DevOps Challenges in Organizations: Through Professional Lens

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DevOps challenges in organizations: Through professional lens

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Abstract. DevOps is a set of organizational practices as well as a culture which tries to eliminate the barriers between the Devs and Ops teams, improve the collaboration and communication among teammates. DevOps is used in different organizations because it supports quicker production, stability and reliability for software development. While the success factors of DevOps adoption have been studied in the extant literature, also the perceived challenges that a company faces during the adoption are crucial to discover. This paper explores and highlights these challenges through an open ended survey (N=15) and in-depth interviews with DevOps professionals (N=16). According to the findings, there are various challenges while implementing DevOps in the organizations. The research suggests that *(i)* lack of team coordination, *(ii)* risky change and development, *(iii)* team members expertise level, *(iv)* lack of focus or differences in development, *(v)* test and production environment, *(vi)* poorly defined functional and technical requirements, *(vii)* poor integration and test process, *(viii)* pipeline execution problems, *(ix)* tools integration challenges, *(x)* people challenges and silo-ed thinking, *(xi)* debugging challenges due to remote execution, *(xii)* feature release challenges, *(xiii)* integrating new standards, *(xiv)* challenges with clients, *(xv)* knowledge sharing, *(xvi)* responsibility distribution issues are the challenges while using DevOps. The founded list of perceived challenges will help future research to suggest mitigation and risk management strategies for successful use of DevOps.

Keywords: DevOps · DevOps challenges · DevOps adoption · DevOps implementation.

1 Introduction

DevOps is an emerging concept for the medium- and large-sized software companies that helps to bridge the gap between the development team and operations team [13]. DevOps employs continuous software development that triggers the continuous delivery and continuous development to support DevOps overall software life-cycle [29]. While delivering the software to clients the software companies deliver through the internet, it is delivered Software as a Service (SaaS), or sometimes it acts as a channel for delivering software directly to customers as the software runs on existing mobile platforms and technologies [17]

The companies are frequently changing and adopting new development strategies to stay in the market. To ensure the good quality of the software development, companies went through different methods from waterfall to agile and gradually to DevOps. Companies

are willing to increase the quality so that software can be released faster with a higher frequency [16]. When companies started using agile methods for software development the performance of the team was developed and improved. The performance was achieved with cross-functional teams settings with a closer collaboration with customers [24]. When DevOps was introduced, the main goal was to expand the cross functional teams activities and bring the operations teams and development teams on the same page [16].

The continuous deployment of software increased opportunities for companies yet it brought many challenges as well [24]. When a company starts implementing DevOps and adopts DevOps terminology then the company faces various organizational, cultural, social, technical, managerial challenges in different phases of the software cycle [3]. As the adoption of DevOps is a challenging process for the companies, the organization supports the process through technological changes, adopting new processes, recruiting trained personnel, consultants and accepting innovations. Adopting DevOps in the company is a unique process which generates many challenges and that impacts on different factor of DevOps.

In this paper, we aim to identify the challenges and adoption phase of DevOps in the various software companies and how the companies mitigate the risks and challenges. We will investigate these issues based on an online survey with open-ended questionnaire (N=15) and in-depth interviews (N= 16) with DevOps professionals from different companies. Consequently, we will address the following research questions in this paper:

RQ1: What are the perceived challenges of DevOps projects for professionals?
RQ2: How to mitigate the challenges and risks for DevOps?

In order to address the research questions we have collected data in two phases. At first we have conducted an open-ended questions through online survey with 15 DevOps professionals. In the second step, we have conducted in-depth interviews with 16 DevOps professionals. We have conducted a qualitative analysis on the data we have collected. Our findings suggests that there are various DevOps challenges, implementation and risk mitigation processes in every companies. This study will contribute to the literature of DevOps research by empirically supporting the perceived DevOps challenges, thus helping further work to form risk mitigation strategies for successful DevOps.

The remaining of this study is organized as follows. Section 2 presents DevOps' definition, DevOps implementation, DevOps adoption, DevOps benefit, DevOps challenges, risk mitigation process and their related literature. It is followed by the description of the empirical data collection and the research process in Section 3. Section 4 presents the results, Section 5 discusses on their impacts, and Section 6 concludes the study.

