

# Challenges for adopting DevOps in information technology projects

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**Abstract** - An Information Technology (IT) project deals with IT infrastructure, information systems, or computers for delivering an IT product within a temporary period. Proper application of software development methodologies assists software designers to run IT projects to the success of achieving the satisfaction of project stakeholders. Because of the issues raised by traditional software development methodologies such as the Waterfall model, the IT industry began to employ Agile methodology for IT project management. However, due to the separation of software development and operation teams, Agile methodology also caused problems. DevOps is a new approach adapted to the Agile methodology that collaborates the software development and operation teams in order to provide continuous development of high-quality software in a short period of time. However, there are practical issues reported since DevOps approach is still in its infancy in the IT industry. The purpose of this research is to analyze the use of the DevOps concept in IT Projects by evaluating the challenges and mitigating strategies practiced by software development firms in order to ensure the success of IT projects. This purpose was achieved by performing a literature study and soliciting recommendations from industry professionals using a questionnaire survey. The findings reveal the critical challenges and prioritization of challenges experienced by software firms while adopting DevOps, as well as their practices for overcoming those challenges. The research findings will help IT project development teams and future researchers to develop strategies for making the success of DevOps adoption with Agile methodology in the IT industry.

**Keywords** - DevOps, DevOps challenges, overcoming strategies

## I. INTRODUCTION

A non-routine complex and single-time effort limited by time, budget, and resources targeted to achieve stakeholder expectations by developing a product or service is considered as a project. [1] The project deals with Information Technology (IT) infrastructure, information systems, or computers considered as an IT project and it produces IT product or service such as software. However, it is not easy for IT project developers to achieve all the expectations of project stakeholders with running projects to the success. There are project failures reported in the IT industry. Proper application of the IT project development principles provides directions to the project managers for their success while reducing the risks which force the project failures. Different types of IT project design and development methodologies provide principles and standards to manage projects for achieving success [1]. When it comes to the IT industry, there are several software

development methodologies are practiced for achieving the success of IT projects.

The traditional and famous software development methodology used by project managers is known as the Waterfall model [2]. It uses a sequential process to develop software. More than the Waterfall model, Iterative Model, Spiral Model, V-Model, Big-Bang Model [3] also used as the software development methodologies. However, IT project developers faced problems with adopting those methodologies since those were not having a flexible development process. Inefficiencies of those methodologies forced the introduction of a new software development methodology that separates the development process into several sprints called Agile methodology. It reduces the problems of previous methods by encouraging adaptive planning, continual improvement, and deliver projects with less time to the customer [4]. However, again IT project managers could find inefficiencies of this Agile methodology. Because it is a developer-centered method than the user-centered [5].

These requirements lead to introduce a new approach to the Agile methodology called DevOps (Development and Operations). It allows development and operations experts to participate together in the entire system development process and now it has become an essential part of the software industry [6]. Theoretically, lots of benefits offered by the DevOps approach along with the Agile software development methodology but there are practical issues reported in the industry. However, this industry experience is not frequently surveyed and reported by researchers since this is an emerging concept [6]. And no more researchers focused to study these challenges and overcoming strategies with comparing literature survey results with the industry experiences. The focus of this study is to analyze the use of the DevOps concept in Information Technology Projects by observing the challenges and mitigating strategies practiced by software development companies while making the success of IT projects. Following research objectives help to achieve the main purpose of the study.

### a. Research objectives

- To identify challenges for applying the DevOps approach in IT Project Development.
- To study the mitigating strategies for facing the challenges of DevOps adoption in IT project Development.

These research objectives were achieved by answering the following research questions.

b. *Research questions*

RQ1- What are the challenges experienced by software companies for adopting the DevOps approach in Information Technology projects?

RQ2-What are the mitigating strategies employed by software companies to make the success of Information Technology projects?

### I. RELATED WORKS

A project is defined by Kathy Schwalbe as “a temporary endeavor undertaken to create a unique product, service, or result”. It involves a person or a large number of people, complete within a small period or long period, and ends with achieving its predefined target [1]. Among the various types of projects, IT projects develop hardware, software, and networks as the results [1]. And Kathy Schwalbe stated that software development methodologies help IT project developers to improve the efficiency of their project development practices and it is mandatory to earn advantages and goodwill in the competitive market.

Traditional software development methodologies such as the Waterfall method apply a sequential method for developing Software. Therefore, it was not allowed rapid changes and poorly supported to increase the efficiency of the software development process [4]. According to the previous studies, user involvement is important over the IT project development life cycle and those requirements were caused by the origin of Agile methodology [7]. Recent estimates proved that more than 90% of IT companies practice the Agile method for their software developments [5]. However, unsolved problems remained in the IT industry while practicing this Agile methodology. The problems are raised by the lack of cooperation with software operation and development teams [8]. Due to these queries, Agile methodology improved with a new approach called DevOps (Development and IT Operations).

