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Automation of DevOps processes with RPA- qualitative research

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TECNOLOGIAS
E ARQUITETURA

Department of Information Science and Technology

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Resumo

DevOps surgiu com o objetivo de resolver a divisão entre as equipas de desenvolvimento e operações, o *Robot Process Automation (RPA)* é uma tecnologia designada para automatizar tarefas repetitivas. Existe uma lacuna na investigação sobre a integração do RPA nos processos DevOps. O principal objetivo deste estudo é explorar o potencial do RPA na automatização dos processos DevOps. Para tal, foi adotada uma metodologia de investigação qualitativa, realizando entrevistas semiestruturadas. Através destas entrevistas, podem ser recolhidas pontos de vista de diferentes funções para identificar quais os processos de DevOps que podem ser automatizados usando RPA e os respetivos benefícios.

Palavras-Chaves: ITSM; Gestão de Serviços de Tecnologia e Informação; DevOps; Automatização Robotizada de Processos; RPA; Automação;

Abstract

As DevOps emerged to address the bottleneck between development and operations teams, and Robot Process Automation (RPA) is a technology designed to automated repetitive tasks. There is a gap in research concerning the integration of RPA with DevOps processes. The primary goal of this study is to explore the potential of RPA in automating DevOps processes. To achieve this, a qualitative research approach was adopted, utilizing individual semi-structured interviews. Through this interviews, insights from various roles can be gathered, to identify which DevOps processes can be automated using RPA and the associated benefits.

Keywords: ITSM; Information Technology Service Management; DevOps; Robotic Process Automation; RPA; Automation;

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Abbreviations and Acronyms

CAMS	-	Culture; Automation; Measurement; Sharing
CD	-	Continuous Delivery
CDT	-	Continuous Deployment
CI	-	Continuous Integration
CM	-	Continuous Monitoring
CS	-	Case Study
CT	-	Continuous Testing
DevOps	-	Development and Operations
MAPE	-	Monitoring; Analysis; Planning; Executing
RPA	-	Robotic Process Automation
SCM	-	Source Code management
SLR	-	Systematic Literature Review

Chapter 1- Introduction

Nowadays, the split found between developers and operations in many organizations, is a major obstacle for fast and frequent releases of applications. These obstacles came from different goals, contrary mindsets, and incompatible processes [1].Whilst developers try to push changes into production quickly, the operations' main goal is to keep the production environment stable [2].Thus, the collaboration and communication between these two teams are mainly based on slow, manual, and error-prone processes. Consequently, it takes a significant amount of time to make changes, new features and bug fixes available in the production environment. Moreover, users and costumers of Web and mobile applications expect fast responses to their changing and growing requirements. It becomes a competitive advantage to implement automated processes that allow quick and frequent releases. To achieve this goal, it is necessary to close the gap between developers and operations [1].

DevOps (Development (Dev) and Operations (Ops)) is an emerging paradigm that integrates [3] both teams close to each other with the use and support of an alternative set of automation tools that are available for different stages in software development [4].

The main goal of DevOps is to automate everything [5] and relies heavily on the five Cs of software development (continuous integration, continuous testing, continuous delivery, continuous deployment and continuous monitoring) [4]. Automation in DevOps improves the speed of development, precision, consistency and increases the number of deliveries [5].

On the other hand, Robotic Process Automation (RPA) is emerging as a new technology and is changing the way we work by automating mundane and repetitive tasks, to reduce the workload of labors [6]. RPA's use by organizations has been rapidly increasing in recent years and it is expected to grow in the foreseeable future by 20% to 30% per year, with a rate of 32.8% from 2021 to 2028 [7].

Many business processes need automation in order to reduce the human-centric tasks[8]. This technology can be adopted by organizations to achieve several automation goals in the form of accuracy, efficiency, increased productivity and reduced operational costs [9].

This study aims to examine how DevOps processes can benefit from RPA. In order to achieve this goal a qualitative approach was adopted involving individual interviews are used to study the use of RPA in some DevOps processes in a real-world organization.

This study is structured as follow: the first chapter includes the introduction of this study, the second chapter presents the theoretical background where it is explained the concepts of DevOps and RPA, the third chapter is the literature review where it is analyzed the existing literature about DevOps process automation, the fourth chapter has the research methodology used and its explanation, the fifth chapter contains the discussion of the results and finally the last chapter contains the conclusion of this study, the limitations and the future work.

Chapter 2- Theoretical Background

2.1 DevOps

Currently, the automation software development has gained more importance since there is a need to remove the gap between the developers and operation's teams. It has been required that the automation of software development systems improves the productivity, accelerates the delivery of products to customers and it needs to operate directly.

According to the authors [10], the experts have created a concept, or a new idea called DevOps to collaborate the abilities of software development management [10].

In the Agile Conference in Toronto carried out in 2008, Debois reported that IT people need to create cross-functional teams between development and operation's teams. In the following year, during the first conference called "DevOpsDays Conference" he named the term "DevOps", recalling the demand to bring the two functions together [11], [12].

DevOps is a combination of the words development and operations [5]. It's an emerging culture that leads to the collaboration of three teams (development, testing and operations) with the aim to deliver product in a continuous and effective manner [3]. The principal goal of DevOps is to eliminate the existing gap between the Developers and operations teams [13].

The Figure 1 (adapted from the authors [14]) shows the cycle of DevOps based on a DevOps approach. One can see that the development team is responsible for the release, plan, code, build, test and deploy whilst the operation team has a responsibility on the operation and monitoring phases.

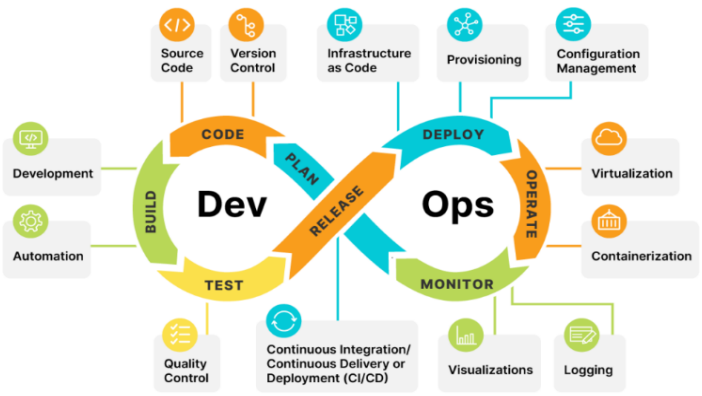

Figure 1-Cycle Based on a DevOps approach (adapted from the authors [14])

According to the Figures 2 and 3 (adapted from the authors [4]), the Development team is responsible for the plan, code, build**,** and test whilst the Operations team is responsible for the release, deploy, operate, and monitor [4].

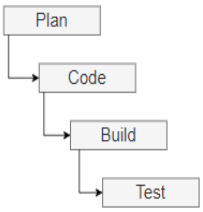

Figure 2-Responsibilities from the Development Team (adapted from the authors [4])

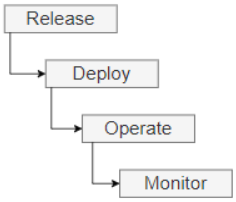

Figure 3-Responsibilities from the Operation Team (adapted from the authors [4])

2.1.1 DevOps Pillars

The authors [15] have highlighted four main pillars for DevOps: Culture, Automation, Measurement and Sharing also known as CAMS**.** It is a module that was created by the inventors of DevOps, and it has become a list of values that have been used by DevOps specialists [13].

2.1.2 DevOps and automation

As mentioned above, DevOps heavily relies on the five Cs of software development, i.e., continuous integration, continuous testing, continuous delivery, continuous deployment, and continuous monitoring) [4].

Continuous Integration (CI) is a practice that helps the member of a team to integrate and merge the development of code. As the developers work in the same code and add new features or resolve some bugs it makes it hard to have a single and updated code. The fact that there is a lack of the updated version of the code is one of the reasons why continuous integrations are needed.

CI allows companies to have shorter and recurrent release cycles that will improve the software quality and the team's productivity by integrating their updated code on a daily basis leading the team to have the most recent and stable version of code.

Some automation tools can be used such as: Jenkins; Bamboo; Buddy; Circle CI; Teamcity; Codeship and Cruise control [4].

Continuous Testing (CT) is one of the most important aspects of the development because it certifies the quality of the product that will be deployed to the end-user. It is a process of testing early, often and everywhere and automate [16].

CT consists in scheduling the automation test after an update is made by the developers instead of the traditional way where the testing part would be done by another team. This will lead to a project having a definite development and deployment phase and consequently, the teams will have more time to release the project with more quality and best deployment while the organization want a faster delivery. Concerning this problem, CT suggests that the testing should be performed in an undisrupted manner and frequently.

Some automation tools that can be used to CT are QuerySerge, Travis, Selenium, JMeter, TestComplete, Appium, Watir and Eggplant [4].

Continuous Delivery (CD) is an approach where an operation team iteratively delivers valuable software in short time to make sure that the software is at a state of release whereas the developer team is making the changes consistently [17]**.** It is also a practice where developers build, test and release code changes to the production team in an incremental manner [4]. It also allows the dev and ops teams to work in a parallel iteration cycle [17].

As the development and operations happen at the same time, the software product can be released quickly to users and, in consequence, gets a faster feedback from users comparing to the traditional method.

Some of the automation tools that CD uses are: Jenking, GitLab, Travis, Ansible, CircleCI, XLDeploy, AzureDevOps, Harness and GitHub Actions [4].

Continuous Deployment (CDT) is a software release process that is used for an instant autonomous deployment to the production after the automated validation. It is used when a feature is ready for delivery and can be released instantly.

Some of the automation that CDT use are: Ansible, Octopus/Deploy, Docker, Puppet, Chef and DeployBot [4].

Continuous Monitoring (CM) is the last phase of the DevOps' lifecycle, it takes place after the software is released to the production environment. CM has the objective to make a continuous monitoring in order to alert both the development and operation teams about any problems that occur in production.

Some automation tools that CM uses are: Tenable, Sensu, Insight, Nagios, SolarWinds and Splunk [4].

2.2 RPA

The Industrial Revolution 4.0 has been having a major impact in every aspect of socio-economic life, particularly in all human field being Robotic Process Automation one of the solutions that appeared from this event [18].

RPA is an emerging technology that has been gaining more attention by companies in the last decades since it can be used as a solution for their employees to focus on the tasks that are more complex and valuable and delegating the monotonous, routine and rule based to the digital colleagues [19].

As stated by the authors [20], the essence of RPA is to use automation and intelligence technology in order to replace people for fixed process operations such as repetitive, low-value, and no manual decision-making with the objective to improve work efficiency and reduce errors [20]**.** Robots, process, and automation are three main ideas that are behind the concept of RPA.

Robots are the software machines that can be programmed to perform a specific job whilst the process is related to the series of steps that are needed to reach a specific objective or result.

As one can see in the Figure 4 (adapted from the authors [21], the process of construction of those robots), the RPA project must follow a lifecycle with six steps: analysis, design, development, deployment, testing and maintenance and operations [21].

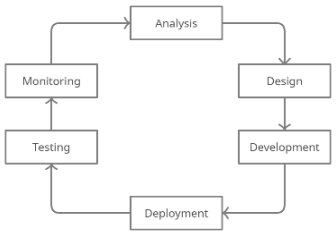

Figure 4-Robotic Process Automation project's lifecycle (adapted from the authors [21])

The adoption of RPA has some advantages such as bringing value to the company by allowing workers to focus their time in more complex and meaningful tasks and the fact

that the automation of repetitive tasks leads to a lower error rate by eliminating human errors.

On the other hand, RPA is facing some challenges considering that being a new technology comes with lack of knowledge and experience in its implementation. The culture resistance is another obstacle on the implementation of RPA as some employees fear the loss of their job by implementing this new technology [19].

Chapter 3- Related Work

The goal of this chapter is to summarize what researchers have been reporting about automation in DevOps processes in studies published on scientific repositories.

In the Figure 5, it is possible to see the structure of the review which is composed by three major phases (Planning the review, Conducting the review, and reporting the results) [22]. Planning the review is the first step and it includes the motivation, objective, and protocol. The next step is to conduct the review which is composed by the selection of articles after applying the filters and performing data extraction and analysis. Finally, the last step consists in reporting the results.

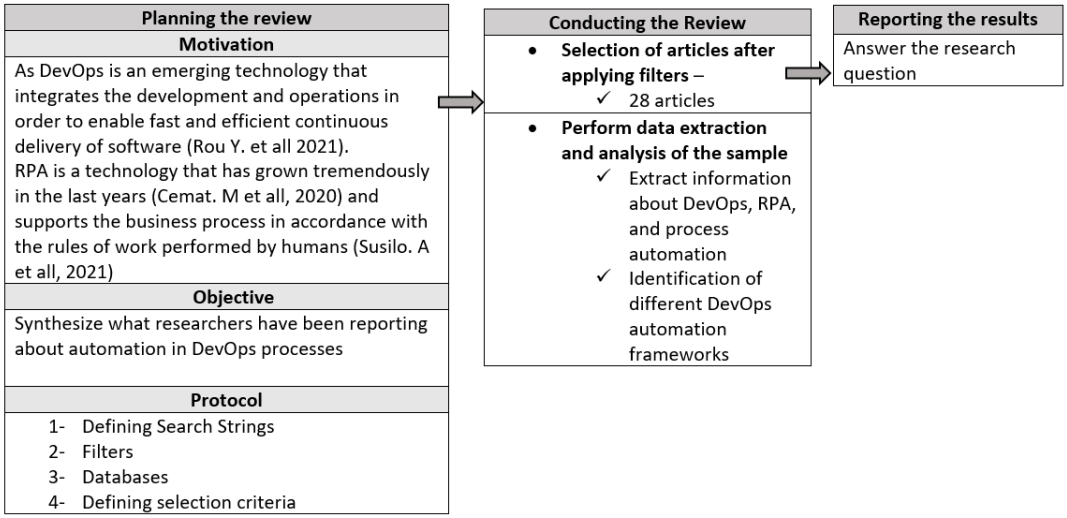

Figure 5-Structure of Systematic Literature Review

3.1 Planning the review

This section belongs to the first major phase of the SLR and includes the motivation, objectives, and protocol.

3.2 Objective

This subchapter aims to answer the following research question (RQ):

RQ1: What has been reported about automation in DevOps processes?

3.3 Review Protocol

This subpart of the phase "Planning the review" consists of explaining how the review protocol was performed.

To perform the research of articles the following scientific repositories were used:

- Scopus: (https://www.scopus.com/);
- Ieeexplorer (https://ieeexplore.ieee.org/Xplore/home.jsp);
- ACM- Digital Library (https://dl.acm.org/);
- Web of Science (https://www.webofscience.com/wos/woscc/basic-search);

- EBSCO (https://www.ebsco.com/pt/produtos/bases-de-dados/academic-search);

The search string and the keywords that were used on these repositories are shown in the Table 1.

The Table 2 represents the inclusion and exclusion criteria whilst searching for articles in the scientific repositories.

After selecting the repositories, the keywords and search strings, the filters were selected, and these can be found on the Table 3.

The first filter showed the results when looking through the search string in all repositories, the second filter was used to inquire the search string in the abstract of the studies. The following filter presents the results of the search string on the title of the studies, the fourth filter eliminates the duplicate studies. Finally, the fifth filter consists in reading the abstract of the articles and remove the ones that weren't related to the core of this study.

Table 1-KeyWords and Search Strings

Keyword	Search String
ITSM; "Information Technology service Management"; Devops; "Robotic Process Automation"; RPA; Automation; Intelligence Process Automation; IPA.	(ITSM OR "Information Technology service Management" OR DEVOPS) AND ("Robotic Process Automation" OR RPA OR Automation OR "Intelligence Process Automation" OR IPA)

Table 2- Inclusive and exclusive criteria

Inclusive criteria	**Exclusive criteria**
Available in full text	Unavailable in full text
Articles in English	Articles in other language than English
Not duplicates articles	Duplicate articles
Scientific paper in journal or conference	Nonscientific paper
Articles related to the literature review objective	Articles unrelated to the literature review

3.4 Conducting the review

The results of the column "Filtration stage 1" were obtained by inquiring the search string in the repositories, representing the number of documents where the keywords are present. Regarding the columns "Filtration stage 2" and "Filtration stage 3", it shows the number of times that the keywords appeared on the abstract and title, respectively. The "filtration stage 4" shows the number of articles after removing the duplicates. Lastly, the column named "filtration stage 5" indicates the number of documents chosen after reading the abstracts from the papers selected in "Filtration stage 4" with a final set of 28 results.

The product of this research is represented in the table 3.

Table 3- Results of the research

Repositories/ Filtration stage	Filtration stage 1	Filtration stage 2 (Abstract)	Filtration stage 3 (Title)	Filtration stage 4 (Duplicate)	Filtration stage 5 (Manual)
Scopus	1841	218	22	8	8
IEEExplore	195	94	7	6	5
ACM	581	37	4	4	4
WEB OF SCIENCE	209	136	14	9	8
EBSCO	2510	100	13	6	3

After having selected the articles, our sample consists of 28 articles where 15 of those were published in the last three years and as one can see in the Figure 6, since 2018 the number of articles has been rising which showcases the growing interest in the core of this study.

