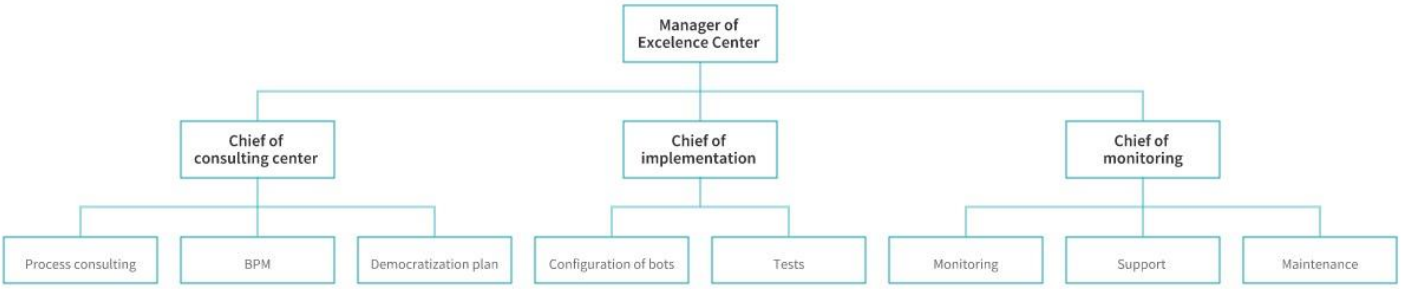


Figure 23 RPA governance model of Bancolombia. Retrieved from Automation Anywhere (2019).

The governance model proposed by Bancolombia in Figure 23 is different than the one proposed in Figure 18, but it fulfilled the same objectives, which was to efficiently lead the RPA initiative. Both models have a leader, but in Bancolombia’s he is in charge of three main areas:

Consulting center: Its mission is to analyze and improve the processes within the company before starting automation and to democratize the RPA initiative in all areas of the company.

Implementation department: This area is in charge of the development of the robots, following the recommendation and requirements of the consulting center. It is also in charge of the quality testing before they go live.

Monitoring department: This area is in charge of monitoring the performance of the robots. It also provides support to users and maintenance to the robots.

This governance model uses all the methodological concepts we've seen previously to generate and manage demand, develop robots, and monitor the digital workforce. Jorge Otalvaro, the operation vice president of Bancolombia, in its conference in the Automation Anywhere Digital Workforce Summit 2019 in Bogotá, emphasized the importance of the methodology they've implemented to achieve the creation of Bancolombia's digital workforce (Automation Anywhere, 2019).

During that same conference, Otalvaro also presented some of the results the company has achieved by implementing RPA:

Implementation of 358 bots

Automation of 169 back office processes (representing 25.000 billion minutes of work annually)

Automation of 7 front office processes

58,8% of improvement of the efficiency in time of services

120,720 hours automated for the commercial team a year

ROI of the project 1/14, which means that for every dollar inverted 14 have been saved or earn, represented as follows:

New incomes: 25.995 billion of Colombian Pesos

Saving in general expenses: 186.225 billion of Colombian pesos

Efficiency: 5.367 billion of Colombian pesos

18% of the operational collaborators have been relocated to other tasks[27]

These results have turned Bancolombia into one the most successful cases of RPA implementation in Colombia. The company's operation vice president's speech shows the

27 All figures cited in the result part are extracted from the operation vice president conferences preformed during the Automation Anywhere Digital Workforce Summit 2019. Video in the reference section.

importance of the methodology and the governance model to achieve significant results from RPA implementation. It also confirms the validity of all the methodological points we developed in the previous chapter by showing how they were implemented in Bancolombia and the economics results of the technology's implementation in their company.

Another interesting point of Bancolombia's case is the area of the RPA's implementation. First, it was limited to back-office processes, but they soon extended the initiative to front office areas. In his speech, Otalvaro described their doubts about the efficiency of RPA in these processes and the great results they gained by overcoming their apprehension. This demonstrates that RPA is not a technology limited to some processes or areas but a cross-functional tool that can generate added value in many fields of activities.

To finish the analysis of this business case, it is important to note the approach and goals of Bancolombia regarding RPA. The operational vice president of the company described them at the very beginning of the conference using the name he had chosen for the talk: "The De-robotization of Talents." As we have seen in this paper, RPA allows for the improvement of many other KPI's beyond the cost of human resources. Instead of seeing the technology as a threat, Bancolombia saw it as a powerful help for collaborators in their everyday work in terms of tasks and efficiency.

This vision, I believe, is the correct one to adopt, and Bancolombia has shown that by using strict implementation methodology involving business requirements, RPA initiatives improve employees' well-being and bring positive economic results.

Conclusion

We have seen that RPA technology is the result of decades of innovation, both in computer science and automation. It can be described as the combination of scientific organization of work, illustrated by automation in manufacturing and the capacity of computation and virtualization. The very name of this technology refers to the virtualization of physical robots.

It requires a precise methodology to implement a digital workforce aligned with a business's necessity. If done correctly, it brings benefits to the and the employees. Companies have raised their margins, standardized their processes, avoided errors, and become more attractive to customers and employees. It has also reduced and removed repetitive and boring tasks for employees, making their work experience much more rewarding, and reoriented on added value work. These virtual robots could become the new best friend of every company and worker.