DevOps was defined by Andrej Dyck and Ralf Penners as “an organizational approach that stresses empathy and cross-functional collaboration within and between the development and operation teams in software development organizations” [9]. And DevOps was discussed as a software development method that extends the agile philosophy to rapidly produce software products and services and to improve operations performance and quality assurance by Maximilien De Bayser in 2018 [10]. Not only that, an in-depth case study conducted in an organization which was having several years’ experience in DevOps argues, DevOps leads to great smartness for the Information Systems through the soft skills and pattern of collaboration of the software teams [5]. Similarly, many researchers verified lots of benefits offered by this DevOps approach. Mainly it reduces the project completion time, improves software quality and improves customer satisfaction. But again, some practical issues are reported in the industry with the application of this new concept in Agile methodology. There are few researchers who were focused on this industry experience [6].

Most of the related studies have identified that developing high secured software is a main challenge of the DevOps approach [11], [12], [13]. But no value for the software which is not fixed with high security. This can be

forced by another DevOps challenge reported as the problems in testing practices. According to similar studies, the whole testing process needs to be changed with the adoption of DevOps [14], it consumes more time [15] and difficult to find expertise [16], and also there are no interesting testing tools available [11], since DevOps is an emerging method to the IT industry.

Similarly, recent empirical studies demonstrate that there are no existing guidelines on developing high-quality logging code [17], and it is challenging to achieve transparency on quality delivered by different teams [18], and hard to balance the quality and speed of the software development process [19] [20]. Because DevOps increases the speed of the software development process while reducing the project completion time, it is a challenge to maintain and improve the quality of the software.

Lack of technical infrastructure for adopting DevOps is also identified as a challenge for IT project management by different recent researchers [21] [23]. There are little amounts of tools and technologies available for DevOps and those are very complex and difficult to use [22]. This can be raised by the problems of the IT industry such as; lack of experts on DevOps concept and lack of DevOps knowledge and experience of the people who are working in the DevOps groups. Not only the technical problems, but researchers have emphasized many psychological problems raised by the interconnection of software development and operation teams. They are separated teams and sometimes work in different locations. DevOps is integrating those two groups with reducing the gap between them and it forces on these types of problems. Changing the habits of people is challenging. Resistance to change is recognized by many studies as a challenge to DevOps adoption. [24] [25]. Also, social and cultural changes of the organization and project teams provide barriers to adopt the DevOps approach [26] [27] [28]. Changing the organizational process to DevOps with collaborating different teams is another challenge created by this new approach [29] [30]. According to Jose M Delos, it is difficult to find people who are having good knowledge and experience about the DevOps concept from the industry [33]. And also, the lack of awareness of the project designers and team members about this DevOps approach provides barriers for adopting it with Agile methodology [32] [31]. The same as previous studies mentioned that poor management support for adopting DevOps is a biggest challenge and this can be a reason for the unawareness of project team leaders and managers about the greatest returns of this DevOps approach [12] [20] [26].

Similarly, a study conducted for evaluating the Impact of DevOps Practice in Sri Lankan Software Development Organizations has mentioned that DevOps adoption consists of hidden costs and it raises problems related to the budget [34]. Cost can be increased while absorbing consideration to reduce the project completion time. And most of the similar studies mentioned that it is very difficult to achieve the compatibility between the DevOps approach and legacy systems of the organizations [29].

As DevOps is an emerging concept attached to the Agile methodology in the software development industry, there is a small number of studies focused on this DevOps approach. Therefore, no more researchers focused on the challenges given by this new approach to the success of the software development process and, strategies are practiced

to solve those problems by IT project team members. This study collected challenges for adopting DevOps with Agile methodology that exist in literature. Since not many researchers focused on this area, this study focused to study more about those challenges and practices for mitigating those problems used by IT project teams from the real experience of the IT industry using a questionnaire survey.

## II. METHODOLOGY

The research followed a systematic literature review study and a questionnaire survey study to identify the challenges for adopting the DevOps approach, and the strategies that can be used to overcome those challenges for making the IT projects successful. The literature review used to study DevOps challenges identified by similar studies and to perceive the practices utilized by IT projects team members for facing those challenges. The questionnaire survey was used to achieve the research objectives more practically by observing the real-time opinion of IT project development team members about the challenges for adopting DevOps in software development and practices utilized by IT projects team members for facing those challenges.