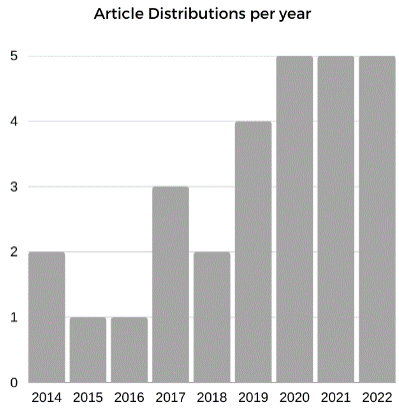

Figure 6-Articles Distributions per year

3.5 Reporting the review

Reporting the findings

It is important to state that there are differences between Business Process Automation and RPA.

Business Process automation's objective is to enhance processes by streamlining existing ones and eliminating inefficiencies [23].

Whereas RPA, as said in chapter two, has the objective to use automating mundane and repetitive tasks, to reduce the employees' workload [6].

RPA is one form of Business Process Automation whose objective is to perform tasks that were previously done by humans, focusing only on repetitive workflows [24].

In the theoretical background, the five Cs of software development lifecycle were identified, and in order to sum up what the researchers have been reporting about

automation in DevOps processes, the findings by segments of software development lifecycle have been described in the chapters 3.1.5.1. – 3.1.5.3.

3.5.1 Continuous testing

DevOps highlights the importance of automating all software development processes in order to improve speed and agility parameters. For that, the automation of testing processes is needed as well as configuring it to run automatically. Therefore, DevOps must build a mature testing framework to help in scripting test cases [25]**.**

Test automation consists of the use of tools with the aim to automatically test the application in software development and follows a lifecycle: how it begins, develops and finishes [26], [27].

Test automation considers aspects such as:

- **Frequent releases,** i.e. with more and recurring releases, teams need to spend more time in testing automation.
- **Tools available**, with more automated tools the development teams need to evaluate them with their integration in the CD/CI pipeline.
- **Data testing and CD/CI infrastructure,** as testing automation itself is a challenge the development team needs to discuss the best testing strategy and create the testing framework.

The authors [25], conclude that the process of test automation with DevOps offers series of benefits like:

- Faster development without compromising the quality of the product.
- Better way to collaborate with the team.
- Security.
- This process increases the coverage of releases, making them more reliable.
- Improves the customers satisfaction.

These authors [25], also conclude that “DevOps helps achieve the benefits of moving faster and being more effective with test automation” [25].

Another author [28] presented an experience report on test automation in a DevOps team and they concluded that with the test automation the team in study had more frequent releases, it increased their productivity, and there was a higher satisfaction of the customers. The team also shared platform work efficiency and high test efficiency [28].

They also noticed some success factors that are shown in the Table 4 (adapted from the authors [28]).

Table 4- Factors of success for test automation (adapted from the authors [28])

Dimension	Factor
Human	Whole team effort
	Expert team members
	Self-motivated team members
Organizing	Allow time for learning curve
	Internal open source community mindset
Technical	Test tool choice and architecture
	Testlab infrastructure
	Product testability
	Telemetry
Process	Incremental approach
	Process observation and optimization

These indicators, stated by the authors in their report, prove the benefits that have been mentioned earlier in this section.

3.5.2 Continuous Deployment

In what concerns continuous deployment, the author supports the DevOps lifecycle by integrating the framework MAPE (Monitoring, Analysis, Planning, Executing) represented in Figure 7 (adapted from the authors [29]).

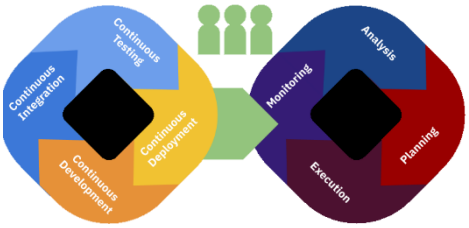

Figure 7-DevOps to MAPE framework (adapted from the authors [29])

Continuous Deployment hints at an automatic release of application changes made by the developers into production. Through the deployment, the DevOps teams have to monitor and manage their infrastructure to guarantee that the services are correctly provisioned and able to perform well [29].

With their framework, the authors [29] conclude that is has the required performance and efficiency and it also supports the deployment and self-configuration in a multi-cloud environment, being one of the functions of DevOps' pipeline. They also state that this framework is accessible to Dev and Ops teams and therefore appropriated to DevOps.

3.5.3 Continuous integration and continuous delivery

Continuous Integration and delivery have appeared as an advantage for traditional application development [3].

In [30] the continuous integration and delivery principles, practices and tools were used to minimize waste, support rapid feedback loops and improve value delivery and maintenance[30].

The authors [30], also refer the main steps for the continuous integrations such as:

- Source code management (SCM).
- Push/pull changes to the repository to trigger a continuous delivery build.
- Check out the latest code and the associated data version from the data repository storage.
- Run the unit tests.
- Testing and validation.
- Package the model and build the container image.
- Push the container image to the registry.

Regarding continuous delivery, the main component of their pipeline are as follows:

- Staging environment.
- Automated triggering.
- Performance monitoring.

After the automation was reported, the improvements were seen in many areas like time to market, integration across business units, breakdown departmental silo, code quality, productivity, and visibility [30].

Another study [3], also reports the implementation of continuous integration and deployment but in a cloud environment, this paper refers enormous advantages of these implementations such as:

- Continuous innovation because of continuous development of new ideas.
- Streamlining of deployment process and improve quality of scripts and integrations.
- No resource bottlenecks.
- Increase delivery in Dev, Test, Pre-Production and Production environments: Elimination of manual and repetitive processes based on deployment.

However, it is important to emphasize that DevOps alone does not make a difference and it relies in multiple frameworks like ITSM, Agile and Lean [30].

To be successful in the DevOps journey, it is necessary to change the business culture, search for executive-level support, choose wisely the tools that fit the business needs, automate (continuous integration, testing and delivery) and to promote success [30].

3.6 Summarize Related Work

In summary, the reports on automation in DevOps processes have been synthesized. The papers analyzed showed innumerous advantages such as the faster development without compromising the quality of the product, security, better collaboration from team members and continuous innovation.

It is also important to pay attention to some critical factors that can determine the success on four dimensions (Human, Organizing, Technical, Process). To obtain these advantages, the business must also make some adjustments such as promoting a culture of success, seek help to executive level and change the business culture.

This SLR describes the automation in DevOps processes. However, the use of RPA in these processes has not been studied, therefore this study intends to provide insights on organizational gains that can be obtained from it.

Chapter 4- Research Methodology

As referred in the Chapter 3, there is little use of RPA in DevOps processes. In order to understand how DevOps processes can benefit from RPA, the research methodology applied in this study is a qualitative research involving individual interviews.

Qualitative research's aim is to answer questions such as "how", "why," and "what" in regard to a phenomenon [31]. The qualitative data can be collected in form of an interview, focus group or via observation [32]. The goal of using interviews in the qualitative research is to gather information about a topic that cannot be achieved using qualitative measures. These interviews can be unstructured, structured or semi structured [33].

In this study, a qualitative research involving individual interviews was performed. These interviews were conducted in two formats, either face-to-face or remotely with the aid of two videoconference software, Zoom and Microsoft Teams.

The semi-structured interviews are constructed to find out subjective responses from individuals concerning a particular situation or phenomenon that they have experienced [34].

According to the authors [34], in order to construct a semi-structured interview it is necessary to follow six steps that are represented in the Figure 8.

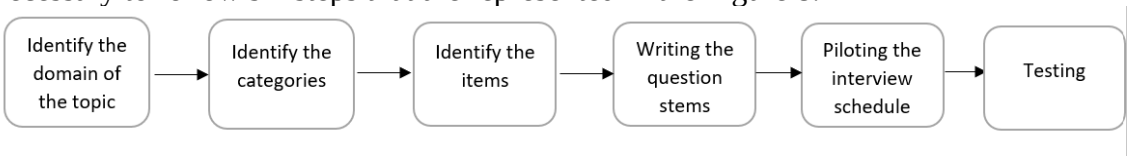

Figure 8-Guide to create a semi-structured interview (according to the authors [34])

Semi-structured interviews are used when the researchers already have some knowledge about the topic they are studying but more detailed information is required [35].

Table 5- Steps to create a semi-structured interview and the description

Steps	Description
Identify the domain of the topic	Bearing in mind that the topic of this study is focused on DevOps processes that can be automated with RPA, its knowledge was obtained through a literature review, acknowledging what is known about this topic through existing literature.
Identify the categories	It is necessary to pinpoint the categories that are most relevant to the reach question [34] . The categories are the identification of the current DevOps processes and their potential for automation.
Identify the items	The identification of items is made by the categories defined [34]. Regarding the category focused on DevOps processes, the question "Which DevOps processes are you familiar with and which one(s) do you use in your work?" provides an understanding on which DevOps

Steps	Description
	processes the interviewee knows. By inquiring "Of the processes you mentioned, which ones do you think can be automated by RPA and why?", it is possible to recognize which of the aforementioned processes can be automated. These questions alongside others that were developed through this process form the semi-structure interview framework.
Writing the question stems	It was followed the three recommendations by [36], specification, division, and tacit assumption. The specification is related to the topic of each question. The division guarantees that the question stems are properly phrased and ordered. Finally, the tacit assumption is the process that clarifies the answers from the participants.
Piloting of the interview schedule and the testing	It was performed the piloting of the interview schedule and the testing to ensure its effectiveness

The participants for this study were selected relying on the professional networks of the author, targeting individuals with experience in DevOps and/or RPA.

A total of 38 invitations were sent with 21 accepting the invitation and the remaining 17 declining.

Participants are interactively invited until theoretical saturation is achieved.

Once a good number of volunteers was gathered, an interview guide (Attachment A) was created based on the authors' [37] recommendation.

Firstly, a brief introduction about RPA was given, followed by the questions of the semi-structured interview.

These interviews had a mix of structured and unstructured questions, each with a specific aim. The structured questions provided an insight on the participants' profile, whilst the unstructured questions acknowledged what they knew of the topic.

An analysis of the data gathered through the interviews was performed. This analysis followed the process of coding and categorization (open, axial and selecting coding) following the guidelines of Ground theory [38].

The following sub-chapters will entail the analysis of the insights provided by the 21 participants in this study. Their answers will be analyzed in regards of their experience in IT, DevOps, knowledge in RPA and their current role.

4.1 Roles of the participants

It is observable that most of the interviewees (11) are Developers, followed by Scrum Masters (5), Chief Technical Titan (3) and Software Engineer (2), showed in the Figure 9.

The participation of Developers and Software Engineers is important due to their knowledge in software development and their capability to identify DevOps processes that can be automated with RPA.

The presence of people with different types of roles is important to obtain different perspectives about the core of this study.

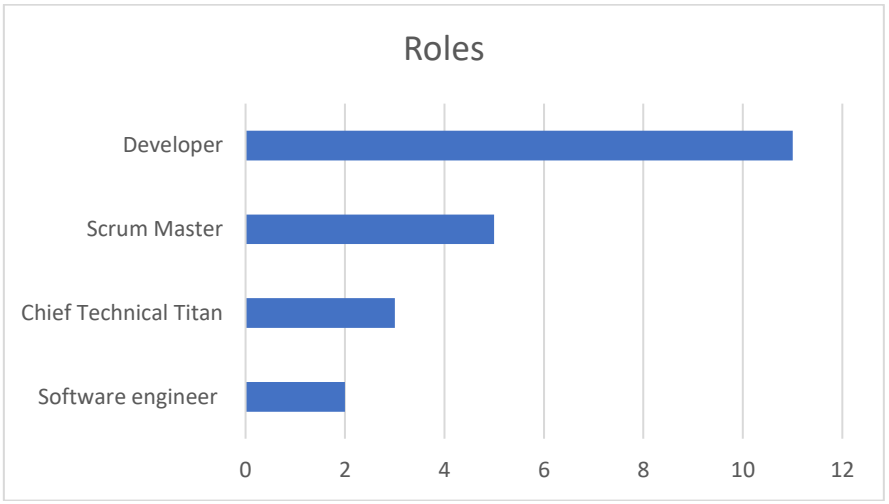

Figure 9-Roles of the participants

4.2 Experience in IT

Concerning the interviewees' experience in IT, the collected data was split into four different categories (0-5, 6-10, 11-15, >15 years of experience), illustrated in the Figure 10.

The bar chart below demonstrates that there was an equal number of participants that had between 0 to 5 years of experience and more than15 years of experience, being each category made of 7 interviewee. On the other hand, the category with less participants belongs to those with 11-15 years of experience, which is composed of 3 participants.

Moreover, the distribution of interviewees shows that there is a good mix of experience levels with an average of 9.9 years of experience.

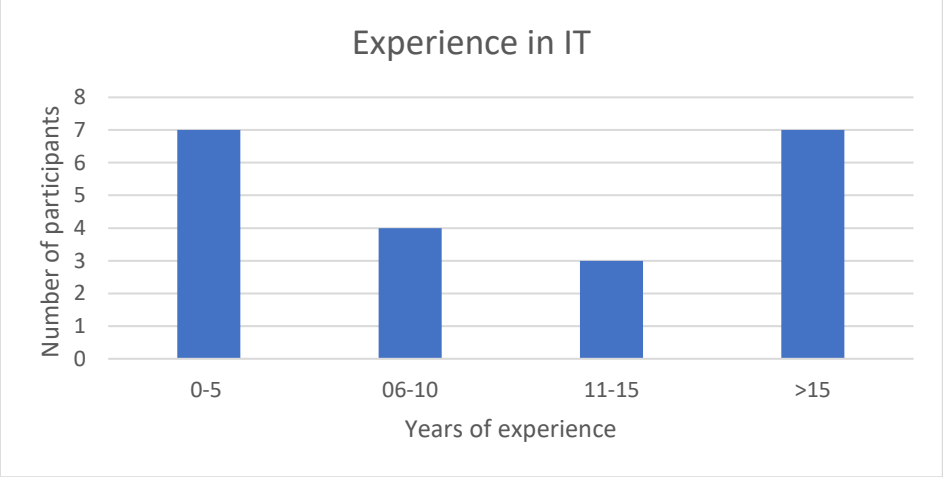

Figure 10-Participants' experience in IT

4.3 Experience in DevOps

In what concerns the volunteers' experience in DevOps, the answers that they provided were divided into three categories, 0-5, 6-10 and 11-15 years of experience in DevOps, represented in the Figure 11.

In this case, years of experience only encompassed work experience in this area of expertise.

By analyzing the bar chart below, it is possible to conclude that most participants (12) have less than 5 years of work experience in DevOps and only 3 interviewees belong to the 11-15 years of experience in DevOps' category. On average, the participants had 4.85 years of experience in this area of expertise.

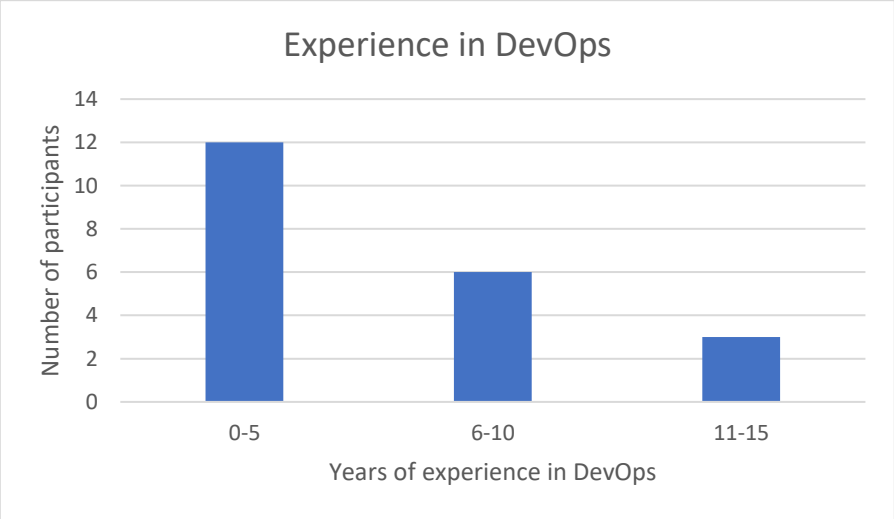

Figure 11-Participants' experience in DevOps

4.4 Comparison between the experience in IT with experience in DevOps

With the aim to understand the relationship between the experience in IT and the experience in DevOps, both datasets were merged (Figure 12). Once joined, it was noticeable that there was a high number of participants that had more than 15 years of experience in IT whilst the same was not verified in the case of DevOps. As mentioned above, 7 out of the 21 volunteers have been working in IT for more than 15 years of experience whilst this category does not exist in the DevOps dataset.

During the interviews, some participants stated that they only started to work in DevOps when they changed job functions, which could justify this difference.

This contrast can also be observed through the averages of the years of experience in both IT and DevOps, of 9.9 and 4.85 years, respectively.