2 Related work

2.1 DevOps as a definition

DevOps describes how cross functional teams work together to build, test and release faster software more reliably [25]. Automation plays a vital role in DevOps operations as its goal is to improve collaboration between two teams in terms of software development. Fig. 1 illustrates the different aspects discussed in various definitions of DevOps.

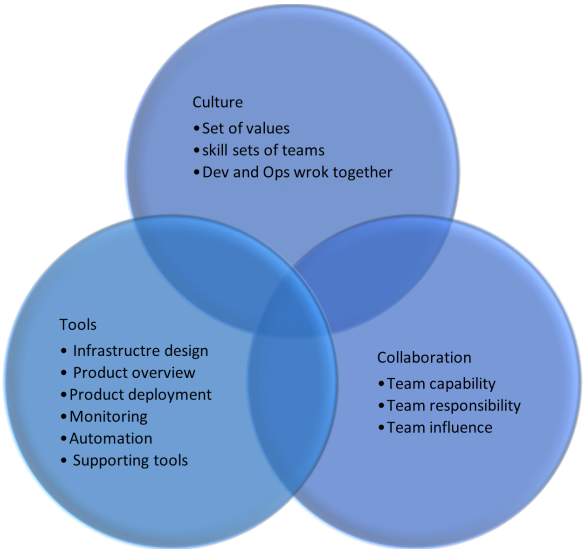

Fig. 1. DevOps definition overview (adapted from [29]).

According to Macarthy and Bass [25] there are two conflicting views of DevOps. They suggested that DevOps is an organizational culture that is used to facilitate and increase software development processes rapidly. The second view suggested that DevOps is a job description lens that requires both skills for software professionals like development skills and operations IT skills for successful execution of job duties. Based on these two views of DevOps practices, we can say that DevOps is not about the automation process only. Though automation play a vital role in DevOps operations, other aspects need to be addressed too [30].

In addition, there are definitions and industrial view of DevOps from professionals. A DevOps professional from Company A—c.f. Section 3—stated that *"Some people define DevOps as a culture. It's partially right, but my kind of opinion would be when you asked a software developer to do operational work he will have a mindset to do it. So basically, it's way of doing things"*.

2.2 DevOps implementation, adoption and benefit

Companies are implementing DevOps and adopting the DevOps culture to improve the software delivery process [32]. DevOps minimizes the gaps between the operation and development teams once it is successfully implemented and adopted within the software organizations. The development process triggers the software deployment and that turns the software into production for the software organizations [13]. The main aspect of DevOps in an organization is to provide continuous delivery and continuous deployment so that the software is delivered faster with short delivery cycles [17].

According to Krey et al. [22] small and medium size enterprises face six major challenges: costs, risks, scope, quality, business value, and time. There are number of

factors which might lead to unsuccessful DevOps implementation. For instance, a lack of communication can make DevOps adoption process unsuccessful. The responsibility of the operations teams are specific and the teams do not pass or monitor different performances that could help the developers for executing tasks [27]. Developers and operations engineers are often concern about conflicting situations among team metrics, as the frequency of release is very important concern for developers and operations personnel [27].

The expectation of customers and users is to get software applications based on their need [18]. Due to this reason and ongoing demand companies are trying to make release frequently and deploy faster. To create this process environment efficiently there should be a proper way to work and tackle the environment. If the system is not utilized properly there will be system failures and that will lead to customer dissatisfaction. DevOps will handle these miscommunications and will fill the gaps with four guiding principlas. According to Gupta et al. [18] automation, culture, collaboration and measurement are four main principals. Gupta et al. [18] also suggested four variables which impacts the implementation process named source control, automation, cohesive teams and continuous delivery.

2.3 DevOps challenges and risk mitigation process

One of the vital issue for the development teams and operations teams is a proper tool as having different toolset can create problems for both teams [8]. Having good communication between Dev and Ops teams should be spontaneous otherwise the lacking of communication might cause delays for both teams operating process [27]. DevOps uses a variety of tools to make the process progress further. Due to the COVID-19 pandemic most of the work went remote which has affected the working process tremendously [26]. As we can understand that only electronic tools cannot solve the problems which could be solved in person. A remote work can never replace an in-person communication. Tools integration is another important issue which can be sometimes problematic and difficult in terms of maintenance and execution [7].