The literature review study was conducted by a systematic mapping research method. This systematic mapping research method helps to survey the state of the art of research areas that are not yet mature [35]. Search terms formed based on the research questions as “DevOps” AND “Challenges”, “DevOps” AND “Overcoming Strategies”, “DevOps” AND “Evolution” and “DevOps” AND “Software Development Methodologies”. These search terms were used to download relevant and similar publications from the Google Scholar, Emerald Inside, Web of Science, and Google Search Engine to fulfill the research purpose. Then following inclusive and exclusive criteria were used to select more related papers to this study from the downloaded publications.

### Inclusion Criteria

- Literature discusses the Software Development Methodologies
- Literature discusses the evolution of DevOps
- Literature discusses the challenges of DevOps adoption in IT projects
- Literature discusses the overcoming strategies of DevOps challenges
- Literature published after the year 2015

### Exclusion Criteria

- Literatures not related to the purpose of the study
- Literature published before the year 2015
- Inaccessible literature
- Duplicated literature

Afterward, the title of papers used to identify more related publications to the research objectives, and as the next filter, abstract and keywords of the selected papers helped to screen most related publications from the above-selected list. Finally, the study was conducted by reading the full paper of the most relevant literature which was selected from this systematic approach as shown in Fig. 1. By reading the full text of the most related literature, this study identified DevOps as an approach to the software development practices and filtered challenges of DevOps

adoption for the success of IT projects. As same as it surveyed the mitigating strategies for facing challenges of the DevOps adoption. Finally, it identified most specified challenges and mitigating strategies by similar studies.

As the next step of the study, a descriptive questionnaire survey was used to investigate the actual opinion of IT project team members about the use of DevOps concept for making the success of their project developments. Variables for the survey were defined as DevOps challenges and mitigating strategies for those challenges. The questionnaire used to collect opinion from the industry DevOps practitioners about the survey variables. Those variables were measured using questions which were designed according to the indicators emphasized by the literature review as listed in Table I and Table II. As same as it used to examine the more challenges and practical strategies used for overcoming those challenges that were not focused on by other researchers. This helps to answer the first and second research questions while achieving the research objectives. The questionnaire consists of questions about the background information of respondents, questions to measure respondent’s awareness of the DevOps approach, questions for measuring the respondent’s opinion about DevOps challenges identified by the literature review, and questions to validate strategies suggested by other researchers for overcoming DevOps challenges. The opinion of the DevOps team members who filled the questionnaire was measured by the Likert scale. Finally, those measurements are used to rank the challenges and mitigating strategies. As same as, the questionnaire asked respondents to express the idea about other challenges and mitigating strategies they practically encountered with adopting DevOps. Finally, the research compared literature review results with results of the questionnaire survey and discussed the most important challenges that need to provide attention for making the success of IT projects with adopting to DevOps concept and most practical mitigating strategies can be used to overcome those challenges.



Fig. 1 Approach for selecting related studies

### III. ANALYSIS

This section includes an analysis of the literature review and questionnaire survey. Initially, the systematic literature review was conducted through the methodology discussed in the previous section. It began with downloading 192 papers using search terms as “DevOps AND Software Development methodologies”, “DevOps AND Evolution”, “DevOps AND Challenges”, and “DevOps” AND “Overcoming Strategies”. Then 34 papers were eliminated based on the exclusion criteria mentioned in the previous section. As the next step, papers with relevant titles were included in the review list as 98 papers. After that, keywords and abstracts of those selected papers were reviewed and that helped to filter the final set of most relevant 31 studies for the review.

The systematic literature review was conducted by reading full texts of thirty-one selected studies and it could identify many challenges faced by DevOps project team members and also the same challenges have been presented by different authors in various styles. Here all the challenges were listed in one place and categorized into similar groups. Based on that summarization, twelve challenges were identified that faced by IT project management teams for adopting the DevOps approach with the Agile software development methodology. As the next step, the frequency of each challenge identified by other researchers was surveyed by the literature review and finally ranked those challenges according to the above-calculated frequency value. As same as the challenges, the literature review used to identify strategies discussed by other researchers for facing those challenges. However, it could identify only four strategies discussed by other researchers for facing the difficulties of the DevOps adoption since no more researchers focused on this field. The results of this analysis are discussed in the next results and discussion section.

More than the systematic literature review, this research was conducted as a questionnaire survey according to the method discussed in the previous section. Population for the survey was the industrial practitioners who have working experience with the DevOps approach. Sample for the study was selected from the population as 100 industrial practitioners. The online questionnaire was designed using Google forms and distributed to the sample industrial practitioners of the study. Finally, 63 completed answers selected for the analysis.

The questionnaire included main four sections and the first two sections were used to analyze background information about the repliers, such as their age, gender, experience on the DevOps concept, and their opinion about the DevOps adoption. Third section of the questionnaire focused on answering the first research question of the study. It provided a list of the most common challenges filtered from the literature and collected opinions about those challenges from the recipients using the Likert scale. The answers collected from this section were analyzed by ranking the challenges based on the opinion of respondents. Those results compared with the results of literature review and finally identified the most affected challenges to the DevOps practices. Not only that, it collected existing challenges for DevOps which were not focused on by the researchers.