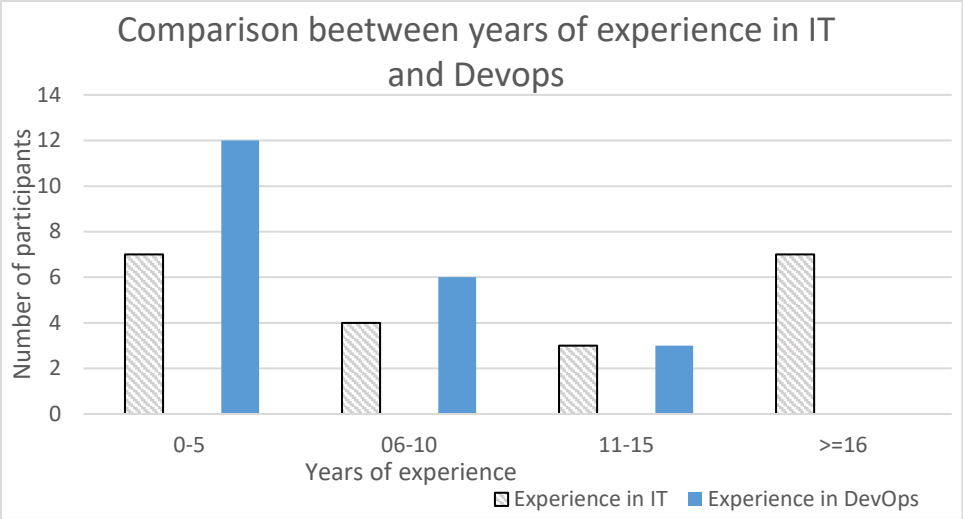

Figure 12- Comparison of participants' experience in IT and DevOps in years

4.5 Knowledge about RPA

Regarding the analysis of the participants' responses on their knowledge about RPA (Figure 13), it was found that out of all 21 participants, 52% (11 participants) knew what RPA was while the remaining 48% (10 participants) did not have prior knowledge of it.

This suggests that RPA is not a widely known technology among the participants of this interview.

Nevertheless, an explanation was given on what RPA is and its advantages such as bringing value to the company and reducing error rate. After this brief explanation all doubts or questions from the interviewees were clarified.

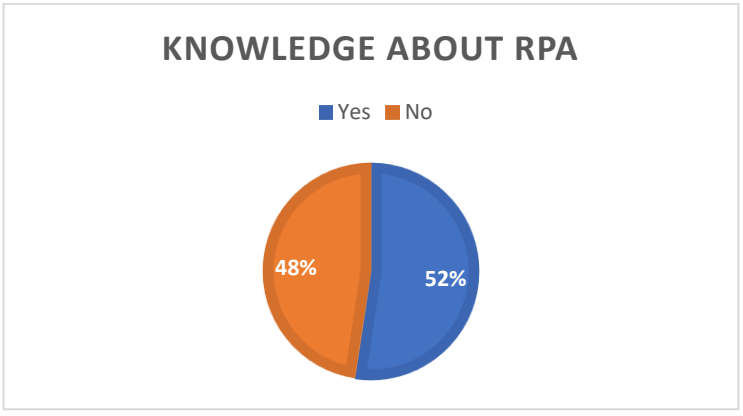

Figure 13-Participants answers about their knowledge in RPA

4.6 Correlation between RPA and experience in IT and DevOps

In order to understand the relationship between the knowledge in RPA and the interviewees' experience in IT and DevOps, the data obtained was divided into two groups: those who have experience in IT and their knowledge in RPA and those who have experience in DevOps and their knowledge in RPA.

Starting by analyzing the bar chart (Figure 14) focused on the experience in IT and its relationship with RPA, it is observable that the participants with more experience, i.e. those with more than 15 years of experience in IT, were the ones that knew what RPA

was (Four participants). Additionally, the biggest group of interviewees who did not know what RPA was (Four participants) were the ones with less working experience (0-5 years of experience).

Looking into the groups focused on the experience in DevOps and its relationship with RPA(Figure 15) , the opposite was observed since the participants that knew more about RPA were the ones that had less experience in DevOps (Six participants). However, it was also the group of interviewees with less experience in DevOps that mostly answered that they did not know what RPA was (also six participants).

Therefore, it can be extrapolated that those who work in DevOps have a bigger chance to cross paths with RPA sooner than those that work in IT in general.

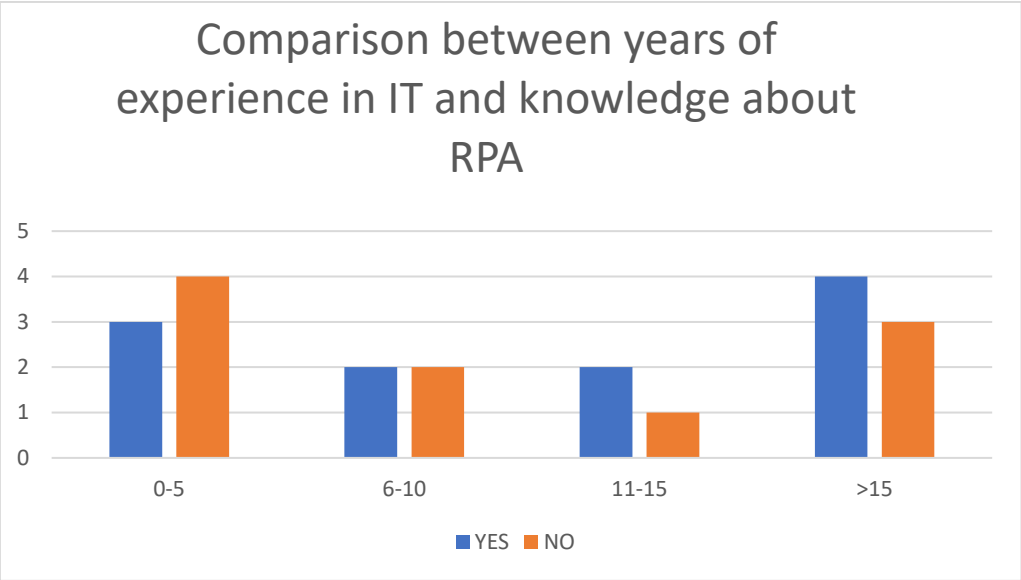

Figure 14-Comparison between participants' experience in IT, in years, and their knowledge about RPA

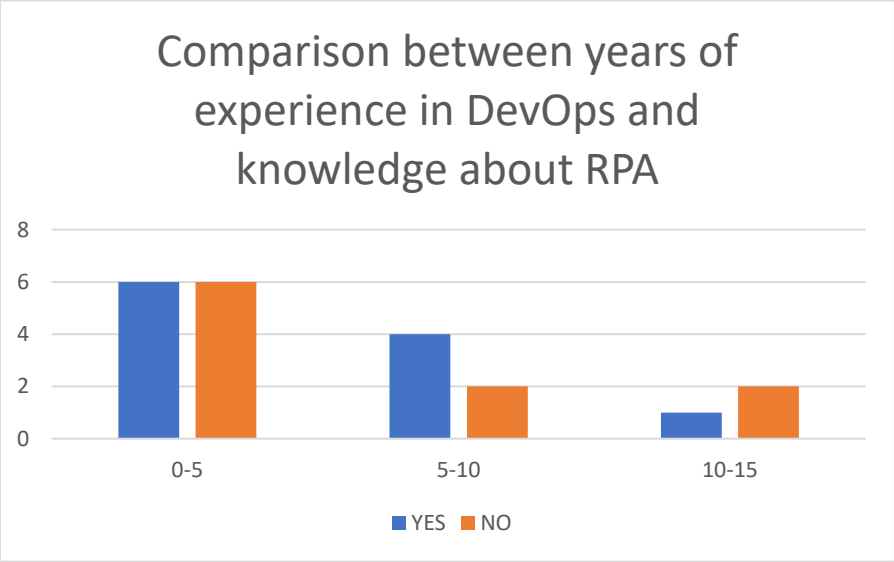

Figure 15-Comparison between participants' experience in DevOps, in years, and their knowledge about RPA

4.7 Profile

In conclusion, there are a few insights that can be taken from these interviews. The participants had on average 9.9 years of experience in IT whilst the interviewees with experience in DevOps had on average 4.85 years. Focusing on the knowledge of RPA, 52% of the participants already knew what RPA was before the interview and the most common role is Developer.
This information is represented in the Table 6.

Table 6-Profile of the participants

Interview	Experience in IT	Experience in DevOps	Knowledge about RPA	Role
1	20	8	Yes	Chief Technical Titan
2	20	10	Yes	Chief Technical Titan
3	3	2	No	Developer
4	23	6	No	Scrum Master
5	11	4	Yes	Developer
6	18	8	No	Developer
7	6	2	No	Developer
8	10	3	Yes	Software Engineer
9	2	1	Yes	Developer
10	2	2	No	Developer
11	1	1	No	Developer
12	22	15	No	Developer
13	15	5	Yes	Chief Technical Titan
14	4	4	Yes	Scrum Master
15	16	5	Yes	Software Engineer
16	8	3	No	Scrum Master
17	5	3	Yes	Scrum Master
18	12	12	No	Scrum Master
19	2	2	No	Developer
20	7	5	Yes	Developer
21	1	1	Yes	Developer

Chapter 5- Results and Discussion

In this chapter, the findings about DevOps processes that can be automated with RPA and the benefits of this automation will be analyzed. The outcome of this analysis will provide a valuable insight about DevOps processes.

5.1 DevOps processes

In order to understand which DevOps processes were chosen by the participants of this study, a bar chart was created (Figure 16). In this chart, it is possible to verify that the DevOps process mostly chosen by the participants is "Continuous Deployment" since it was referred 16 times by the 21 participants. The second process that was mentioned the most is "Continuous Delivery" with 11 references.

Continuous Deployment, as it was referred in chapter two, is a release process that is used to automate the deployment of the changes to the production environment. Therefore, it is possible to conclude that the teams want to quickly deliver their software.

Continuous Delivery, as mentioned above, was the second most mentioned DevOps process by the participants. This indicates that the teams are working to deliver the software quickly so that they can get the clients' feedback as soon as possible.

The participants' selection of DevOps processes was made freely, without being provided a list with DevOps processes.

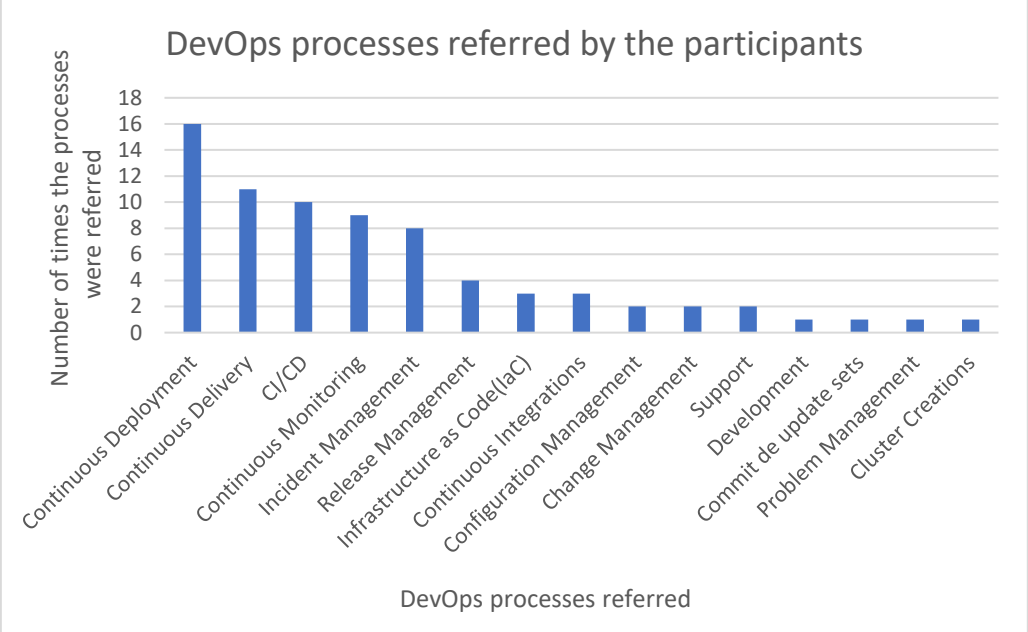

Figure 16-DevOps processes referred by the participants

After each interview, the saturation point was calculated. This point happens when no new information is added from the collected data, in this case, from the interviews performed [39]–[41].

In the dispersion graph (Fig 17), it is observable that the saturation point has been reached since no new DevOps processes were added from the last four interviews compared to the previous ones.

The percentage of the saturation point was calculated based on the following formula:

$$\frac{New\ DevOps\ processes\ said\ in\ the\ interviews}{Total\ of\ DevOps\ processes} * 100$$

The “Total of DevOps processes” only refers to a unique process, for example, if in the interviews the process “Continuous Deployment” was referred 16 times, it only counts as one.

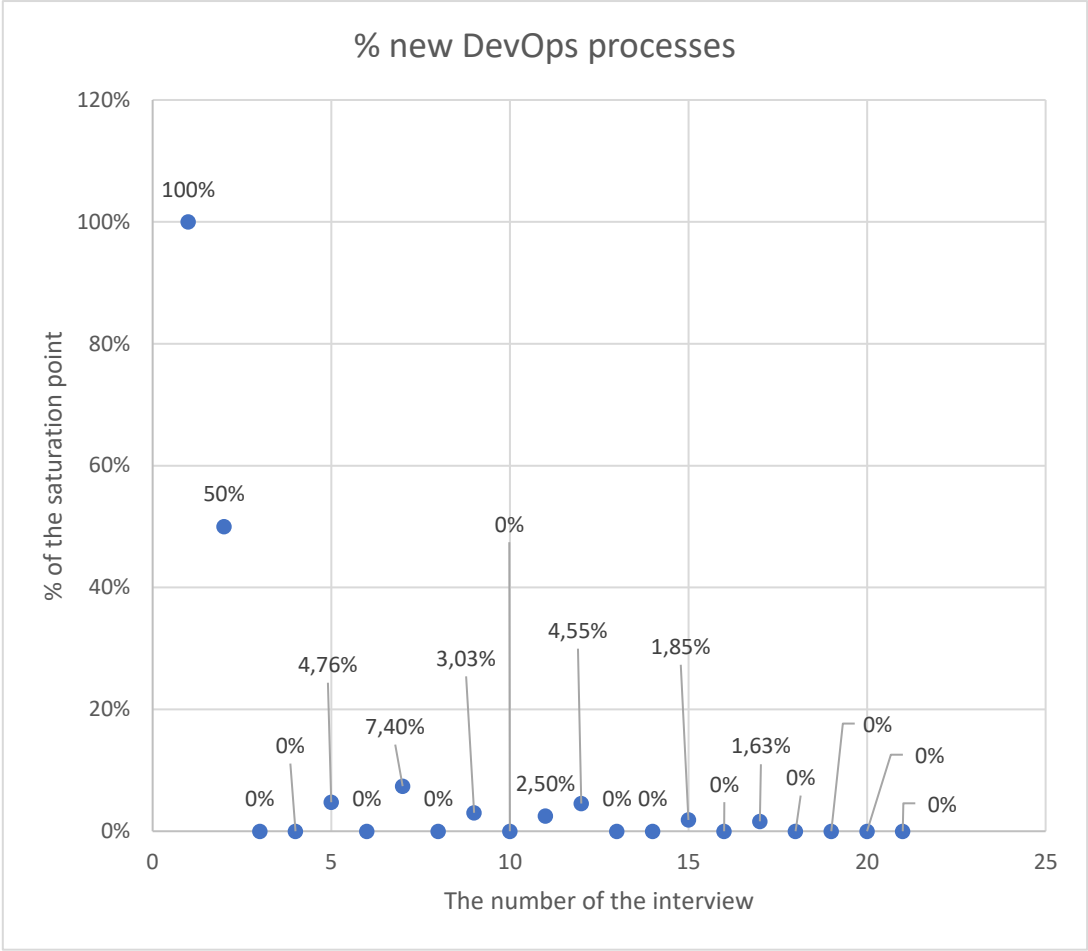

Figure 17-Saturation point for the DevOps processes referred by the participants

5.2 DevOps processes that can be automated by RPA

After the participants answered the question regarding which DevOps processes, they are familiar with, they were asked of those processes which ones could be automated by RPA and the answer are present in the bar chart of Figure 18.

In order to understand the processes, the ones presented in this bar chart will be analyzed in this study.

Comparing with the bar chart that represents which DevOps processes the interviewees are familiar with (Figure 16), the data referring to which processes should be automated (Figure 18) also highlights the processes “Continuous Deployment” and “Continuous Delivery” as the ones with the most references.

Regarding the saturation point for DevOps processes that can be automated with RPA (Figure 19), the conclusions drawn are the same as the saturation point in Figure 17. Considering the last participants could not add new data, this point was reached.