But as did automated robots in industry, RPA will completely change the work paradigm by destroying "old" jobs and creating new ones. A 2017 study on the impact of automation estimated that more than 1 million jobs were at risk due to technologies like RPA in just the United states, Poland, India, and The Philippines (Sethi & Gott, 2017). With the development of predictive analytics, deep learning, and an artificial general intelligence capable of cognitive decision-making, we can expect in the near future entirely autonomous virtual robots, which will threaten many more jobs than today.

Think of a future where virtual robots hosted in virtual machines are accessible from anywhere and available on demand to perform any type of digital work. Organized and specialized like a robotic car factory, they would receive a job and perform a specific task before sending the remaining work to another robot until the job is complete. In this imaginary future, how many jobs would be at risk? Even if it’s still hypothetical, technological change will inevitably lead us to a scenario of this kind.

Throughout history technological innovations have destroyed and created new jobs and necessities. RPA and its evolution will have the same impact on jobs that today seem irreplaceable by programs and machine. It is inevitable. Instead of trying to fight this evolution, we should prepare and adapt to be able to avoid social crisis.

References

AI Multiple. (2019). 61 RPA Use Cases / Applications / Examples: In-Depth Guide [2019]. Retrieved from https://blog.aimultiple.com/robotic-process-automation-use-cases/#common-business-processes

Allan, R. A. (2001). *A history of the personal computer: the people and the technology*. New York: Allan Publishing.

Arogyaswamy, B., & Hunter, J. (2018). The Impact of Technology and Globalization on Employment and Equity: The Need for a Vigorous Corporate Response. *Proceedings of the Northeast Business & Economics Association*.

Automation Anywhere. (2019). Conozca cómo Bancolombia incrementa su eficiencia con Automation Anywhere. Retrieved from https://www.youtube.com/watch?v=DI4MtfW8Z8U

Bhat, N. (2012). Jack St. Clair Kilby Chip and Dare Saga. *Reson*, *17*, 1035–1047.

Buyya, R. (2010). Cloud computing: The next revolution in information technology. In *2010 First International Conference on Parallel, Distributed and Grid Computing (PDGC 2010)*.

Casey, K. (2019). Why Robotic Process Automation (RPA) projects fail: 4 factors. *The Entreprise Project*. Retrieved from https://enterprisersproject.com/article/2019/6/rpa-robotic-process-automation-why-projects-fail

Cave, M., Majumdar, S. K., & Vogelsang, I. (2005). Technology evolution and the internet: introduction. In S. Majumdar, I. Vogelsang, & M. Cave (Eds.), *Handbook of Telecommunications Economics*. Amsterdam: Elsevier.

Cooper, S. B., & van Leeuwen, J. (Eds.). (2013). *Alan Turing: his work and impact*.

London: Elsevier.

Deloitte. (2017). The robots are ready. Are you? Untapped advantage in your digital workforce. *Deloitte*. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/tr/Documents/technology/deloitte-robots-are-ready.pdf

Field, K. (2019). A Look Inside Tesla's Fremont Automotive Factory. *Cleantechnica*. Retrieved from https://cleantechnica.com/2019/03/31/a-look-inside-teslas-fremont-automotive-factory-cleantechnica-exclusive/

Forrester Consulting. (2019). The Impact of RPA on Employee Experience. Retrieved from https://dfe.org.pl/wp-content/uploads/2019/04/Forrester_RPA-Impact_Employee-Engagement.pdf

Graff, M., Kenwood, A. G., & Lougheed, A. L. (2014). *Growth of the International Economy, 1820-2015*. London: CRC Press.

Kosoff, M. (2017). One Amazon Employee's "Human Error" May Have Cost the Economy Millions. *Vanity Fair*. Retrieved from https://www.vanityfair.com/news/2017/03/one-amazon-employees-human-error-may-have-cost-the-economy-millions

Leiner, B. M., Cerf, V. G., Clark, D. D., Kahn, R. E., Kleinrock, L., Lynch, D. C., … Wolff, S. (2009). A brief history of the internet. *ACM SIGCOMM Computer Communication Review*, *39*(5), 22–31.

Light, J. S. (1999). When computers were women. *Technology and Culture*, *40*(3), 455–483.

Marks, E. A., & Lozano, B. (2010). *Executive's Guide to Cloud Computing*. New Jersey: Wiley.

McCann, D. (2016). Robots, robots everywhere! *CFO*, *32*(7), 34–38.

Moore, G. E. (1965). Cramming more components onto integrated circuits. *Electronics*, *38*(8), 114–118.

Myers, B. A. (1998). A brief history of human-computer interaction technology. *ACM Interactions*, *5*(2), 44–54.

Olsen, K. A. (2013). *How information technology is conquering the world: workplace, private life, and society*. New York: Scarecrow Press.

Osborne, A. (1976). *An introduction to microcomputers*. New York: McGraw-Hill.

Platzman, G. W. (1979). The ENIAC Computations ol 1950 Gateway to Numerical Weather Prediction. *Bulletin of the American Meteorological Society*, *60*(4), 302–312.