As same as the third section of the questionnaire, the final section also used the Likert scale to evaluate the opinion of

the respondents about suggested strategies for solving the challenges of DevOps adoption. Those strategies also suggested using the results given by the above literature survey. This section provides the answer to the second research question. The answers given by respondents through the Likert scale were used to calculate the rank of each suggested strategy. According to that, this study could suggest the best strategy for facing the challenges given by DevOps adoption to make the success of IT projects. Not only that, the questionnaire was used to collect more practices which are not included in the questionnaire applied by the respondents to solve the problems of DevOps adoption.

### IV. RESULTS AND DISCUSSION

Initially, the systematic literature review was used to examine the challenges and overcoming strategies of DevOps adoption identified by the related studies. It was conducted by reading thirty-one related studies and it identified many challenges faced by IT project management teams for adopting the DevOps approach with Agile methodology.

TABLE I. CHALLENGES IDENTIFIED BY LITERATURE REVIEW FOR DEVOPS ADOPTION

No	Challenge	Identifies Literature
C1	Difficult to change the organizational culture for DevOps adoption	[7] [9] [11] [12] [14] [16] [17] [18] [20] [22] [23] [28] [29] [30] [32] [34]
C2	Difficult to find experienced and knowledgeable people to support DevOps practices	[7] [9] [13] [14] [17] [20] [22] [23] [27] [28] [29] [32]
C3	Lack of management support for DevOps adoption	[10] [12] [13] [14] [16] [18] [22] [23] [28] [29] [30] [32]
C4	Difficulties for adopting an organizational process to DevOps	[11] [12] [13] [17] [16] [18] [19] [30] [32] [18]
C5	Difficult to change the habits/ mindsets with DevOps practices	[3] [7] [9] [10] [13] [18] [20] [22] [23] [29]
C6	Difficult to replicate complex technology environments needed for DevOps.	[11] [14] [15] [16] [17] [22] [24] [27] [30] [33]
C7	Difficult to make collaboration of software development and operation teams	[7] [10] [13] [14] [16] [19] [22]
C8	Achieving a secure DevOps development process is challenging	[4] [6] [18] [19] [20] [21] [29]
C9	Difficulties for implement and use DevOps technology	[15] [16] [20] [21] [28]
C10	DevOps increases the complexity of the developing process.	[2] [12] [17] [28]
C11	Difficulties for moving from legacy systems to DevOps tools and techniques	[11] [20] [28] [29]
C12	Project cost can be increased by the DevOps practices	[16][23][29]

Different authors have presented these challenges in different ways. This study mapped identified challenges into main twelve areas and ranked them according to the frequency of each challenge identified by previous studies as shown in Table I. In the same way, those related studies presented some tactics that can be used for facing the challenges and this study mapped those strategies into four main areas with ranking according to the frequency of each strategy identified by other researchers as shown in Table II. The next part of the research used to validate and analyze DevOps adoption challenges and mitigating strategies by collecting feedback from the people who are working in the IT industry and having experience with DevOps adoption. Sixty-three completed feedback could be collected from the hundred people who were selected as sample for the study. Finally, the most important challenges and mitigating strategies were presented and discussed by comparing the results of the literature survey and the questionnaire survey.

TABLE II. MITIGATING STRATEGIES IDENTIFIED BY LITERATURE REVIEW FOR THE CHALLENGES OF DEVOPS ADOPTION

No	Overcoming Strategy	Identifies Literature
C1	Establish communication, platform, procedures, and tools for enhancing communication between software development and operation teams.	[35] [36] [37] [15] [32] [29] [34] [33]
C2	Improve knowledge about DevOps adoption through recent research findings.	[37] [32] [34] [33]
C3	Rearrange the development group to include people who have good experience with DevOps.	[3] [32] [33]
C4	Communicate and celebrate the success of DevOps in the development process.	[3] [34]

The first section of the questionnaire was used to identify the demographic profile of the participants. According to that, most of the respondents were male (94%) and 61% of participants represent their age group between twenty years to thirty years and 36% represent from thirty to forty years. The Education level marked completed the bachelors by 70% and other 19% of the participants have completed the Masters and rest of 11% of the participants have a Diploma.

All respondents were working in the IT industry and 50% of the sample were experienced people in the IT industry for one to five years. And 33% of respondents have worked more than five years in the IT industry and the rest of the 17% also was working in the IT industry from the last year. More than the industry experience, the questionnaire was used to identify their job role in the IT project management team. Sample of the study consists of 20% of project team leaders/managers, 40% of software developers, another 11% of software testers, 13% of software operators, and the rest of other 16% also working as project team members. Some of the responses mentioned that they were working in more than one job role.