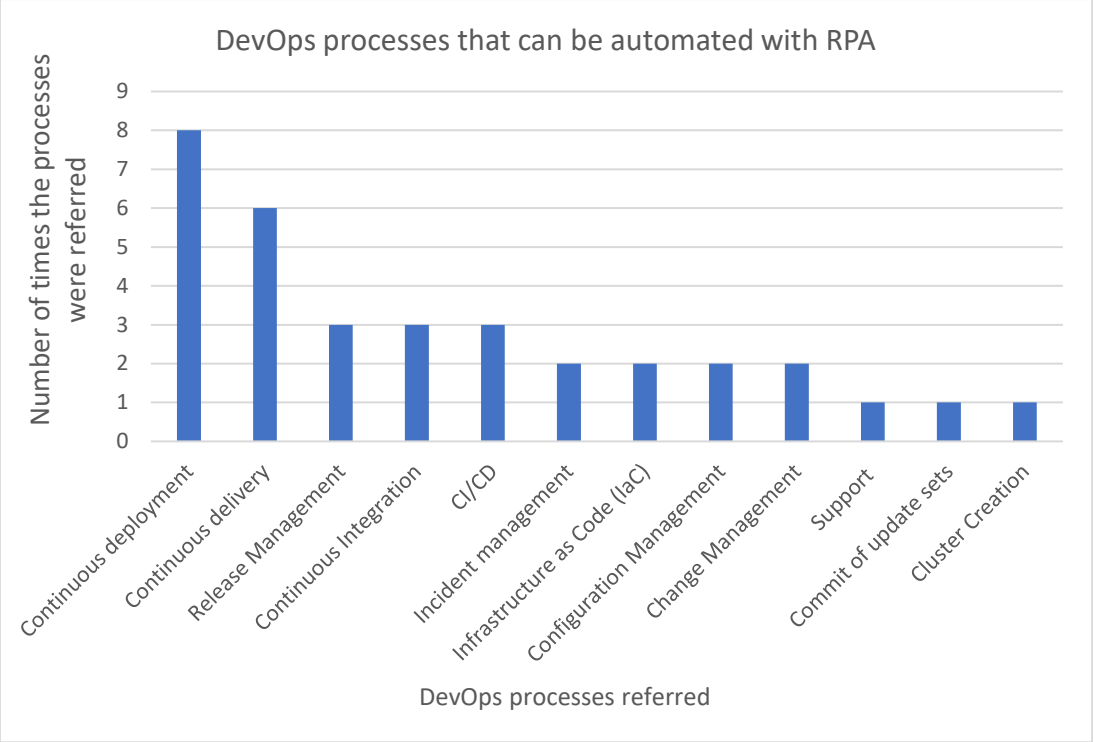

Figure 18-DevOps processes referred by the participants that can be automated with RPA

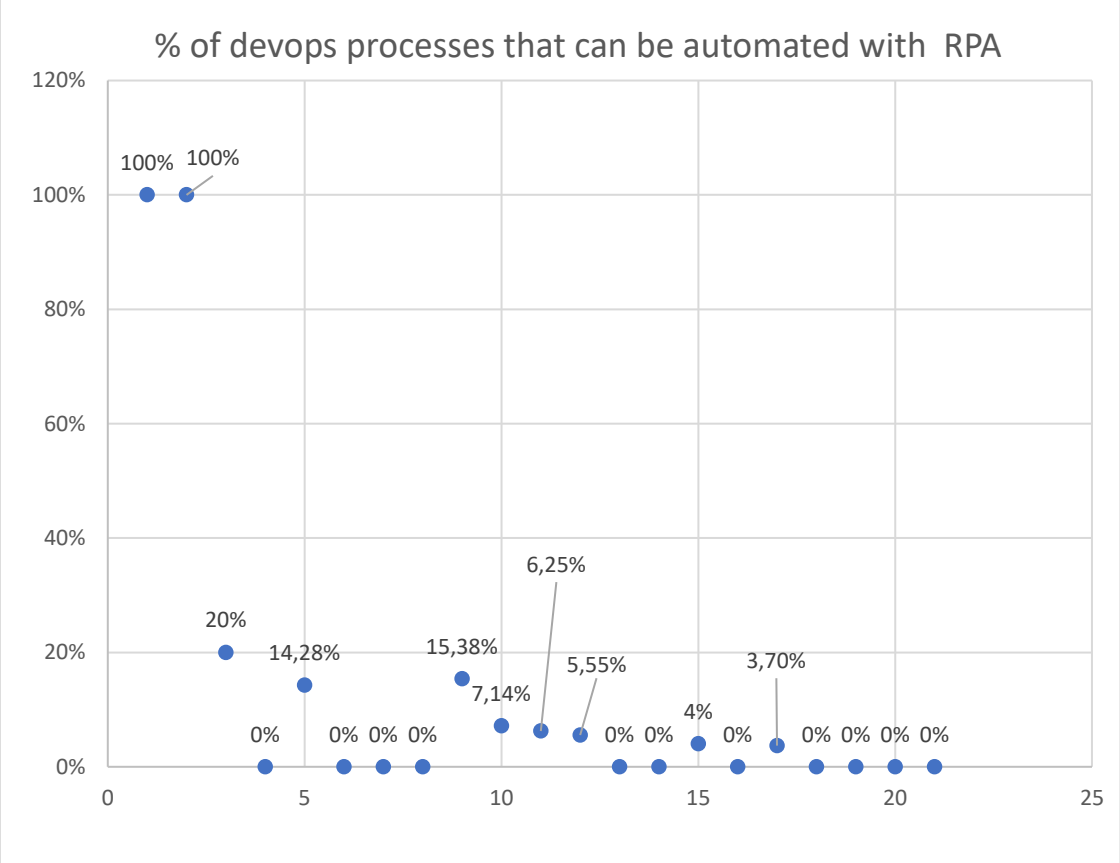

Figure 19-Saturation point for the DevOps processes referred by participants that can be automated with RPA

5.2.1 Continuous Deployment

Regarding the DevOps process "Continuous Deployment", it was referred eight times as a process that can be automated by RPA. To further understand the importance of this process within the distinct roles in IT, the participants' functions were analyzed. From all interviewees, the ones who mentioned "Continuous Deployment" belonged to the following roles: two are Chief Technical Titans (ID 02 ,ID 13), two are Developers (ID06, Id 21) , three are Scrum Masters (ID 04, ID 14, ID 16), and one is a Software Engineer (ID 15), represented in the Figure 20 . This showcases that different roles agree that this is a good process that could be automated, and it is possible to look into the different perspectives as to why this process is important. It has been attributed an ID to each participant so that it is easier to identify their quotes about this topic.

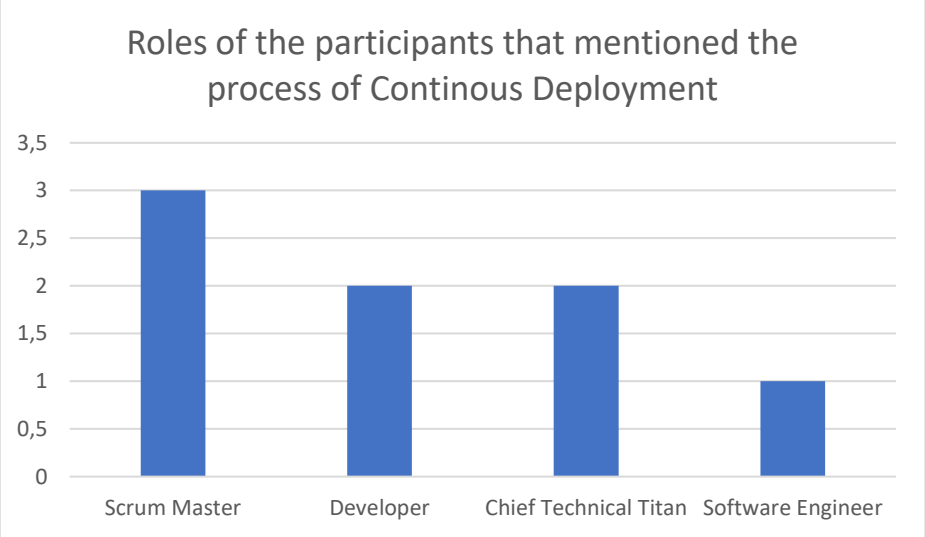

Figure 20-Roles of the participants that mentioned the process of Continuous Deployment

The benefits referred by the participants are showcased in the bar chart (Figure 21), and it is possible to conclude that the benefits "More time for development" and "Error Reduction" were the most referred, each with two references and in total eight benefits were mentioned about this process.

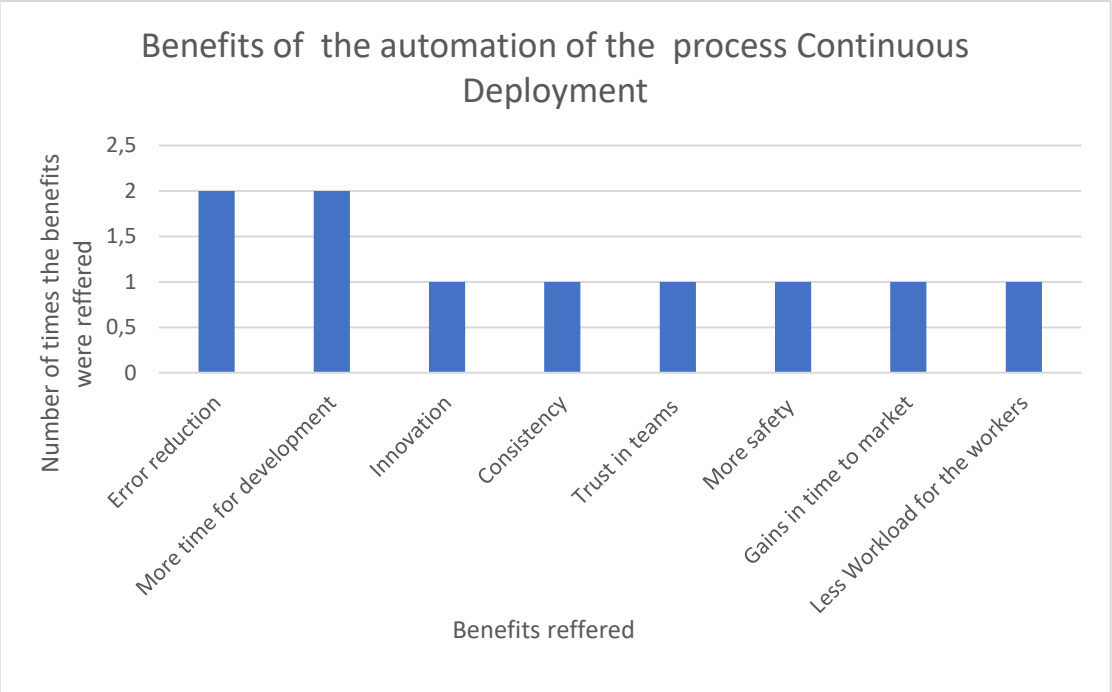

Figure 21-Benefits of the automation of the process Continuous Deployment

In order to understand the advantages highlighted by the participants in distinct roles, a scheme was created (Figure 22).

In this scheme it is represented each ID that was attributed to each participant previously.

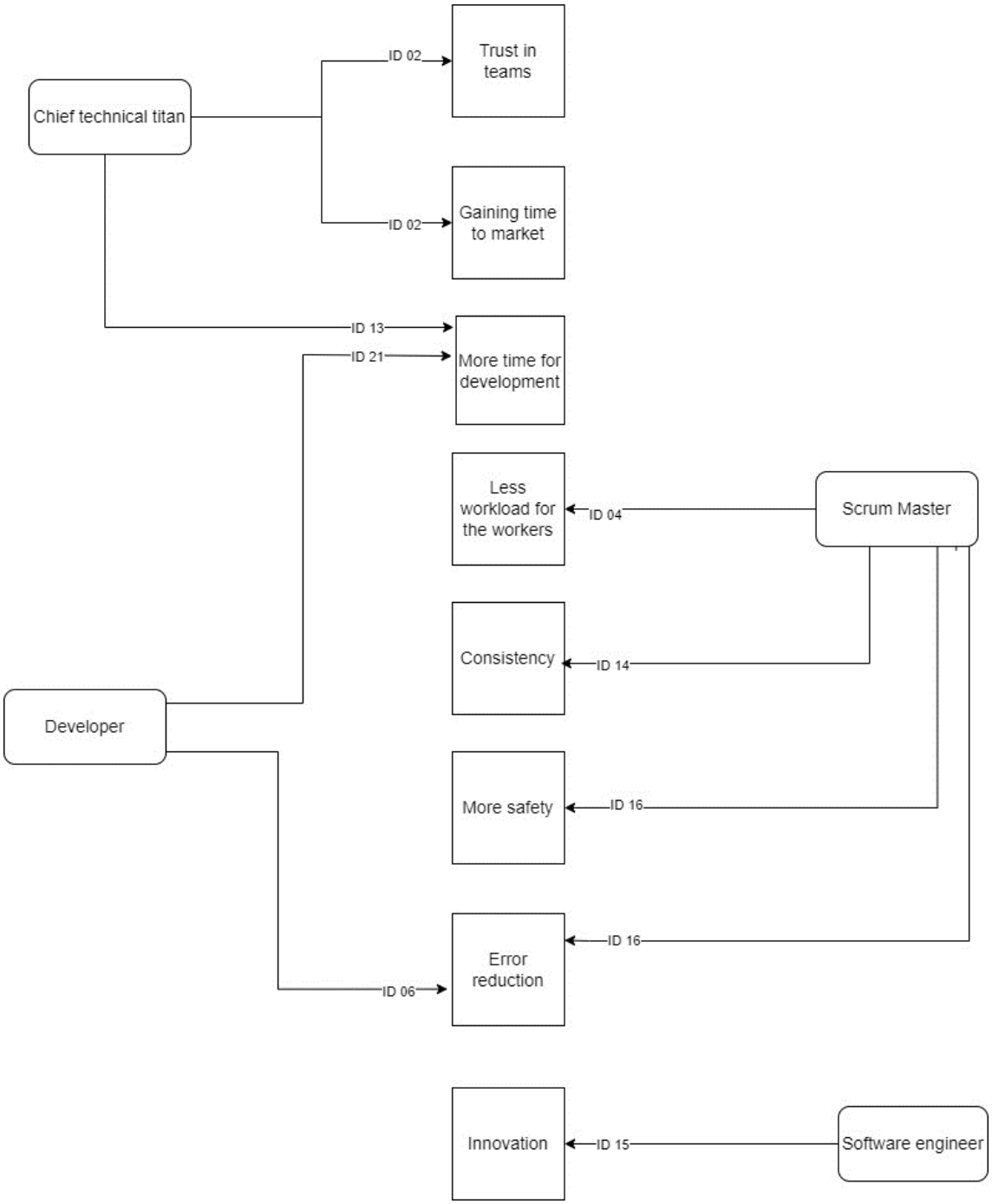

Figure 22-Advantages highlighted by different roles

In the following paragraphs, an analysis of what was said about the advantages of the automation of the process "Continuous Deployment" will be performed.

One participant, whose role is Chief Technical Titan (ID02), highlighted the advantage of "Gains in time to market". According to his insights, automating the DevOps process "Continuous Deployment" can accelerate product delivery to the client. He stated, "*With the automation of the DevOps process Continuous Deployment the product will be delivered quicker to the client"*.

Another advantage mentioned by this participant, is the increased trust among team members, he showcased how automating this process removes potential problems in the

testing and production environments, during the deployment thus increasing confidence among teams, as he expressed "*As the deployment process is automated, whatever is automated will not cause problems in the environment (test,prod) in which it is deployed, and so the teams will have more confidence"*.

For this process, it was referred that they use GitHub to help in the Continuous Deployment.

The other participant with the same role (ID03), stated that by automating this DevOps process, the teams would have more time for development. He justifies this advantage by explaining that automated deployment would allow developers to focus on implementing and accomplishing more crucial tasks for the company. He voiced, *"By automating the process of "Continuous Deployment", the developers can have more time to develop more important task for the company"*.

Regarding the role of Scrum Master, the participant with the ID04 highlighted the advantage of reducing the workload for the workers as a result of automating this process. The ID16 mentioned two advantages (safer and reduced error) whereas the participant with the ID14 only referred to the consistency. The latter participant (ID14) also mentioned the use of GitHub and Jenkins for the Continuous Deployment.

By automating this process with GitHub, the development environment maintains consistency as the code is updated as soon as possible, enabling developers to work with the latest version. Thus, it facilitates better collaboration and communication with the team members.

Furthermore, updating the code in the master branch simplifies the testing and validation of the new software functionality. This participant stated, "*Ensures consistency in the development environment with the most up-to-date branch master source code*".

Additionally, this participant stated that automating this process also includes steps to clean the code, ensuring that it is well organized and without any problems. This increases efficiency and enables faster code submission, allowing software and bug fixing to reach the customer quicker, as the participant voiced "*The code submission* process is faster, allowing the software and patches to get to the customer faster. With automation the code is more organized and cleaner".

Meanwhile the participant ID04 referred that automating this process would result in a reduced workload for the workers, by allowing the users to make the deployment on the production environment instead of relying on developers. This would allow workers to have more time for other tasks, enabling them to focus on developing more stories and creating greater value for the company.