To overcome risk and challenges the companies could apply some strategies. Some of those strategies could be overcoming the Dev and Ops mentality, common understanding on the continuous delivery practice, shifting the infrastructure and architecture to microservices, test automation strategy implementation, prioritizing tools, release ownership of teams, resistance to change, continuous learning etc. According to Jones et al. [21] a company can introduce a job crafting that might help DevOps professionals to meet their personal needs and goals. Job crafting is an individually driven design process that initiates proactive strategies to change characteristics of some one's jobs so that there is a better alignment of personal improvement. Job crafting can help employees to exercise three primary avenues: *(i)* Exercise greater control over the task, *(ii)* determine the way task are perceived, and *(iii)* deciding on the social context and relationships that will be encountered at work [6]. According to Jones et al. [21] task, relational, and cognitive are three ways of job crafting that can increase work performance while adopting DevOps in the companies. Liete et al. [23] suggested that there could be three solutions while implementing DevOps adoption in the companies. Those solutions

includes *(i)* department collaboration, *(ii)* DevOps teams, and *(iii)* cross functional teams in the organization.

3 Research approach

Our aim was to understand DevOps challenges and risk mitigation through professionals' observation. In our study we have set two research questions. To answer these research questions, We have used an explorative qualitative research approach. We have used two methods for data collections. We have conducted survey with open ended questions and took semi structured interviews of DevOps professionals. From the open-ended survey questionnaire, we have got various data from professionals. Some of the answers and concepts were not clear enough from the open-ended questions. Then we have conducted semi structured interviews which gave us concrete and clear perceptions regarding DevOps challenges and risk mitigation process. Both methods (open ended questions and interviews) were used because data triangulation in qualitative inquiry help researchers in a broader understanding of the phenomena. If researchers limit the data collection to one methods then the result might exclude many insights and the results will give a partial view of the phenomenon [20]. Below we will discuss the data collection and data analysis process elaborately.

3.1 Data collection

For the data collection process, the first method we have used is an open-ended survey questionnaire. According to Schluter et al. [28] open-ended survey questionnaire is an efficient method for data collect from respondents. We have followed the method proposed by Schulter et al. and collected data from a specific group of respondents who are specifically working on DevOps as professionals. For the data collection we have conducted the survey through online platform. A questionnaire theme included DevOps process, DevOps adoption, DevOps challenges, DevOps implementation and DevOps risk mitigation process. There were 25 questions developed for the survey and implemented by using Google Form. The survey was published in the first quarter of 2022.

There were five demographic questions regarding country origin, role in the company, company size, and work experience in software development process. The respondents explained their thoughts and wrote their experience for using DevOps in their teams.

For collecting our responses we have shared the survey link through different social media platform. We got the survey responses were from Finland, Netherlands, Spain, Sweden, Trinidad and Tobago, and United kingdom. We have got a good amount of data from the responses which helped us for data analysis later. Partial responses were rejected. In the end, there were 15 usable answers.

The size of the company they represented had 50-20,000 employees. The position they hold in the company were Head of technology, Tech lead, Scrum Master, Site Reliability Engineer, DevOps Engineer, Software Specialist, Business Analyst, Cloud Engineer, Technical Project manager and Software Engineer. The respondents had a working experience in the software development industry from 3 to 20 years.