Experience on DevOps of the respondents was collected by the second part of the questionnaire and all of them agreed that DevOps provides a good impact on their projects as shown in Fig. 2. This result emphasizes the importance of examining the DevOps approach and it will

be very useful for the software development companies in the IT industry.

Out of sixty-three participants, sixty repliers (94%) practice DevOps in their team. Other three participants also mentioned that they have a good idea about this DevOps practice. Most of the repliers (38%) have experience on DevOps for one to two years and 36% of them were working in the DevOps team from last year. Rest of the responses represent 27% and they have DevOps experience over two years.

Do you think DevOps provide good impact on your work?  
 63 responses

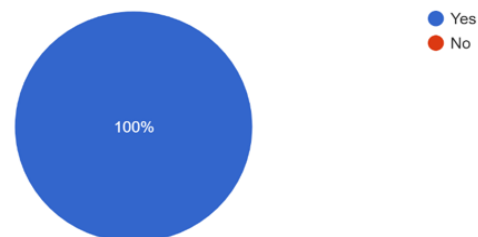


Fig. 2 Impact of the DevOps for making IT projects success

How many years do you have practical experience in DevOps approach?  
 63 responses

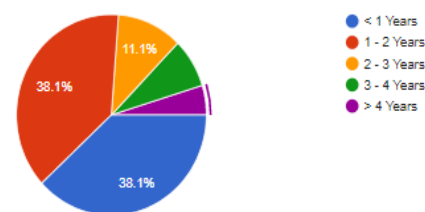


Fig. 3 Experience in DevOps approach of the responses

This DevOps experience of the participants graphically displayed in Fig. 3. However, their DevOps working groups consist of less than ten members for 38% and other 36% were working in the DevOps group which has more than ten members. According to the opinion of the repliers, 48% of them have estimated their understanding of DevOps concept as in “Average” level, and 30% mentioned their knowledge as in “Good” level. Further, 14% of respondents have “Extensive” knowledge about this DevOps adoption while 6% of them don’t have very good ideas. Rest of the respondents (2%) have stated that they are having limited understanding about this DevOps concept as shown in Fig. 4.

Next section of the questionnaire targeted to validate the challenges identified by the literature review with the actual opinion of DevOps practitioners. And to identify more available challenges practiced by the IT project team members while adopting DevOps with Agile methodology which were not focused on by other researchers. The five points Licker’s scale used to measure how those barriers are challenging to them and to identify the most affecting challenges by ranking them according to the overall values of each challenge. The overall level was calculated by multiplying the number of responses for each level of the Likert’s scale by weight for the respective level.

How do you estimate your understanding of DevOps concept?  
 63 responses

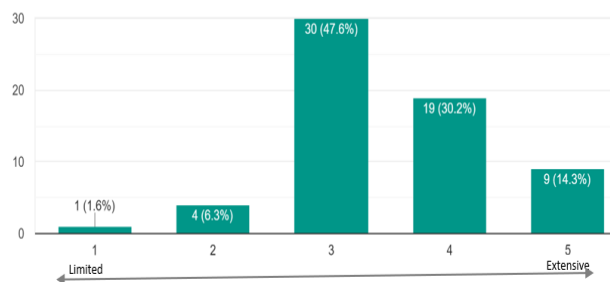


Fig. 4 Response’s knowledge about DevOps

Table III shows the challenges according to their ranks which are calculated by the number of responses for different levels of each challenge.

According to the analysis of results from both literature review and questionnaire survey, changing the organizational culture for adopting the DevOps concept with Agile methodology has become the first ranked challenge faced by IT project management teams. Culture of an organization is the common assumptions practiced by the people who are working in that organization. DevOps collects the software development and operation teams over the project lifetime with changing the culture as working separately. Therefore, it is providing the biggest challenge to adopt DevOps practices to make the success of IT projects.

As claimed by the questionnaire survey, achieving a secure DevOps development process is ranked to the second place and it has ranked to the eighth place in the results of literature review. A main target of DevOps is to reduce the project completion time. Security can be reduced while providing more attention to decrease the project completion time. Therefore, it has become a very important challenge from the practical opinion of the industry people. But this is not captured by many researchers who study the DevOps challenges. According to the literature review study, the second important challenge is the difficulty to find experienced and knowledgeable people to support DevOps practices. This problem can be raised because this concept is emerging in the industry. Responders for the questionnaire also marked this as an important challenge and they have raised this problem into the fifth step of the challenges list.