They could also pursue new certifications or improve their focus on their current work. As this participant stated, "*Allows users to have the possibility to deploy to production environments instead of those deployments being done by the developers as it is done nowadays* ".

He also claimed, "*While having a reduced workload, workers have numerous opportunities to utilize their free time, such as engaging in story development, pursuing new certifications, or simply enhancing their focus on their current tasks*".

As mentioned above, the other Scrum Master, ID16, highlighted two advantages for automating this process: safer and reduced errors.

Starting with the analysis for the safety improvement, it was referred that with the automation of the continuous deployment, all of the safety practices would be applied in all different environments (development, testing and production). This would make the software safer during its lifecycle and increases the software quality, as it was stated by the participant "*Allows all security practices to be applied across different environments (Dev,Test and Pro)*".

The other advantage is related to the reduced errors. The automation of the process could reduce the errors and inconsistencies in the configuration.

By reducing errors, the company can save money as the workers would not need to spend their time fixing the errors on the configuration. Instead, they can work in other tasks that add value to the company and it can save the developers' time since they would not need to fix the errors on the configuration.

As the participant stated, "*By automating the infrastructure preparation, you reduce errors and inconsistencies in configuration*".

The advantages of this automation mentioned by the two Developers that participated in this study, will be analyzed below.

Starting with the participant with the ID06, he referred the advantage of error reduction as considers the automation of repetitive task such as the deployment would reduce the errors in comparison to doing it manually.

As this participant stated, "*With the automation of Continuous Deployment, it will be possible to observe an error reduction in the repetitive task like the deployments in comparison by doing these task manually*".

Regarding the participant ID13, the advantages for the automation of this process are similar to the previous participant's viewpoint. This participant refers that automating this process would provide more time for the development.

According to his statement, by automating the continuous deployment, developers would have more time to develop more complex and more strategic tasks for the company, as it was highlighted "*With automation, teams become more focused on more complex and strategic tasks*".

Finally, analyzing the last role, Software Engineer, it was highlighted that innovation was considered an advantage for automating this process.

It was emphasized that with the reduction of the workload of repetitive tasks, workers could have more time for the development and would make them more focused on completing stories.

Another suggestion referred by this participant, is that the reduction of repetitive tasks can promote the innovation. He believes that developers can spend their time in innovating and exploring new working methods or develop new software features.

The participant stated, "With the automation, it would be possible to reduce the workload of repetitive tasks leaving the developer more time to develop stories, and principally to innovate as they can find different ways to do their work".

5.2.2 Continuous Delivery

In relation to the DevOps process Continuous Delivery, it was mentioned six times as a suitable process for automation using RPA. As it was done in the previously process (Continuous Deployment), it will be analyzed the viewpoints of different roles that considered this process beneficial for automation. This analysis aims to further understand the significance and importance of automating this process. Among all the participants, three are Developer (ID03, ID07, ID 11), two are Software Engineer (ID08,ID15) and one is Chief Technical Titan (ID02) as it is showcased in the Figure 23.

Having participants with three different roles, this allows to understand the different perspectives of each role regarding the benefits of automating this process.

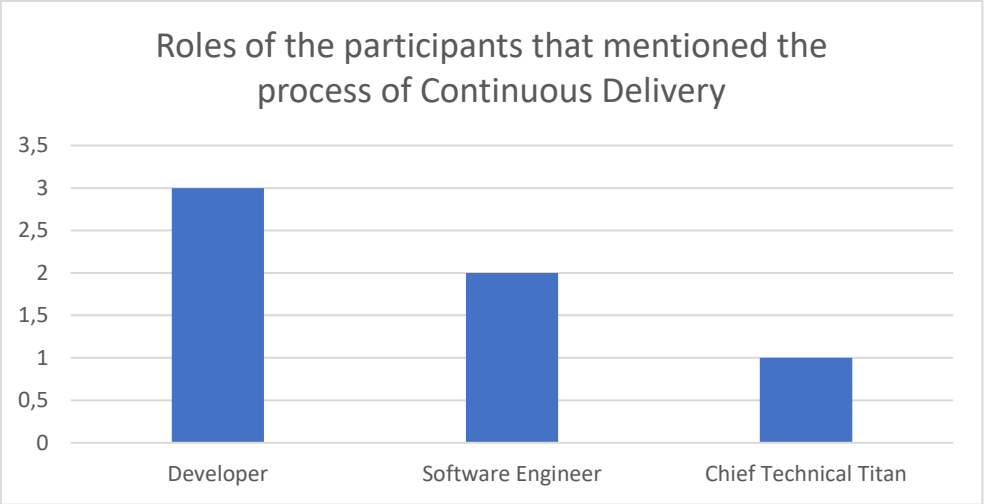

Figure 23-Roles of the participants that mentioned the process of Continuous Delivery to be automated

The benefits mentioned by the participants are represented in the bar chart (Figure 24). It is possible to conclude that such as, the last process analyzed "Continuous Deployment", the benefit that had most reference is the "More time for development" with two reference, all of the other benefits had one reference.

The presence of multiple benefits with one reference indicates a diverse range of perspectives regarding the automation of this process.

In the Figure 25, it is represented a scheme that correlates the roles with the benefits mentioned by each role, along with the corresponding participant ID.

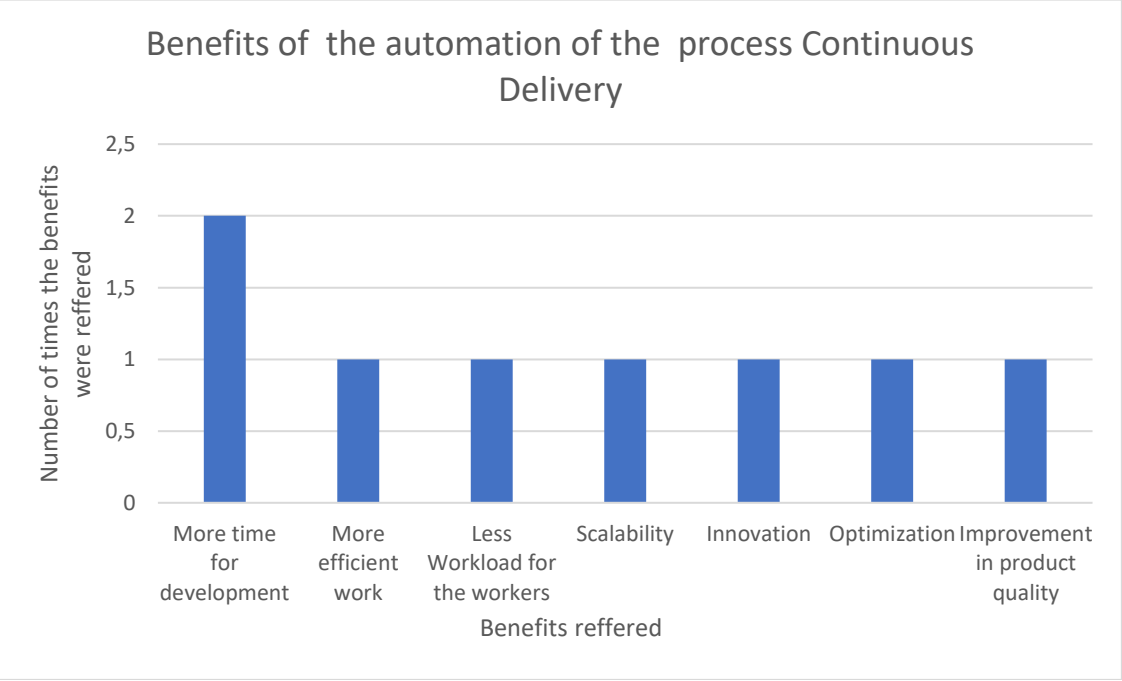

Figure 24-Benefits of the automation of the process Continuous Delivery referred by the participants

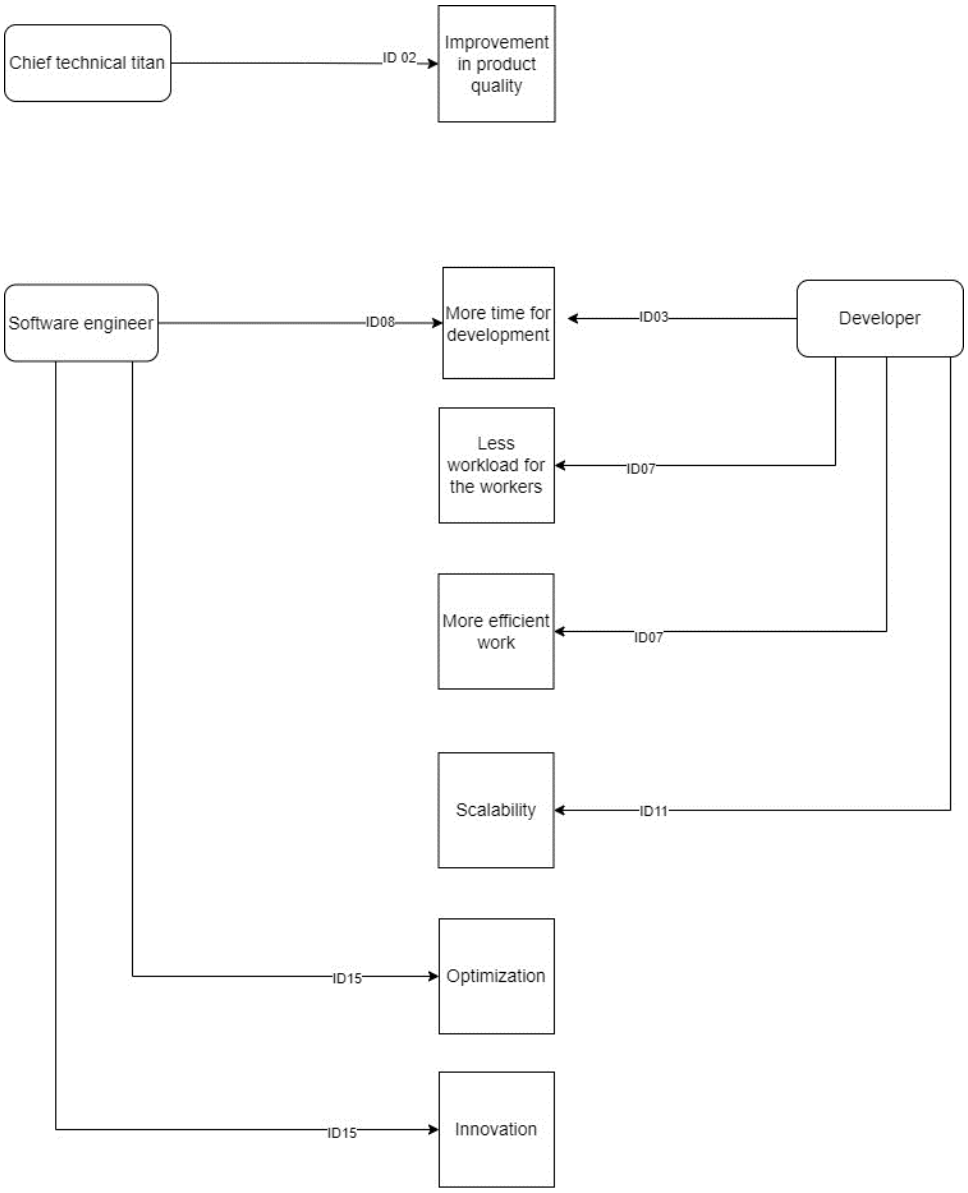

Figure 25-Advantages highlighted for the process of Continuous Delivery by different roles

In the subsequence paragraphs, an analysis will be conducted on the reported advantages of automating the DevOps process of Continuous Delivery.

Beginning with the role of Developer, the participant with the ID03 mentioned that one potential benefit of automating this process with RPA is having more time for development.

This participant highlighted that by automating this process, particularly the test automation would provide developers with more time for development as he justifies as the developers would focus more on their works instead of spending time on repetitive task that can be automated. He stated, "*The developers would be more focused in developing their tasks instead of being concerned with repetitive tasks*".

In regard to the participant with the same role as the previous one, identified by the ID07, he referred two advantages of this automation: Less workload for the workers and more efficient work.

Regarding the advantage of reduced workload, this participant emphasized that automating the continuous delivery process, could enhance work efficiency by automating repetitive tasks.

Additionally, the participant highlighted another way in which this automation could reduce the workload for developers, which is through the improvement of code maintenance.

He stated, "*By automating the Continuous Delivery process, it could reduce the workload of the developers by two ways, the first is a general reason as the most repetitive task will be automatized with RPA and the second one is more specific and is related to the improvement of the code maintenance*".

The other advantage is related to more efficient work, as the participant emphasized the advantage of test automation. He highlighted that this automation would result in faster software testing and enable more frequent deployments.

According to his statement "*With test automation, testing would be faster, and it would make the testing phase quicker and if everything goes well, it will also make more frequent deployments*".

The last participant with the role of participant identified with the ID11, stated that with the automation of this process, would provide more scalability.

According to this participant, test automation would enable the testing of a larger number of software requirements in shorter time. Additionally, this approach could be applied to bigger projects, and with more frequent testing of the software would allow the company to deliver a better product to the client and instill greater trust within the team.

As he stated "*With the automation of the continuous delivery, allows for a larger number of tests to be conducted in shorter time, making it applicable to bigger projects. This positively impacts the team's confidence, as they deliver a product that has undergone extensive testing. Additionally, it enables the company to deliver more products to the client*".

This participant also mentioned that his team uses Jenkins and Dockers for the process of Continuous Delivery.

Regarding the role of Software engineer, two participants (ID08 ,ID15) mentioned this process.

Beginning with the participant with the ID08, he emphasized that automating this process would allow developers to have more time for actual software development.

As per the viewpoint of this participant, by automating task such as testing and implementation, he believes that developers would only need to monitor the pipelines instead of performing manual testing and implementation.

This automation would free up more time for developers to focus on software development task.

The advantage highlighted by this participant is specifically related to the use of Jenkins, the software tool his team uses for the Continuous Delivery.

He mentioned, "*With the automation of Continuous Delivery, it will be possible to simply monitor the pipeline states instead of manually conducting testing and implementation, thus providing more time for development tasks*".

The participant identified with the ID15 highlighted two advantages: innovation and optimization.

He shared a similar viewpoint to the previously analyzed DevOps process (Continuous Deployment) in terms of the benefit of innovation. This participant believed that automating this process would free up developers' time, allowing them to focus on innovation and finding more efficient ways to work.

According to this participant "*Similar to the process of Continuous Deployment , innovation can also be a benefit of automating this process. I believe that by automating this process, the team would have more time to explore new ways of working and make their work more efficient*".

The second advantage that this participant mentioned, is related to optimization. He considered that by automating this process, specifically the test automation it would enable the detection and optimization of procedures.

With comprehensive testing off all software features and the possibility to conduct these test more frequently, the team could identify redundant tests and optimize them for better results.

Ultimately, this optimization would lead to delivering a higher-quality product to the client.

As this participant referred, "*With the test automation it is possible to deliver a higher-quality product to the client, by conducting tests more frequently, the team can identify areas where tests are redundant and optimize the process accordingly".*

The last role that mentioned this process is the Chief Technical Titan, identified with the ID02.

This participant considers that automating this process leads to improved product quality.

According to the viewpoint of this participant, test automation would allow the team to have more confidence of the product delivered to the client , by subjecting the software to a higher number of tests compared to the current manual approach, the team can eliminate human errors and gain more trust in the product's quality.

He stated, "*Through the test automation the team's confidence in the product quality increases as it eliminates human errors and enables more extensive testing.*

Consequently, we deliver a high-quality product to the client, and this would also increase the team's confidence".

5.2.3 Release Management

Regarding the DevOps process of Release Management, it was identified as suitable for automation using RPA by three different participants. The analysis will focus on examining the perspectives of these participants regarding the benefits of automating this process.

The participants who mentioned this process include a Software Engineer (ID15) and two Developers (ID12, ID19), as indicated in Figure 26.