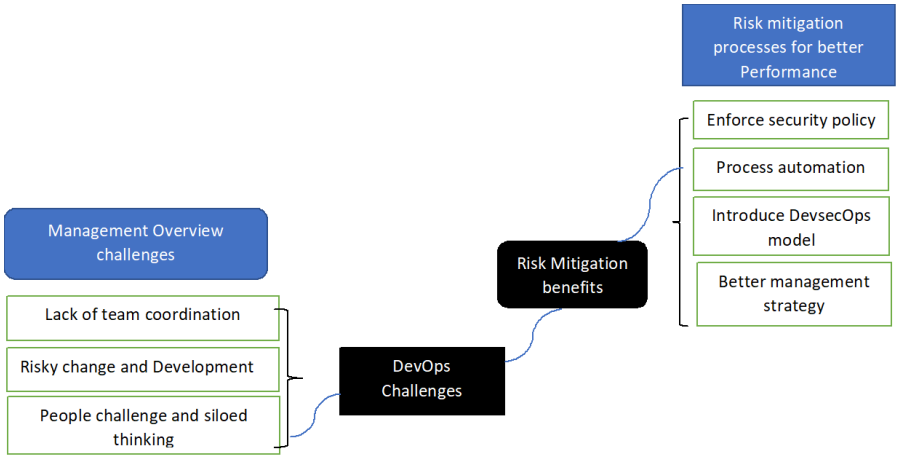

Fig. 2. Thematic maps for DevOps challenges and risk mitigation(adapted from [27]).

We have also conducted interviews with DevOps professionals. This was our second research method for collecting data for the research. The researchers were intending to take the interviews to align the academic literature findings, validate concepts, challenges professionals faces with their DevOps operations, professional practices, DevOps implementation and adoption in the companies. For conducting interviews we developed an interview questions. There were 31 questions which covered five DevOps themes. Those themes included overview of challenges on Management, Integration and Deployment, Infrastructure management and monitoring, Technical and social and cultural overviews.

The interviews were conducted through an online meeting tool Microsoft Teams for 45 minutes. It was recorded after taking the permission from the interviewees. Those who were not comfortable with recording were skipped from recording and notes were taken instead for gathering information. The recording was done due to further revision and validation if required. Overall, 16 interviews were held. The interviewees were DevOps professionals, working mainly either with software engineering or project management duties. The interviews were done during the second quarter of 2022.

The 15 survey respondents and 16 interviewees represented 18 different companies. For the data analysis and reporting phase, we put together the data concerning the same company. In the reporting of the results, we refer to these companies with letters from A to R.

3.2 Data analysis

For data analysis part we have used thematic mapping method. According to Cruzes et al. [12] thematic analysis is a method which helps to identify, analyze, and report themes and patterns within the data. It helps to understand the dataset in an organized way and interprets many aspects of research topic [9, 12] .

Two researchers were involved in coding and categorizing the data in two phases. The researchers at first coded and categorized the survey data. Then the interview data was coded and analyzed separately. Both analysis process involved repeated and careful readings. Then the data was sorted and While doing the categories the researchers put sub categories based on themes of the texts. After completing the coding process the researchers compared their views with each other.

4 Results

This section presents the findings of our data analysis which identifies various challenges overviews of DevOps professionals. Our findings discusses several DevOps implementation challenges the professionals face while working in teams. Below we discuss five overviews of the professionals.

4.1 Management overview challenges

In our interview with 16 individuals we tried to know four management overview aspects of DevOps implementation and adoption process in the organization. We have found several challenges for management overview. Among those challenges Lack of team coordination, Risky change and development, People challenges and siloed thinking, Challenges with clients, Responsibility distribution issues, DevOps implementation challenge, DevOps adoption challenge including new skills and capabilities and DevOps adoption consequences. some of the challenges are discussed below. We will discuss more about challenges in discussion section.

Scenario of DevOps implementation experience

The scenario of DevOps first implementation is different experience for most of the engineers. Respondent from Company A quoted that when he *"joined the company as a web developer, there wasn't much stuff. They used AngularJS and Node. js for development purposes and then they started using Docker and GitLab very slowly and the new tools implementation made the software process faster".*

A professionals from Company H stated that, *"Basic principles for the base layer is same and the idea is to automate the things for internal development environment. So wherever we are developing the products, the first task is to automate most of the things like testing the deployment. It really is whatever comes up altogether, so we have to automate the whole process or the pipeline".*

DevOps adoption challenges for professionals

According to DevOps professionals there are various challenges. The challenges could be managerial, social, administrative, technical and communication challenges.

New skills and capabilities. The engineers faces some challenges related to different issues as DevOps is the combination of different sort of operations. Some professionals stated that when they had to move from web development to DevOps, there were lots of things like cloud, new technology, new language and development environment. Moreover good knowledge on different technology is required for developers and due to that developers needs to keep learning. So this is a challenge if someone is not very experienced with DevOps. Another challenge is the complexity in the setup process of DevOps in the company. There are various connecting factors related to to DevOps setups for the first time. It is time consuming and any new adoption takes time for companies and employees to get adjusted with the working process. This is one of the vital challenge for DevOps adoption.