Managers and Leaders’ support for making the success of DevOps adoption is less based on this study. Most of the researchers have emphasized this problem and it is the third challenge identified by the literature review. When it comes to the practical opinion of DevOps team members, they also mentioned it as an important challenge and it ranked to seventh place of the challenges list. Most of the managers and other IT project team members are not aware about the DevOps concept since it is new to the IT industry. It is proved by the feedbacks of the questionnaire survey as shown in Fig. 4, nearly half (47.6%) of the participants marked their knowledge about the DevOps as “Average”. Therefore, they don’t have a good idea about the benefits of DevOps and not motivated to adopt DevOps advantages to their organizations.

According to the questionnaire survey, the third important challenge is to achieve compatibility between DevOps and legacy systems.

TABLE III. CHALLENGES IDENTIFIED BY QUESTIONNAIRE SURVEY FOR DEVOPS ADOPTION

No	Challenge	No of responses					Overall value
		1	2	3	4	5	
Weight		1	0.75	0.5	0.25	0	
01	Changing deep-seated company culture to support DevOps adoption is challenging.	16	12	17	15	4	33.5
02	Achieving a secure DevOps development process is challenging.	7	27	13	9	8	33.5
03	It is challenging to achieve compatibility between DevOps and legacy systems.	11	12	24	14	3	32.5
04	Adapt organizational processes to DevOps is challenging.	8	19	13	20	4	30.7
05	Difficult to find experienced professionals to support DevOps practice.	13	11	17	16	7	30.5
06	Difficult to replicate complex technology environments needed for DevOps.	6	18	18	18	4	30.5
07	Difficult to obtain management support for DevOps practices.	8	11	17	24	4	27.7
08	There are hidden costs associated with DevOps adoption.	6	13	22	16	7	27.5
09	DevOps increases the complexity of the developing process.	8	11	16	12	17	26
10	Difficult to make the collaboration between Development and Operations.	4	12	18	21	9	25.2
11	Hard to adapt mindsets to achieve successful DevOps.	4	13	12	29	6	25
12	Hard to implement and use DevOps technology.	3	12	20	22	7	24.2

Because the DevOps approach changes the whole process of the project completion. It is required to have the best idea about the DevOps adoption and legacy systems for facing this challenge. Therefore, feedback from the industry survey ranked this to the third point but this is not focused on by many researchers like other challenges and this is the eleventh challenge in the literature review challenge list. However, this is a very considerable challenge for the adoption of the DevOps approach to make the project's success and it is a good area to research for future researchers.

Problems with adapting organizational processes to DevOps also recognized by many of the previous studies and also responders of the questionnaire survey have marked this as an important challenge. Whole organizational process is changed while adopting DevOps and it converts the organizational hierarchy. Because of that, this problem has become the fourth challenge of both DevOps challenge lists. As same, the fifth challenge identified by the literature review is difficulties for changing habits of team members and their mindsets. It is very difficult to change human habits without improving their motivation. Therefore, it is very important to motivate IT project team members by informing them about the advantages of DevOps adoption to make projects successful and their improvements. However, this challenge is not in the top list of the challenges of the questionnaire survey.

The sixth rank of both challenge lists marked as difficult to replicate complex technology environments needed for DevOps. Here many researchers identified DevOps technology as complex and respondents for the survey also agreed with that problem. The next important focus is the project cost. Small number of literatures have identified increasing project cost with DevOps adoption as a challenge and it has become the last problem of the challenges identified by literature. But from the actual opinion of project team members, this challenge was raised into the eighth place of the challenge list of questionnaire surveys. It is very challenging to balance the time, quality, and cost of the IT projects. Those three are the triple constraints of projects. Project cost can be increased while reducing the project completion time by DevOps.

However, challenges identified by the literature review were proved by the questionnaire survey and most of the psychological challenges were identified by many previous researchers. That reason raised those challenges into the top list of the challenges identified by the literature review study. Other than the challenges stated in the other similar research papers, responders for the questionnaire have mentioned more practical challenges they face with adopting DevOps as follows;

- DevOps using lots of tools and too much focus on tools
- Moving from legacy infrastructure to microservices is challenging.
- Implementation of DevOps for projects based and product based companies is difficult.
- Sometimes DevOps might be overhead.
- Challenges come from the technology changes.