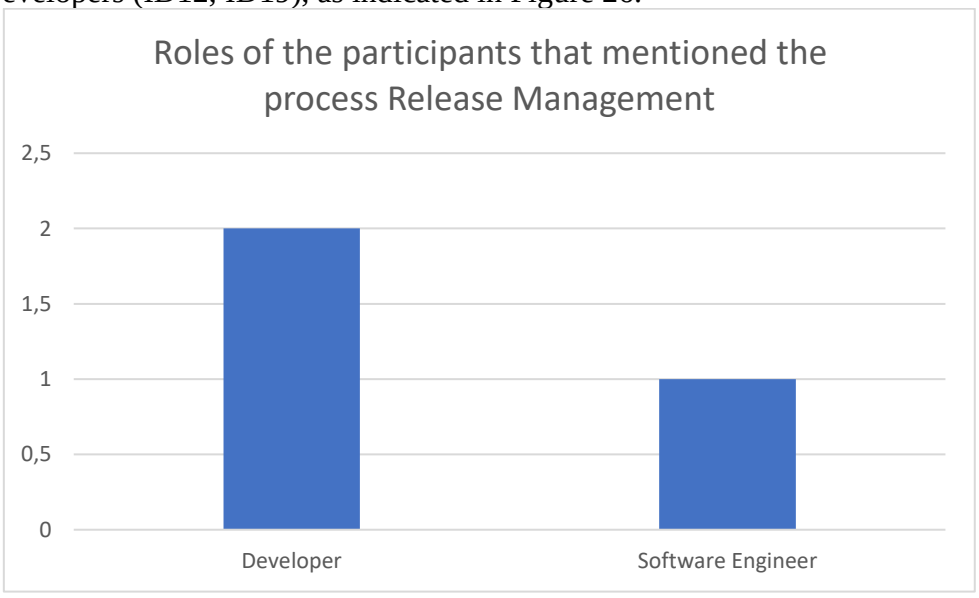

Figure 26-Roles of the participants that mentioned the process Release Management

The Figure 27 highlights the benefits mentioned by the participants, revealing that the advantage of “Better Product Quality” was referenced twice, while the advantage of “More time for Development” was mentioned once.

Analyzing the Figure 28, both Developers emphasized the benefit of “More time for development” while the role of Software Engineer referred to the other advantage.

This indicates that developers perceive the automation of this process as significant for enhancing product quality, which will be further explained in the subsequent subchapter.

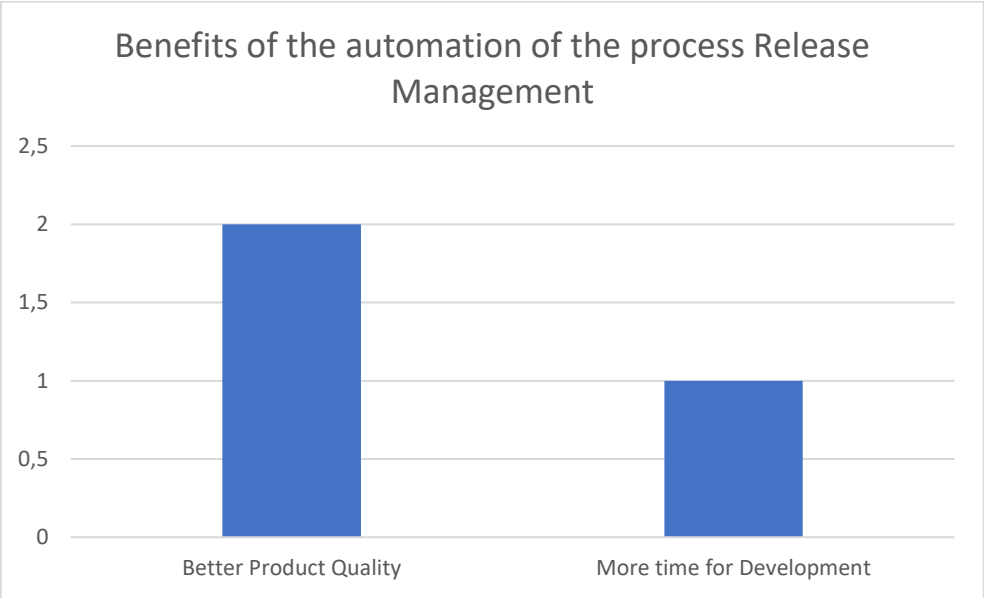

Figure 27-Benefits of the automation of the process Release Management

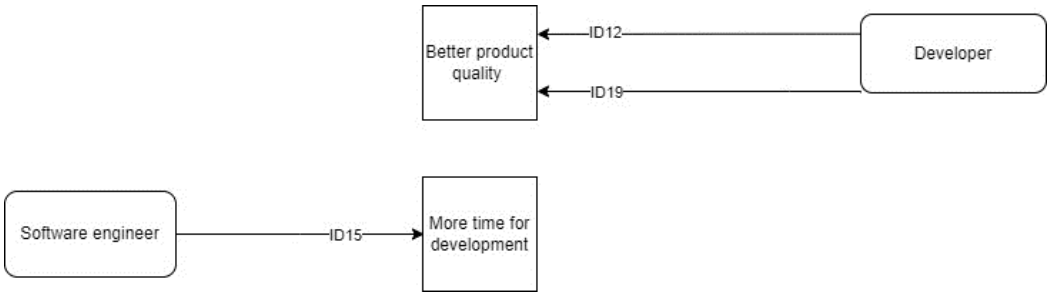

Figure 28-Advantages highlighted for the process of Release Management by different roles

Beginning with the aforementioned advantage of “Improvement in product quality”, it was referred by the participants who work as Developers, identified as ID12 and ID19.

The participant with the ID12, highlighted that automating this process leads to faster deployment in the testing and production environments enabling the delivery of new functionalities and the prompt resolution of errors.

As a result, clients can provide feedback to developers more quickly, leading to an improvement in product quality.

This participant further emphasized that automating the process helps enhance product quality by reducing human errors during the deployment of new features.

As he stated, " *With the automation of the process release management, it is possible to observe an increase of the product quality, because it enables quicker deployment in the environments of production, testing and dev, facilitates the delivery of new functionalities and allows for error corrections.*

Another way it enhances product quality is by reducing occurrence of human errors, particularly during the deployment of new functionalities or error resolution in the production environment.

The other Developer, identified with the ID19, supports the same advantage of automating this process and draws a comparison with manual work.

According to this participant, automating this process reduces the risk of errors and inconsistencies when performing the same task but manually.

These errors can include forgetting essential steps during software deployment in the production environment or deploying the wrong version of the software.

Such errors can be detrimental to the product quality, leading to incorrect software functionality, and it can lead to security issues. By automating this DevOps process, the participant believes that it will improve the quality of the product by eliminating these errors that are prone to occur during manual execution.

In the participant's own words, "*Automating this process helps to mitigate the risk of errors and inconsistencies by comparing it to doing it manually. Common errors include failing to follow deployment steps properly, resulting in delays or deploying the wrong software version. Such errors can impact the product quality of the product and the security. Therefore, by automating this process it would improve the product quality and prevent these errors from occurring".*

In regard to the participant with the role of Software Engineer, he emphasized that automating this process would provide developers with more time for actual software development.

With the automation of this process, essentially repetitive tasks such as preparing the production environment and testing the new software versions, developers can allocate their time to develop more crucial tasks for the company such as developing new software functionalities and improving the software quality.

This participant expressed, "*By eliminating the workload associated with repetitive tasks like the preparing the prod environment and conducting repetitive tests, developers can dedicate more time to the development of more important tasks for the company such as the development of new functionalities of the software and enhancing of software quality".*

5.2.4 Continuous Integration

Three participants mentioned the DevOps process of Continuous Integration as suitable for automation with RPA. The analysis will center on analyzing the viewpoints of these participants regarding the benefits of automating this process.

The roles of participants that mentioned this process as suitable for automation consist of a Chief Technical Titan (ID01), Developer(ID07), and Scrum master (ID14) as highlighted in Figure 29.

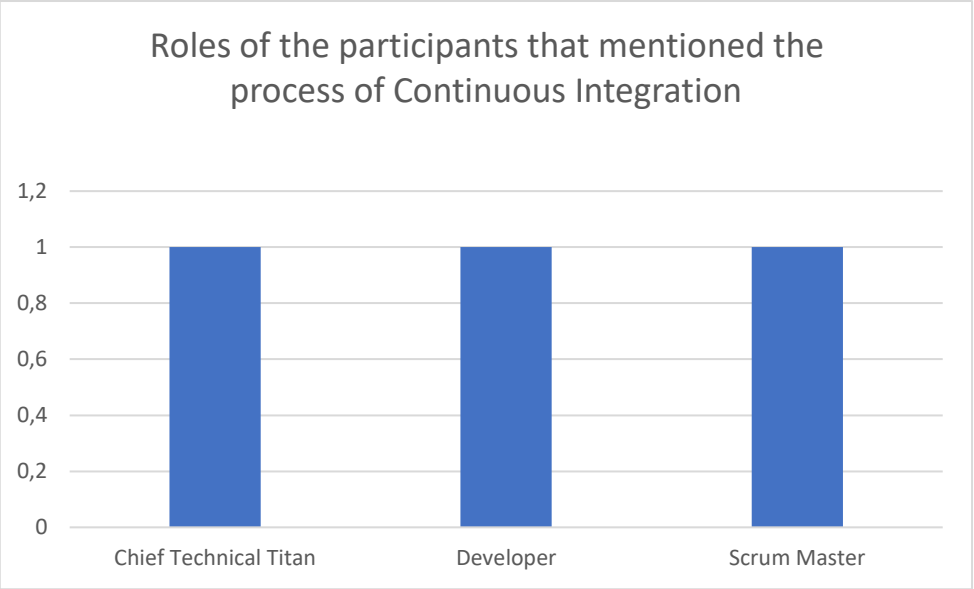

Figure 29-Roles of the participants that mentioned the process of Continuous Integration

In Figure 30, the showcased benefits mentioned by the participants indicate that each role reported a unique benefit of automating this process.

Upon analyzing Figure 31, the Chief Technical Titan identified with the ID01 referred to two advantages for this automation: Consistency and Improvement in product quality.

The participants whose roles were Developer identified as ID07, and the role of Scrum Master identified with the ID14, mentioned one advantage each.

The Developer mentioned that with this automation the workers would have a reduced workload and the Scrum Master voiced the speed and increase of efficiency.

The subsequent paragraphs will focus on analyzing the discussed benefits of automating the Continuous Integration process.

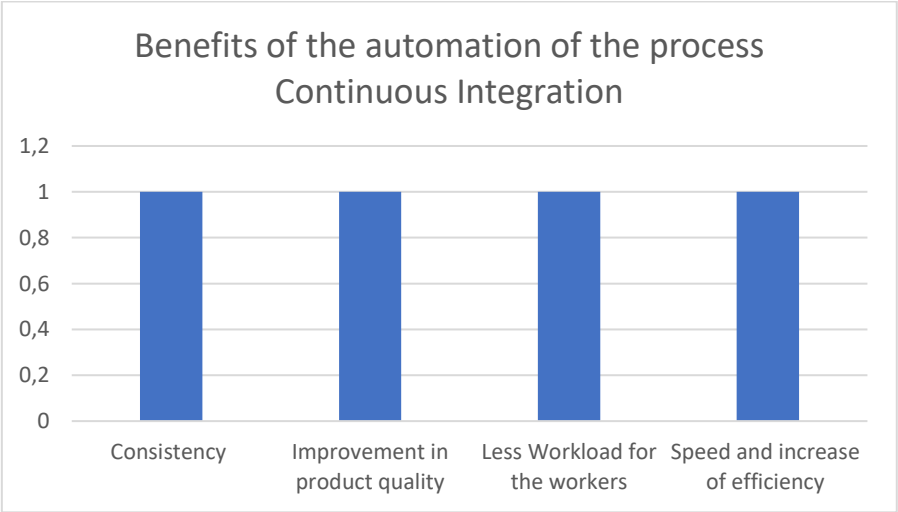

Figure 30-Benefits of the automation of the process Continuous Integration

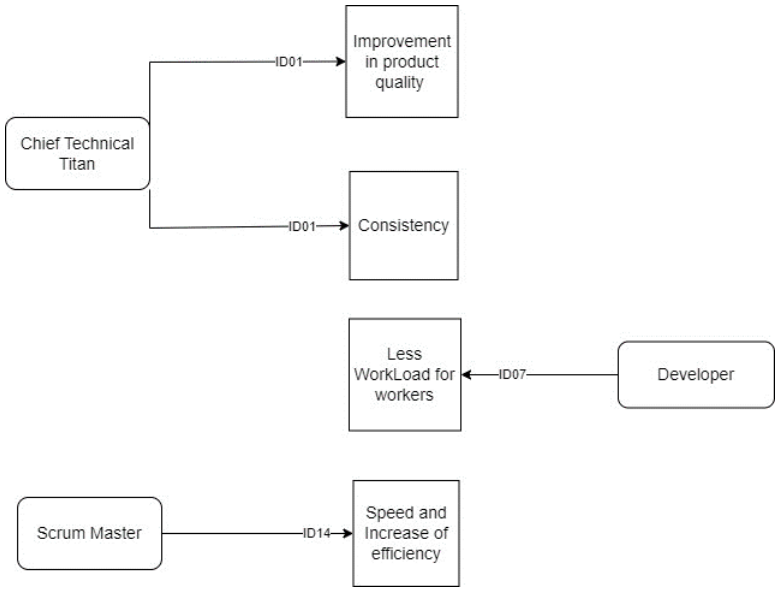

Figure 31-Advantages highlighted for the process of Continuous Integration by different roles

As mentioned earlier, the participant with the role of Chief Technical Titan (ID01), identified two benefits of automating this process.

Beginning with the advantage of improvement in product quality, the participant highlighted that the automation of this process would enable the possibility of conducting more extensive testing. This would allow an earlier detection of product problems and obtain a faster feedback from the client, improving the quality of the product that will be delivered to the client.

As the participant referred, "*By automating the DevOps process of Continuous Integration it is possible to observe an increase in the product's quality, since it would be possible to test more thus the problems would be detected in an earlier stage and it would allow to have more feedback from the client which would improve the quality of the product delivered".*

The second advantage referred by this participant is related to consistency, specifically regarding code quality.

According to the participant, automating this process can contribute to code consistency by enabling automatic code checks in order to detect bugs or vulnerabilities.

Additionally, with this automation it would also be possible for the team to have more visibility of the tracking code metrics and it would be possible to check its' quality.

This participant also stated that for this process, he uses Bitflow and Github.

As he stated, "*Another advantage of this automation, is the improved consistency of code quality.*

By automating this process, it becomes possible to perform automated code verification, which facilitates the detection of bugs and vulnerabilities.

Furthermore, this automation enhances consistency by providing greater visibility of code metrics, delivering a more comprehensive assessment of code quality. The ability to track code metrics more effectively ensures that the code meets established quality standards and contributes to overall consistency in the development process".

In terms of the role of Developer, there was one participant identified with the ID07 that mentioned this process as suitable for automation.

According to this participant, automating this process would result in a workload reduction of the workers, allowing them to focus on more complex and valuable tasks to the company.

One way that the workload can be reduced is related to the automation of repetitive tasks like testing more precisely unit testing and performance testing, as this participant highlighted that by automating this part of the process it would allow the developers to have more time to focus on more important tasks for the company.

Considering that the participant referred, "*By automating this process, it would be possible to observe a decrease in the workload for the workers, specifically through the automation of unit and performance testing. This would also have a positive impact on the company, as the workers would be able to dedicate more time to valuable tasks instead of spending it on repetitive tasks".*

The last participant to mention this process holds the role of Scrum Master (ID14).

According to this participant, automating this process yields benefits in terms of speed and code consistency.

Regarding the speed, the participant emphasizes the time it takes to send the code to the repository where it can be stored and managed. He also referred that they used Git as their repository.

Concerning the benefit that automating this process brings on the speed at which the code is sent to the repository, he considers that with the automation of this process the procedure of sending the code to the repository will be faster. This, in turn, would allow quicker error corrections and a faster delivery of the software to the client. The participant also referred that by sending the code to the repository at a faster rate the software tests would also be quicker.

In terms of code consistency, the participant highlights that automation not only results in cleaner and more understandable code, but it also facilitates enhanced quality checks. This, in turn, leads to faster delivery of code to the client and enables quicker feedback from them.

As he stated, " *With the automation of this process, we can observe the benefits of increased speed and improved code consistency. With faster code submission to the repository, we can expedite software testing and deliver the software to the client more quickly.*

Automation also positively impacts code consistency by making it cleaner and more understandable, resulting in faster delivery to the client and faster feedback from the client."

5.2.5 CI/CD

In relation to the DevOps process CI/CD, it was mentioned three times by the participants as a process suitable for automation with RPA.

Among the participants who mentioned this process, two are Developers (ID09, ID21) and one is a Scrum Master(ID18) as depicted in Figure 32.

The benefits mentioned for the automation of this process are showcased in Figure 33 and encompass aspects such as consistency, a controlled environment for application development, and error reductions.

Figure 34 represents the benefits associated with the participants' roles, and their respective ID.

The following paragraphs will analyze the mentioned advantages.