DevOps professionals from Company B stated that *"We face challenges with the pipeline sometimes and there is a knowledge gap in teams. Because there is a lot of things to learn, so when we face something new we try to learn it and fix it".*

Company H professional's stated that *"right now in the market finding the right person who is capable enough of doing all related activities is a challenge. They have lack of knowledge regarding DevOps adoption".*

According to the respondents the challenges at this moment for DevOps adoption is insufficient knowledge in industries and the engineers also have a knowledge gap. Though they might have some strong understanding or knowledge or background in some specific part of the software development but DevOps practices still needs to be understood by many of them. DevOps needs proper communication with Software developer. The engineers witnesses that sometimes a developer only working on his coding but when deployment comes, he doesn't have really much idea what's happening in the back end or in the cloud system and also the automation is unclear to him.

Consequences of DevOps adoption in the companies. There are a lot of positive consequences for DevOps adoption. DevOps helps developers to think less and there is less complexity in the flow of work. When a developer works they develop codes and push it to the repository. Someone will review the codes and after that the developers do not need to do anything if there is 100 percent automation. When there is a good automation developers just wait so that continuous testing, continuous integration and all these tasks are done automatically. The adoption of Devops helps the production cycle smooth and help the companies to save time and cost.

One respondents form company C stated that

> *"Companies needs to hire good and experienced DevOps personals for DevOps implemention and adoption. Company is spending time and money on that. Though the expenditure is increasing, but on the other hand they are saving lot of mishaps in the software development process".*

Another DevOps professional from the company stated that *"Biggest challenge that adaptation is not much welcoming for many people or organizations".*

4.2 Technical overview challenges

Our second theme was to know the technical overviews of DevOps in the organization. As all companies have different setups and tools for DevOps operations, it was really

important to know the overall workflows of the DevOps and how tools can be a challenge for the DevOps process. From our responses we have identified some technical challenges. Among those Test and production environment, Poorly defined functional and technical requirements, Debugging challenges due to remote execution, work flow or practices for deployment challenges are some technical challenges.

Work-flows/practices for deployment and operational use in production process For the technical part developers need to put 15 test or any number of tests they want to put in the testing process. Everything will be tested so the engineers don't need to worry about small things and small details. The system needs to be setup once so that from the next time everything's will be checked automatically without any hassle.

According to a professional *"At the beginning even before starting the development, various tools like JIRA is used for the task management. There they used to maintain a backlog. The product owner maintains the backlog. Four developers get the task based on the importance and requirements. The developers develop and also maintain the tasks. They develop new features, but if there is something broken then they prioritize stuff and fix it. The company has 21 days sprint. So after every 21 days the engineers have a meeting for this Sprint review and retrospective. And then the release starts".*

From company E a professional quoted that

> *"If there is no dependence, I just finish it and then I push my code to the Gitlab. I push my code to Gitlab and then someone from my development team has to review that one. So when I push my code. There is certain test for all the codes. when my development task is finished, I push my branch to the repository and there is certain pipeline for that. Certain taste for that. So if the pipeline succeeds, that means everything went well".*

4.3 Integration and deployment overview challenges

Our third theme was related to integration and deployment. This theme has covered a helicopter view of DevOps processes in different organizations. We asked DevOps professionals about the levels and stages when software changes are integrated build and tested. To support the building and testing what tools are used, to ensure the quality what practices other than testing is required, for deploying and delivering product to customers what processes the company use, for the deployment pipelines how the quality is assured and finally what are the most important challenges regarding quality. From the responses we have found some challenges named quality of product assurance challenges, quality assurence in development pipeline, Tools integration challenges and lack of focus or differences in development.

Quality of the product assurance Quality of the product depends on many things. For example, most of the codes the developers use are unstable. Only testing does not contribute to the quality of the product. whenever we are pushing codes to the development container we can see the progress in the graphs. In the monitoring system we can check is everything going right. And there are lots of checks in different phases of the process. For example, there is one check going on that whether the user can log in

or not to the system. So if the login fails, that means there are some problems in the log in process. Then developers fix the issues.