The questionnaire survey was also used to identify the methods that IT project team members use to manage the above-mentioned challenges. The questionnaire survey analysis suggested four strategies that can be used to solve DevOps challenges which were identified by the initial literature survey and those methods are shown in Table IV. To meet the challenges posed by DevOps adoption, the majority of them establish communication, platforms, procedures, and tools to improve communication between software development and operation teams. Therefore, in both questionnaire surveys and literature study, this option has become the first strategy for dealing with the challenges of DevOps adoption. According to the literature survey, the second strategy is to improve knowledge about DevOps adoption through recent research findings, and the third strategy is to rearrange the development group by including people who have good experience with DevOps. However, according to the results of the survey, all of these options are used by IT project team members, and they didn't mention them as those are used frequently. In addition to above mentioned suggestions, they have answered the questionnaire by providing following practices for dealing with DevOps challenges as follows;

- Use DevOps framework as CALMS (Culture, Automation, Lean, Measurement, and Sharing)
- First, define a specific development flow for the team and the product. Then, for each operation point, identify experts and later synthesize their knowledge into a single document (diagram)

However, small sample size is recognized as a limitation of the questionnaire survey and the results can be further generalized by improving the sample size.

TABLE IV. STRATEGIES FOR OVERCOMING DEVOPS CHALLENGES

No	Overcoming Strategy	Number of responses			Over all value
		1	2	3	
Weight		1	0.5	0	
01	Establish communication, platform, procedures, and tools for enhancing communication between software development and operation teams.	37	19	8	55.25
02	Communicate and celebrate the success of DevOps in the development process.	33	24	7	54.5
03	Rearrange the development group to include people who have good experience with DevOps.	30	27	7	53.75
04	Improve knowledge about DevOps adoption through recent research findings.	23	29	12	50.75

## V. CONCLUSION

This research examined the adoption of DevOps concept in IT Projects by evaluating the challenges and mitigating strategies practiced by software development firms to ensure the success of IT projects. The research purpose was accomplished by obtaining responses for two research questions as "what are the challenges experienced

by software firms in adopting the DevOps approach in Information Technology projects?" as well as "what are the mitigating strategies employed by software firms to ensure the success of IT projects?". A comprehensive literature review and a questionnaire survey were used to answer the questions. Results of the literature review and responses of the questionnaire survey were utilized to rank the challenges and mitigating strategies, and the rankings of both studies were compared. It answered the first research question, while the second question was answered by assessing the identified mitigating strategies practiced by the IT project teams using the questionnaire survey. Based on this, twelve major hurdles for adopting DevOps were identified and changing deep-seated company culture to support DevOps adoption is identified as the first ranked challenge in both studies. According to the frequency of attention by comparable researchers, the second and third-ranked challenges are, difficult to hire experienced and knowledgeable people to support DevOps practices and the lack of management support for DevOps adoption. According to the DevOps practitioners, the second and third most important challenges are ensuring a secure DevOps development process and achieving compatibility between DevOps and legacy systems respectively. Moreover, it also revealed unfocused challenges experienced by IT project teams. The survey analyzed and ranked not only obstacles, but also mitigation techniques employed to tackle the issues. It revealed that, many IT project teams use the way of establishing communication, platform process, procedures, and tools for enhancing communication between software development and operation teams to lessen the problems of DevOps adoption. The questionnaire survey yielded further recommendations for ensuring the success of IT projects using the DevOps approach. These findings assist future researchers in developing a conceptual model for the critical success factors of DevOps and validate the conceptual model using primary data in order to reap the benefits of DevOps approach while reducing the hurdles associated with using DevOps in Agile methodology for enhancing the success of IT projects.