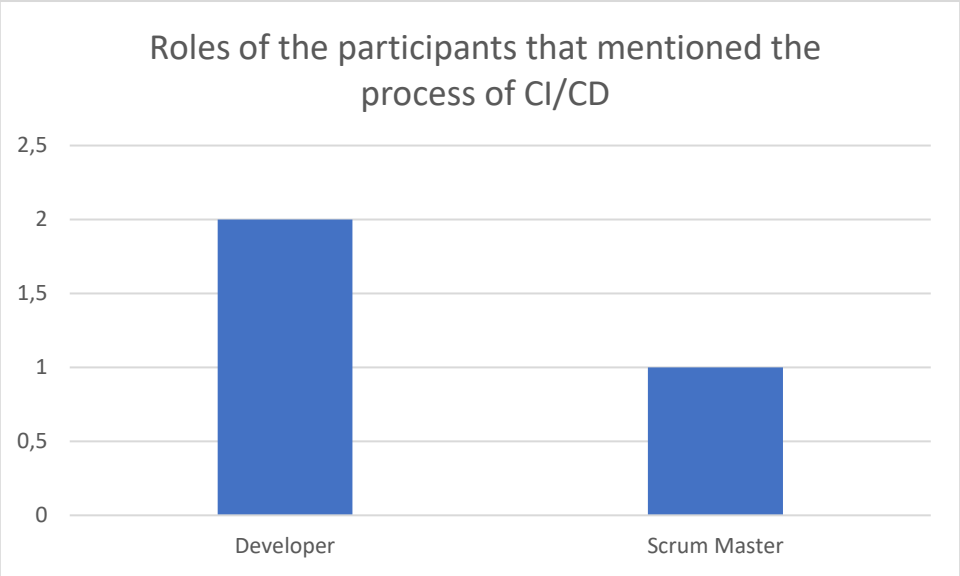

Figure 32-Roles of the participants that mentioned the process of CI/CD

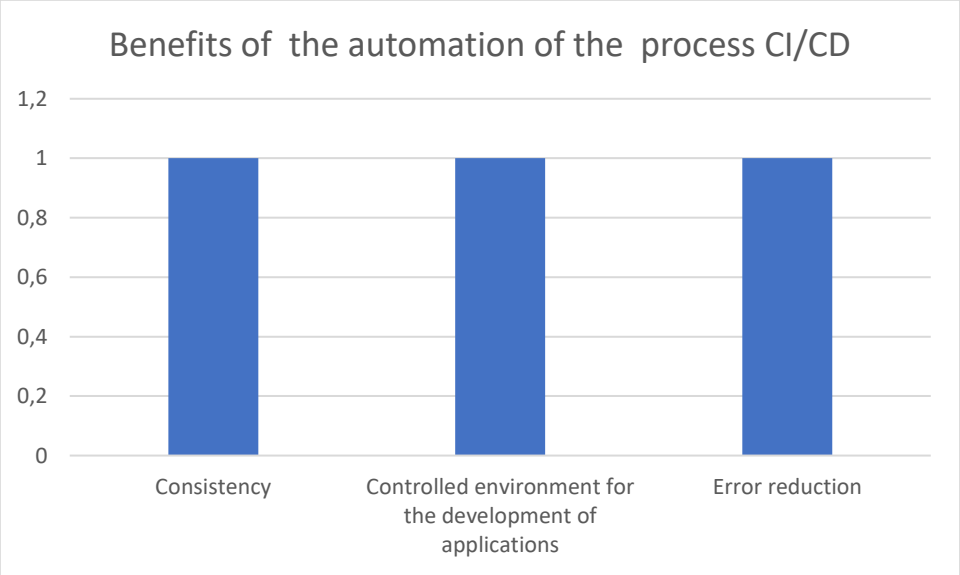

Figure 33-Benefits mentioned by the participants regarding the automation of the process CI/CD

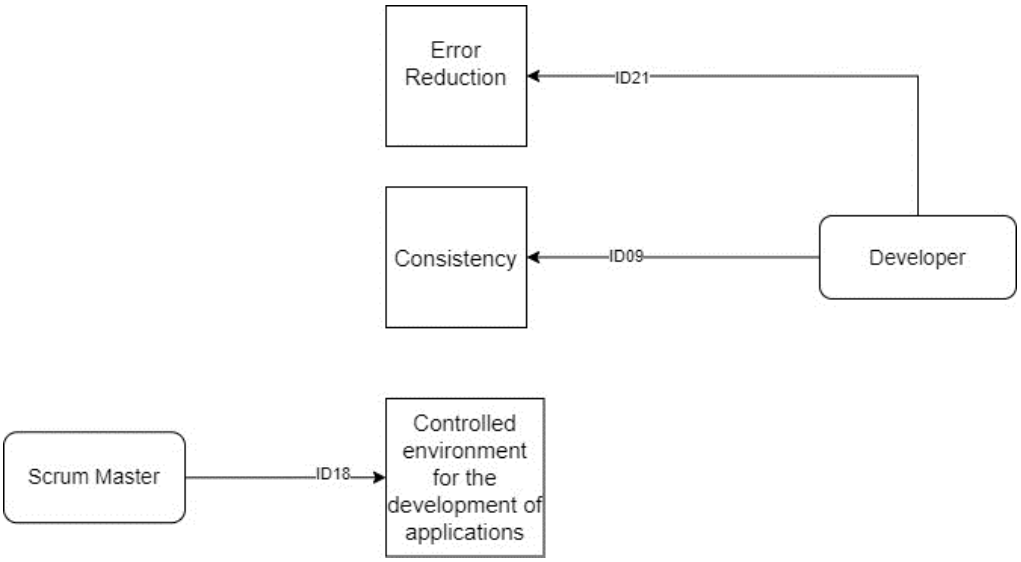

Figure 34-Advantages highlighted by the participants regarding the process of CI/CD by different roles

Staring the analysis with the participant who holds the role of Developer and is identified with the ID 09, he mentioned that automating this process would result in improved consistency, particularly in the software delivery.

Through automation, it becomes possible to deliver the software continuously and consistently, without errors. As the tasks are automated, the likelihood of human error is eliminated.

As he stated, "*With the automation of the DevOps process CI/CD, a noticeable improvement in consistency can be observed, especially in software delivery.*

By delivering the software consistently and automatically, it eliminates human error and reduces the error rate".

The other participant, also holding the role of Developer and identified with the ID21, highlighted the advantage of error reduction.

Errors can lead to delays in delivering the product to the client and increase the likelihood of problems occurring in the production environment. Consequently, this can undermine the trust and confidence between the team and the client.

By automating the DevOps process CI/CD, these problems can be addressed by replacing repetitive tasks.

So the automation of this process would resolve these problems, since it would replace the repetitive tasks.

As this participant referred, "*The automation of the DevOps process CI/CD, helps reduce errors that are responsible for the delay and increase the probability of errors in the environment of production, this in turn, contributes for a discomfort between the relationship of the team and clients.*

By automating these repetitive task, we can effectively resolve these issues".

The role of Scrum Master is held by the last participant identified with the ID18, who mentioned that this process is suitable for automation.

According to this participant, one of the benefits of automating the CI/CD process is the establishment of a controlled environment for the application development.

The participant believes that with the automation of this process, it becomes possible to ensure consistent and stable environments (developing, testing and production) for the release of the application, This automation helps to prevent errors in these different environments and reduces the probability of errors occurring during the software deployment process.

As he stated, "*The automation of the process CI/CD would enable more consistent and stable deployment across different environments (dev,test,prod).*

Additionally, it would help to reduce errors during the software deployment".

5.2.6 Incident Management

In regards, to the Incident Management process, it was referred twice by the participants who share the role of Developer.

The benefits provided by these two participants regarding the automation of this process are depicted in Figure 35.

It is possible to conclude, that the advantage of having more time for development was referred twice, while the advantage of reduction the number of incidents was mentioned once.

Figure 36 displays the advantages highlighted by the participants, identified by their respective ID.

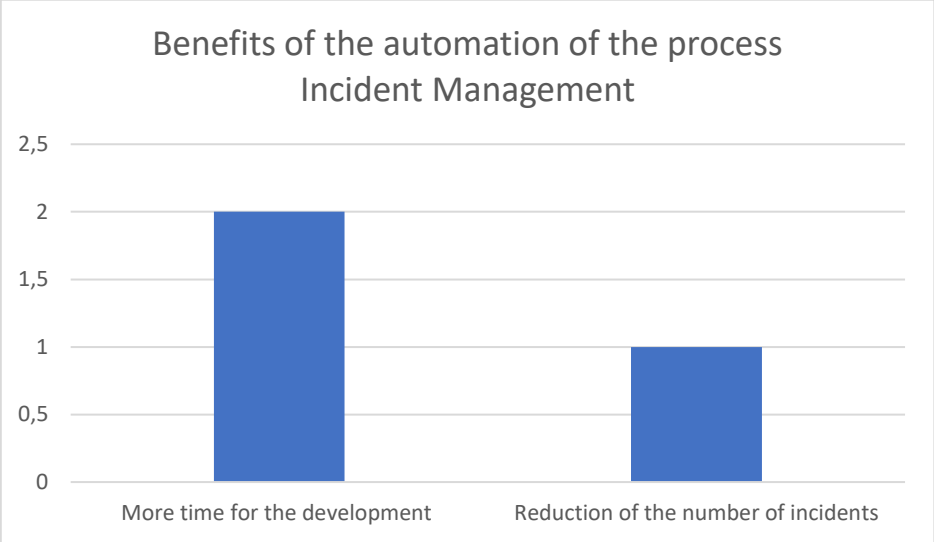

Figure 35-Benefits of the automation regarding the process Incident Management

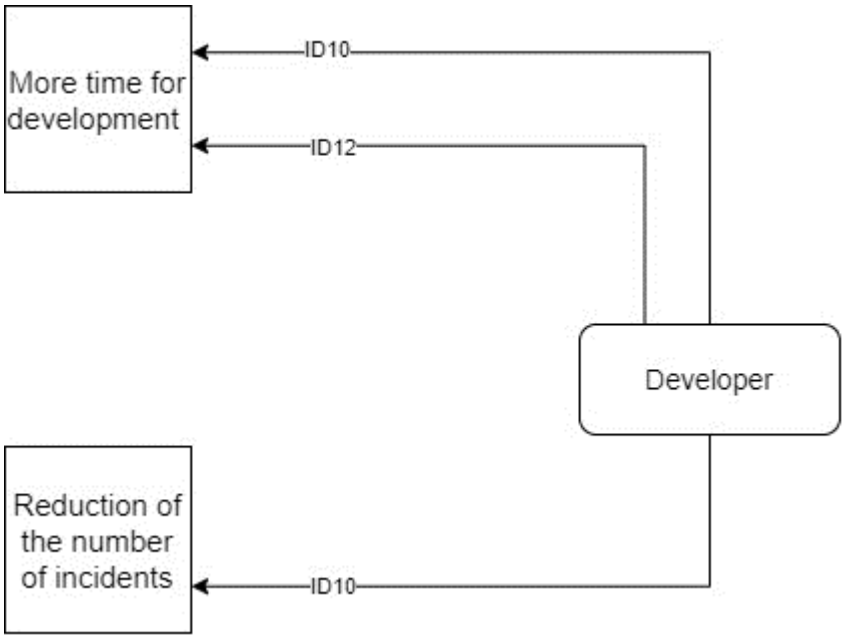

Figure 36-Advantage highlighted for the process of Incident Management by the role of Developer

Concerning the analysis with participant identified with ID12, he mentioned that automation in the incident management process enable developers to have more time for development.

According to his statement, he considers that automation reduces the time spend by developers in incident resolution, allowing them to focus on more complex tasks.

The participant also emphasizes the importance of automating the steps of notifying the developer and the incident detection, as these tasks do not require manual intervention.

As he states, "*Through the automation of DevOps process, Incident Management, developer can dedicate less time to incident resolution and focus more on the development of complex tasks.*

In the Incident Management, I believe that automating the steps of developer notification and incident identification can be achieved".

The participant with the ID10, also mentioned the benefit of having more time for development and highlighted the advantage of reduction of the number of incidents.

Regarding the benefit of having more time for development, the participant believes that by quickly resolving incidents, developers can allocate more time to working on complex tasks and adding value to the company.

As the incidents are resolved swiftly and efficiently through automation, developers do not need to spend time fixing problems or errors manually.

He referred, " *The automation of Incident management, can expedite incident resolution, allowing developers to dedicate more time to complex tasks that create more value to the company.*

With quicker and more efficient incident resolution, developers have more time for development and do not need to spend time addressing errors or problems thar arise with incidents".

The other advantage this participant highlighted, is the reduction of the incident numbers.

He considers that trough automation, incidents can be identified more quickly enabling faster response and resolution, as a result, the overall number of incidents would be reduced.

As the participant affirmed, "*By implementing automation, incidents can be identified more quickly, leading to faster response and resolution.*
This ultimately contributes to a decrease in the number of incidents."

5.2.7 Infrastructure as Code

In relation to the DevOps process, Infrastructure as Code, two participants referred as a process suitable to be automated with RPA.

From all interviewees, the one who mentioned this process works as Developer (ID11) and Scrum Master (ID18) as shown in Figure 37.

The benefits mentioned by the participants are highlighted in the bar chart represented in the Figure 38.

It can be observed that two benefits were mentioned, consistency and error reduction.

The advantages highlighted by the participants identified through their ID are represented in Figure 39.

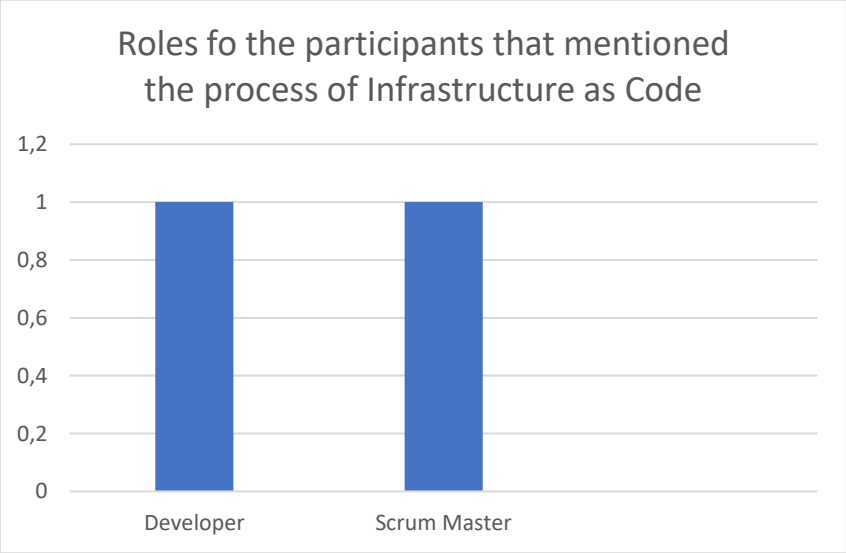

Figure 37-Roles of the participants that mentioned the process of Infrastructure as Code

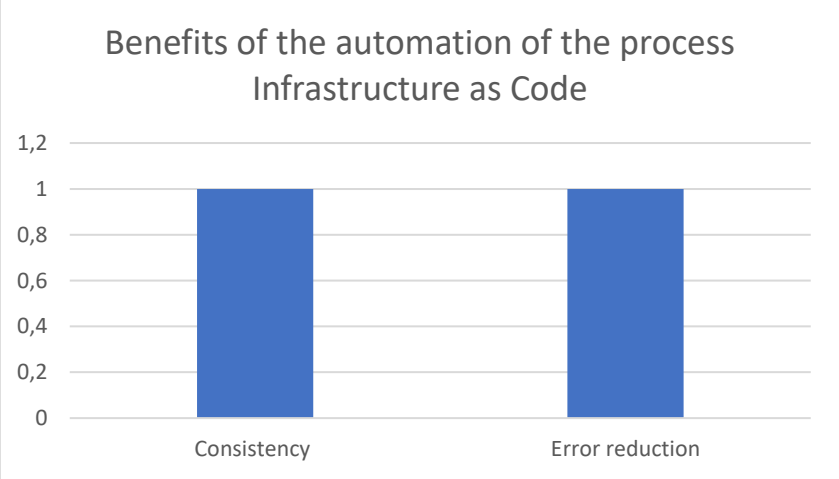

Figure 38-Benefits of the automation of the process Infrastructure as Code

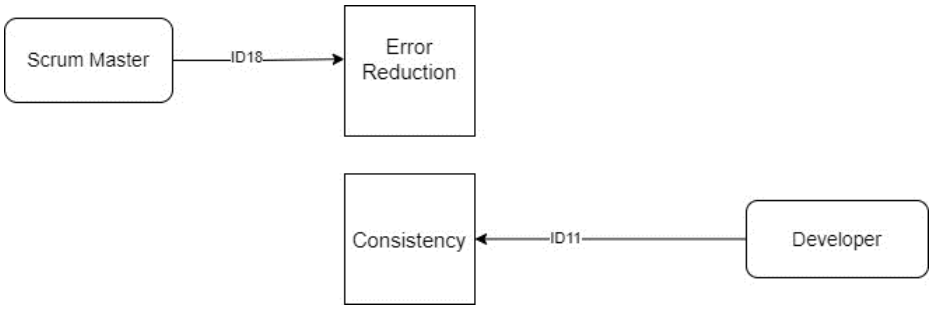

Figure 39-Advantage highlighted for the process of Infrastructure as Code by different roles

The participant who works as a Developer (ID11) referred to the advantage of consistency.

This participant believes that by automating this process, it is possible to achieve consistency across the environments of production, testing and development.

According to this participant, automating this process reduces the probability of errors and decreases inconsistencies among the environments of production, test and development, as the configuration it will be done automatically and will be the same in the three environments.

With the automation of these configurations the percentage of human error will reduce, additionally this participant mentioned using the tool "Terraform" for this process.