Ralston, A. (1981). Computer Science, Mathematics, and the Undergraduate Curricula in Both. *The American Mathematical Monthly*, *88*(7), 472–485.

Ruparelia, N. (2016). *Cloud Computing*. Cambridge, MA: MIT Press.

Russell, B. (2014). Preserving the dust: The role of machines in commemorating the industrial revolution. *History and Memory*, *26*(2), 106–132.

Sethi, A., & Gott, J. (2017). The Widening Impact of Automation. *A.T.Kerney*. Retrieved from https://www.atkearney.com/digital-transformation/article?/a/the-widening-impact-of-automation-article

Smith, D. (2003). The Cost of Lost Data The importance of investing in that " ounce of prevention ". *Graziadio Business Review*, *6*(3), 1–9.

Stevens, L. (2017). Amazon Finds the Cause of Its AWS Outage: A Typo. *The Wall Street Journal*. Retrieved from https://www.wsj.com/articles/amazon-finds-the-cause-of-its-aws-outage-a-typo-1488490506

Strack, R., von der Linden, C., Booker, M., & Strohmayr, A. (2014). Decoding Global Talent 200,000 Survey Responses on Global Mobility and Employment

Preferences. *BCG*. Retrieved from https://www.bcg.com/publications/2014/people-organization-human-resources-decoding-global-talent.aspx#chapter5

The Irish Times. (2009). Processing IBM's data history. *Irish Times*. Retrieved from https://www.irishtimes.com/business/processing-ibm-s-data-history-1.770988

Turing, A. M. (1937). On Computable Numbers, with an Application to the Entscheidungsproblem. *Proceedings of the London Mathematical Society*, *s2-42*(1), 230–265.

UNDESA. (2007). *Industrial Development for the 21st Century: Sustainable Development*. New York: United Nations.

Yin, Y., Stecke, K. E., & Li, D. (2018). The evolution of production systems from Industry 2.0 through Industry 4.0. *International Journal of Production Research*, *56*(1–2), 848–861.

Zmolek, M. (2013). *Rethinking the Industrial Revolution: Five Centuries of Transition from Agrarian to Industrial Capitalism in England*. Leiden: Brill.

Annexes

Annex 1: Gartner Magic Quadrant for RPA (May 2019)

Annex 2: RPA Subscription plan

Subscription
Definition and price

blueprism
Robotic Process Automation Software

Subscription	Characteristics	Pricing [USD]
Subscription BluePrism *1 year subscription	• X number of developers at the same time • Queuing management, automatic launch of process and schedguling • Works without requirement of active desktop screen • Allows creation administration, monitoring and implementation of resources in his environment • Host and run from virtual machine • Elerning plateform access	$ 10,500

Subscription
Definition and price

UiPath

Subscription	Characteristics	Pricing [USD]
Studio (Developñent) 1 year subscription/users	This subscription is used to create the robots (development)	$3.000
Robot – backoffie unattended 1 year subscription	• Work on virtual machine • Active with or without Orquestrador • Works without requirement of active desktop screen • Queuing management, automatic launch of process and schedguling with Orchestrador	$8.000
Robot – front office attended 1 year subscription	• Work on virtual o physical machine • Manualy activated by users • Required unlock computer with activated desktop screen to run • Don´t manage schedguling or automatic process initiating • Queuing with Orchestrador	$1.200
Orchestador Standard 1 year subscription	Orchestrator which allows to manage the creation, monitoring and implementation of resources in there own environment. It Works on the same manner as an integration point with the solutions and aplications of other parties. Until a limit of 100 robots	$20.000
Orchestador Basic término a 1 año	• Limited at one client • Maximum of 5 robots • Maximum of 5 studios	$9.000

Subscription
Definition and price

AUTOMATION ANYWHERE

Subscription	Characteristics	Pricing [USD]
Enterprise Level Starter Pack	**Starter Pack includes:** • 3 Control Room • 10 Bot Creators • 5 Bot Runners **Incremental Cost:** • 1 Control Room = $11K* • 1 Bot Creator = $3.3K* • 1 Bot Runner = $5.5K*)	$110.000
Business Level Starter Pack	**Starter Pack includes:** • 2 Control Room • 3 Bot Creators • 3 Bot Runners **Incremental Cost:** • 1 Control Room = $11K* • 1 Bot Creator = $3.3K* • 1 Bot Runner = $5.5K*	$55.000

Subscription

Definition and price

Subscription	Characteristics	Pricing [USD]
Partner Level Starter Pack	**Starter Pack includes:** • 1 Control Room • 3 Bot Creators • 1 Bot Runners **Incremental Cost:** • 1 Control Room = $11K* • 1 Bot Creator = $3.3K* • 1 Bot Runner = $11K*	$11.000
Digital Workforce Starter Kit	**Starter Pack includes:** • 3 Control Room • 3 Bot Creators • 6 Bot Runners (3 attended / 3 Unattended) **IQ Bots :** • 20,000 # of pages in Production / Year • 5 IQBot Creator Licenses • 5 IQBot Validator Licenses	$49.500