## REFERENCES

- [1] K. Schwalbe, Information Technology Project Management, United States of America: Cengage Learning, 2016.
- [2] Mariela Stoyanova, "SMART CONCEPT FOR PROJECT MANAGEMENT – TRANSITION TO DevOps," KNOWLEDGE – International Journal, pp. 93-97, 2019.
- [3] Pulasthi Perera, Roshali Silva, Indika Perera, "Improve Software Quality through Practicing DevOps," IEEE, pp. 13-18, 2017.
- [4] David Bishop, D.Sc. , Pam Rowland, Cherie Noteboom, Ph.D., "Antecedents of Preference for Agile Methods: A Project Manager Perspective," in 51st Hawaii International Conference on System Sciences, 2018.
- [5] A. Hemon-Hildgen, Barbara Lyonnet, Frantz Rowe, Brian Fitzgerald, "From Agile to DevOps: Smart Skills and Collaborations," Information Systems Frontiers, 2019.
- [6] Alok Mishra, Ziadon Otaiwi, "DevOps and software quality: A systematic mapping," Elsevier Inc., 2020.
- [7] S. M. Mohammad, "DevOps automation and Agile methodology," SSRN Electronic Journal, pp. 946-949, 2017.
- [8] L. E. Lwakatare, "DevOps Adoption and Implementation in Software Development Practice," University of OULU, 2017.
- [9] Andrej Dyck, Ralf Penners, Horst Lichter, "Towards Definitions for Release Engineering and DevOps," in IEEE/ACM 3rd International Workshop on Release Engineering, 2015.
- [10] Maximilien De Bayser, Leonardo Guerreiro Azevedo, Renato Cerqueira, "ResearchOps: The case for DevOps in scientific applications," Research Gate, 21 April 2018.
- [11] Saima Rafi, Muhammad Azeem Akbar, Wu Yu, "Towards a Hypothetical Framework to Secure DevOps Adoption: Grounded Theory Approach," 2020.
- [12] Mahmoud Sheyyab, "Managing Quality Assurance Challenges of DevOps through Analytics," 2019.
- [13] Asif Qumer Gill, Abhishek Loumish, Isha Riyat, Sungyoun Han, "DevOps for Information Management Systems," VINE Journal of Information and Knowledge Management Systems, 2018.
- [14] Abubaker Wahaballa, Osman Wahballaa, Majdi Abdellatie , Hu Xiong, Zhiguang Qina, "Toward Unified DevOps Model," 2015.
- [15] Kati Kuusinen, Admir Muric, "A Large Agile Organization on Its Journey Towards DevOps," in 2018 44th Euromicro Conference on Software Engineering and Advanced Applications, 2018.
- [16] Anna Wiedemann, Nicole Forsgern, Manuel Wiesche, "The DevOps Phenomenon," 2019.
- [17] Boyuan Chen, "Improving the software logging practices in DevOps," in IEEE/ACM 41st International Conference on Software Engineering, Canada, 2019.
- [18] Masud Fazal-Baqaie, Baris Guldali, Simon Oberthur, "Towards DevOps in Multi-provider Projects," Workshop on Continuous Software Engineering, 2017.
- [19] LE Lwakatare, T Kilamo, T Karvonen, T Sauvola, V Heikkilä, J Itkonen, P Kuvaja, T Mikkonen, M Oivo, C Lassenius, "DevOps in practice: A multiple case study of five companies," Information and Software Technology, 2019.
- [20] L Leite, Carla Rocha, Fabio Kon, "A Survey of DevOps Concepts and Challenges," ACM Computing Surveys, 2019.
- [21] M. Munoz, M. Negrete, J. Mejia, "Proposal to avoid issues in the DevOps implementation: A Systematic Literature Review," 2019.
- [22] Mayank Gokarna, Raju Singh, "DevOps: A Historical Review and Future Works," 2020.
- [23] Saima Rafi, Wu Yu, M A Akbar, "Towards a Hypothetical Framework to Secure DevOps Adoption: Grounded Theory Approach," 2020.
- [24] Liang Yu, Clemente Guerra, "Exploring the disruptive power of adopting DevOps for software development," 2020.
- [25] Asif Q Gill, A Loumish, Isha Riyat, Sungyoun Han, "DevOps for Information Management Systems," 2019.
- [26] Stephen Jones, Joost Noppen, Fiona Lettice, "Management Challenges for DevOps Adoption within UK SMEs," 2016.
- [27] Pulasthi Perera, Roshali Silva, Indika Perera, "Improve Software Quality through Practicing DevOps," 2017.
- [28] Morgan Rowse, Jason Cohen, "A Survey of DevOps in the South African Software Context," in 54th Hawaii International Conference on System Sciences, 2021.
- [29] Welder Luz, Gustavo Pinto, Rodrigo Bonifacio, "Adopting DevOps in the Real World: A Theory, a Model, and a Case Study," 2019.
- [30] Breno B. N. de França, Helvio J. Junior, Guilherme H. Travassos, "Characterizing DevOps by Hearing Multiple Voices," 2016.
- [31] LE Lwakatare, T Karvonen, T Sauvola, P Kuvaja, H Olsson, Jan Bosch, Markku Oivo, "Towards DevOps in the Embedded Systems Domain: Why is It so Hard?," in 49th Hawaii International Conference on System Sciences, 2016.
- [32] Ineta Bucena, Marite Kirikova, "Simplifying the DevOps Adoption Process," 2019.
- [33] Jose Maria Delos, "The Definitive Guide to DevOps," 2021.
- [34] Pulasthi Perera, Madhushi Bandara, Indika Perera, "Evaluating the Impact of DevOps Practice in Sri Lankan Software Development Organizations," in International Conference on Advances in ICT for Emerging Regions, 2016.
- [35] Vaishnavi Mohan, Lotfi ben Othmane, "SecDevOps: Is It a Marketing Buzzword? (Mapping Research on Security in DevOps)," IEEE, 2016.
- [36] Havard Myrbakken, Ricardo Colomo-Palacios, "DevSecOps: A Multivocal Literature Review," 2018.
- [37] L.R. Kalliosaari, S. Mäkinen, L.E. Lwakatare, J. Tiihonen, T. Mannisto, "DevOps Adoption Benefits and Challenges in Practice: A Case Study," p. 590–597, 2016.