As he referred, "*By automating this process, the probability of errors is reduced and the inconsistency between the different environments (dev,test,prod) are minimized.*

The automation ensures that configurations are performed automatically, resulting in consistency and a decrease in human error".

The other participant that also mentioned this process, has the role of Scrum Master and it is identified with the ID18.

He believes that with this automation, error reduction can be achieved in the Infrastructure as Code process. By automating the configuration of infrastructure, the participant emphasizes the human error can be eliminated. The participant also referred that he uses the tool git and terraform for this process.

As this participant, described "*The automation of the Infrastructure as Code can reduce the errors. By enabling automatic configuration it will eliminate the human error."*

5.2.8 Configuration Management

Two participants, identified as the ID09 and ID19, hold the role of Developer, and mentioned the DevOps process Configuration Management as suitable for automation.

The advantages mentioned by these participants are showcased in the bar chart represented in Figure 40.

It can be observed that three benefits were mentioned: consistency, error reduction and more time for development.

Figure 41 represents the advantages mentioned by these participants, along their respective IDs.

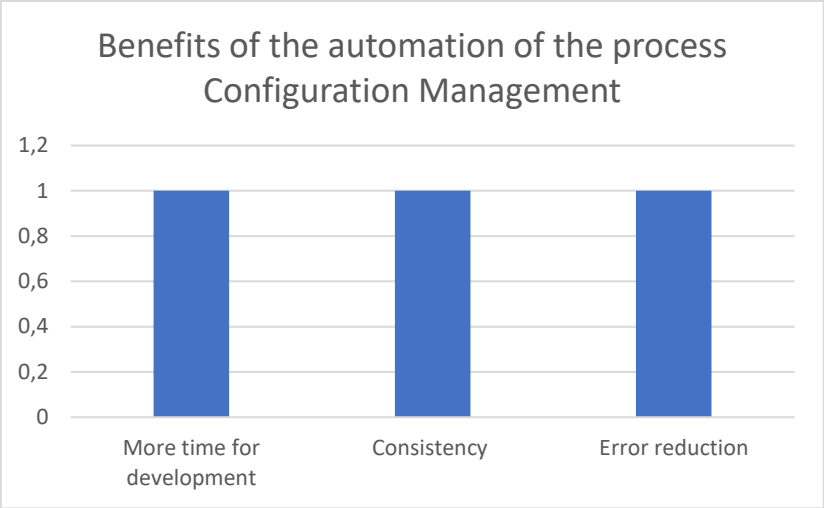

Figure 40-Benefits of the automation of the process Configuration Management

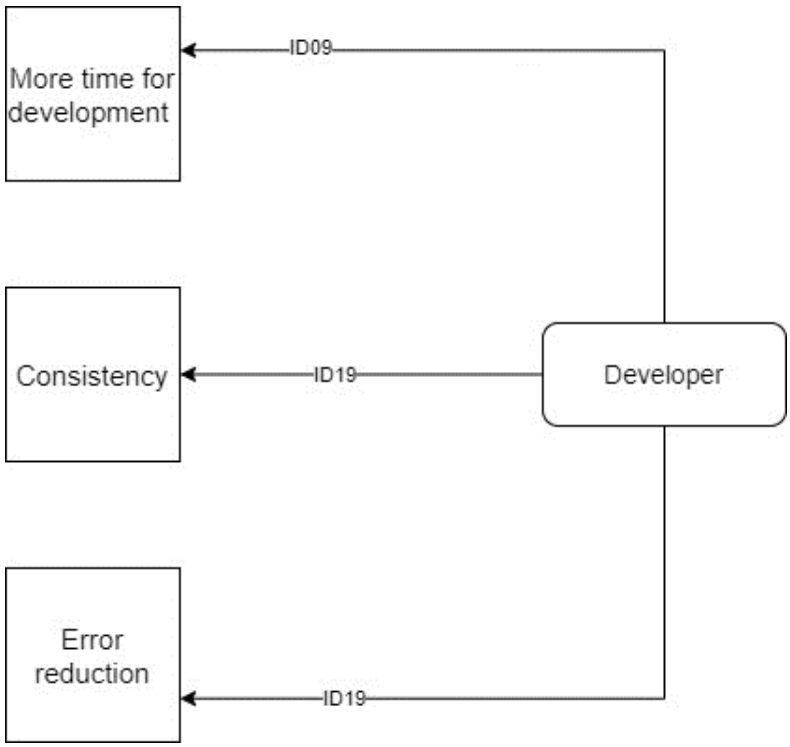

Figure 41-Advantage highlighted for the process of Configuration Management by the role of Developer

Starting with the Developer with the ID09, he considers that the developers have more time for development by automating this process.

According to him, automation increases the speed of the deployment as they can be performed automatically. This enables developers to allocate the time previously spent on deployments to more valuable tasks.

The participant also emphasizes that automation leads to error reduction. By automating deployments, the participant argues that human errors can be eliminated, thus freeing up developers' time and avoiding the need for error fixes.

This participant referred that they use the tool "Terraform" for this process.

As he stated, "*With the automation of the Configuration Management process, I believe that it is possible for the developers to have more time for the development. Automation enhances deployments speed and eliminate the errors from these deployment and as a consequence it would free up time for the developers to focus on more valuable tasks"*.

The other participant identified with the ID19 that also mentioned this process, referred two benefits regarding this process, consistency and error reduction.

Regarding the advantage of consistency, the participant believes that automation can ensure consistent configuration across different environments. By applying the configuration automatically, the participant argues that incompatibility issues can be reduced, thus mitigating the risk of configuration inconsistencies among the development, test and production environments.

The other advantage that this participant referred, is the error reduction as a consequence from the previous advantage, i.e. by eliminating the need for manual configuration, the participant contends that the risk of human error is minimized.

As this participant stated, "*By automating the process of Configuration Management, I believe that it will be possible to achieve error reduction and improve consistency across the environments of dev, test and prod.*

Automatic configuration enables us to avoid human errors and ensures a more reliable and consistent environment".

5.2.9 Change Management

Regarding the DevOps process of Change management, two participants referred that this process is suitable for automation.

One participant holds the role of Developer, and it is identified as the ID 20, while the other participant holds the role of Software Engineer, and it is identified with the ID 15 as it showcased in the Figure 42.

Each participant mentioned one specific advantage of automating this process, which is represented in Figure 43.

The Figure 44 shows the advantages referred by the participant with their respective ID showcased.

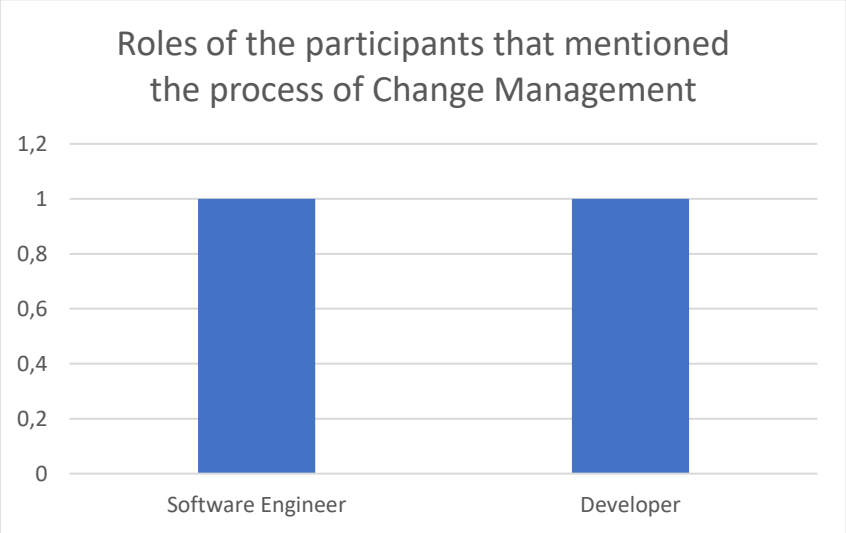

Figure 42-Roles of the participants that mentioned the process of Change Management

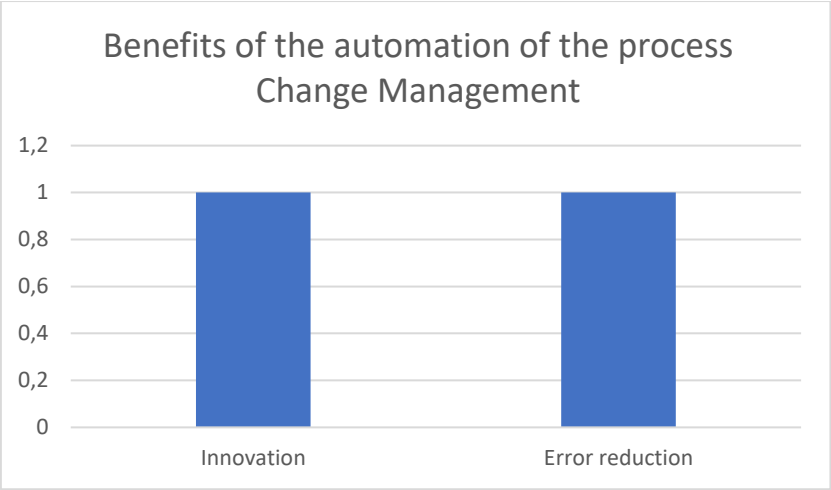

Figure 43-Benefits of the automation of the process Change Management

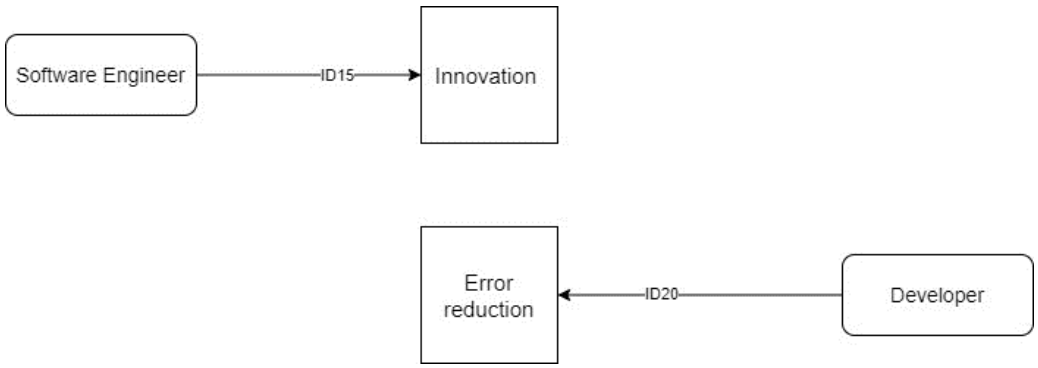

Figure 44-Advantages highlighted for the process of Change Management by the different roles

The participant holding the role of Software Engineer and identified as the ID15, mentioned the advantage of innovation.

It is important to note that this participant previously mentioned this advantage in two other processes (Continuous Delivery and Continuous Deployments), as he considers all of these processes can reduce the workload on developers, allowing them more time to find ways to search innovative ways to improve their work method.

As he stated, "*The automation of the process Change Management brings the advantage of innovation as it reduces the workload from the developers, and they can have more time to explore new ways to innovate the way that they work".*

The other participant that mentions this process, has the role of Developer (ID20) and considers with the automation this process it is possible to observe an error reduction.

According to the participant, automating this process would result in fewer errors in comparison with the manual process, thereby saving time for developers to engage in additional tasks.

As this participant referred, "*I believe that by automating this process, we can significantly reduce errors compared to the manual process.*

This reduction in errors allows developers to allocate more time to perform additional tasks."

5.2.10 Support

This process was mentioned by only one participant, with the role of Developer identified as ID 03.

The participant stated by automating this process, basic errors would no longer need to be reported, as a result, developers would be able to focus on their tasks instead of spending time on repetitive tasks.

As he mentioned, "*With the automation of the support, basic errors would no longer need to be identified, freeing developers from repetitive tasks and allowing them to focus on their own development tasks."*

5.2.11 Commit of update sets

The process of the commit of update sets was mentioned by one participant who has the role of Developer, identified as ID 05, and he referred that with the automation it will be possible for the developer to have more time for the development and to create value for the company.

It is important to emphasize that the benefits that were provided by this participant are related to the ServiceNow platform, specifically the automation of update sets.

Update sets are a part of ServiceNow, and they are used to develop the tasks needed. Firstly, these update sets are created in the development environment to accomplish the designated task. Once completed, they are deployed to the test environment for testing purposes and finally, they are deployed in the production environment.

According to this participant, automating this process allows the workers to have more time for the development of stories thus bringing more value for the company through the development, as they would spend less time dealing with the commit of update sets.

Furthermore, the participant highlighted that this automation would reduce the error during the deployment by eliminating human error. For instance, it removes the risk of not following manual steps correctly, which could lead to deployment errors.

As this participant stated, "*With the automation of update sets, developers can focus more on developing stories and spend less time on committing update sets and thus create value for companies as they develop more stories, and it can also reduce the probability of human errors during the deployments*".

5.2.12 Cluster Creation

One participant with the role of Scrum Master and identified as ID 17, considers that the automation of this process would provide developers with more time for development, and it would also increase security.

Regarding the advantage of more time for development, this participant said that the manual creation of clusters is a time-consuming process, and that by automating this process, developers would have additional time to focus on creating features or performing operational tasks.

In relation to the increase of security, he considered that the automation would eliminate the human error and facilitates the replacement of clusters when they begin to lose functionality.

This would enhance overall security.

As he stated, "*By automating this process, I believe that it is possible to observe two benefits.*

First, the developers will have more time for development and second, it would increase the security.

Regarding the advantage of the developers having more time for the development, the creation of a cluster is a long process and by automating it would allow the developers to have more time for development.

In relation to the increase of security, the automation would eliminate the human error and it would make it easier to replace a cluster when it started to lose its' functionalities."

Chapter 6- Conclusion

The aim of this study is to understand how DevOps processes, such as Continuous Delivery, Continuous Deployment, CI/CD among others, can be automated using RPA and the benefits of this automation.

In order to achieve this goal, the method of qualitative research was chosen, and individual semi-structured interviews were performed. The inclusion criteria for the participants selected for this interview was the fact that they needed to be experienced in DevOps and/or RPA.

The participants chosen for this study hold different roles which provides different viewpoints not only about the processes that can be automated but also about the advantages of this automation.

Through the interviews it was possible to acknowledge the several advantages that could come from the automation of the DevOps process mentioned by the participants. From all the benefits mentioned the most relevant ones are related to error reduction, increase of developers' time to do other tasks that can benefit positively the company and the improvement of the product quality.

The limitations of this study are related to the lack of knowledge that 48% of participants had regarding RPA. Although a short description of RPA was provided to every participant at the beginning of the interview, and despite that their doubts were clarified, it remains a limitation that some participants may still not fully understand the capabilities of RPA.

The findings from this study contribute to professionals by providing insights into which DevOps processes would be more beneficial to automate, based on the benefits mentioned in this study.

Additionally, the study makes a significant contribution to academia by addressing the current lack of research on process automation with RPA. It offers valuable insights into these two themes and expands the understanding of RPA's application in DevOps processes.

Regarding future work, it would be interesting to verify if the benefits of automating the DevOps processes analyzed in this study hold true through case studies. Moreover, conducting further studies on the DevOps processes that had fewer mentions could provide valuable insights.

Table 7-Benefits of the automation of DevOps processes

DevOps processes	Benefits of the automation
Continuous Deployment	Error Reduction; More time for development; Innovation; Consistency; Trust in teams; More Safety; Gains in time to market; Less Workload for the workers
Continuous Delivery	More time for development; More efficient work; Less Workload for the workers; Scalability; Innovation

DevOps processes	Benefits of the automation
Release Management	Better product quality, More time for development
Continuous Integration	Consistency, Improvement in product quality, Less Workload for the workers, Speed and increase of efficiency
CI/CD	Consistency, Controlled Environment for the development of application, Error Reduction
Incident Management	More time for the development, Reduction of the number of incidents
Infrastructure as Code	Consistency, Error reduction
Configuration Management	More time for the development, Consistency, Error reduction
Change Management	Innovation, Error reduction
Support	Error reduction, More time for the development
Commit of update sets	More time for the development, Create value for the company
Cluster Creation	More time for the development, Increase of Security

Table 7 presents the benefits of automating DevOps processes with RPA. The most frequently mentioned benefit is the allocation of more time for development, which is achieved by reducing manual tasks. This, in turn, promotes innovation and enhances product quality. Furthermore, the automation of these processes ensures consistency and error reduction contributing to trust within the team.

Scalability, optimization and security improvements are additional advantages in specific areas, such as Continuous Delivery, Release Management and Cluster Creation.

In conclusion, automation of DevOps processes lightens the workload for workers while enhancing the efficiency and reliability of the software development lifecycle.

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Attachments

Attachment A- interview guide

1. How many years have you worked in IT?
2. What is your role?
3. How many years of experience do you have in DevOps?
4. Did you already know what RPA was?
5. Which DevOps processes are you familiar with and which one(s) do you use in your work?
6. Of the processes you mentioned, which ones do you think can be automated by RPA and why?
7. What could be the benefits of this automation?