A DevOps professional, from company F, stated that

> *"Testing is the part like when you have kind of predefined set of logics already implemented before developing the product. We have these use cases where the test should have passed before submitting to the actual production. So this setup impacts the quality of the product, integration and deployment".*

Most of the professionals believes that code review is a major issues to consider and a certified reviewer can impact on the overall development process. The most senior developers review the codes. This sort of checks ensures a good quality for the integration.

Quality assurance in the development pipelines Quality assurance in the development pipeline was seens as a bit challenging. When software is deployed many times the system faces issues, which will come from the customer sides. Though before the deployment testing, review, verification and lot of things are processed. Before deployment the engineers try always try to cover up or implement those process so that they don't see any problem after the deployment.

4.4 Infrastructure management and monitoring overview challenges

This themes discusses about the infrastructure management and monitoring processes. We asked questions from professionals to know who is responsible for managing and maintaining infrastructure, does the development team has access to resources in production, how the non functional requirements and information about configurations are communicated to developers, how different environments of applications are managed, how the software changes deployed in production and how monitoring process is performed in production. We have found some challenges named infrastructure management challenges, Development teams production challenges due to resourses, feature release challenges,pipeline execution challenges etc.

Infrastructure management. Infrastructure management is very important for DevOps process. Cloud platform engineer and cloud engineers are responsible for maintaining the infrastructure. There are a bunch of different sections. DevOps engineers does coding. But there are some other people who are more focused on Operational side of the system. So they're not necessarily a very good or a strong coder, but they have very good operational knowledge or at least they're kind of guru in Linux based things. So these are a bunch of people who were responsible like maintaining or creating the infra like cloud engineer platform engineer or DevOps or site reliability engineer.

Development teams access to resources in production. Development teams has a little access to the resources in production. Some companies maintain mainly development, production and infra and everything for the internal use as the companies do not need to maintain any websites or web applications. For some of the projects where the applications are customer facing the production setup is kind of untouchable or there are very few people who have the access. Most of the time the access is restricted and for the development process.

4.5 Company cultural and mind set overview challenges

Our last theme included DevOps culture in the organization, We aimed to know does the company support DevOps approaches, mindset, development culture in the organization and the management support for the development practices with culture visibility. We have found some challenges including Integrating new standards challenges, knowledge sharing challenges, Development culture and mindset challenges and management support challenges.

Development culture and mindset. The development culture and mindset of a company is very crucial for a successful DevOps implementation in the organization. The mindset of the team is to make the customer happy with the product, keep the production ongoing with efficiency and make the process bug free so that there should not be any problem. Another mindset explained by the professionals are to run the current production perfectly as much as possible and then adding more features for the production process.

From a company to a company, or from a team to a team the culture and mindset varies. Although they are working with the same kind of technologies. The teams needs to have a clear mindset and purpose. In case of coding, for example, the code reviews can be done in various ways. Some people are managing the actual code base in GitHub or Beat bucket. So not all teams following the same kind of principle in this case. At the end the aim to ship the codes to the production. The mindset al. so depends on the size of the production.

One respondent from company H stated that

> *"Most important part, as a DevOps engineer or any developer is that they need to be adjusted with the changes and needs to be agile. So if they have the mindset that they will not change and will continue with the traditional way of doing then definitely they will be way behind the industry practices".*

Management support for the development practice. Different organizations have different kind of management support for the teams. according to the professionals the employees get support mostly but every requirements of the DevOps teams are not always accepted.

According to a respondents from company C

> *"The top management always decide what they think is good for the company. I think they decide on that and due to that all the time we don't get what we want. Though most of the time management supports our needs for the team".*

4.6 Risk Mitigation

Risk mitigation process for better performance For risk mitigation and better performance there could be several approaches. According to the respondents there are four approaches which could help the professionals to handle risks for the organization. Those approaches includes enforcing security policy, process automation, introducucing DevsecOps model and better management strategy.

It is necessary to create a comprehensive environment where the securities issues can be handled. For creating this environment effective communication and establishing

governance is required. There should be a good security system or a set of cybersecurity approaches where the security processes will be easy, transparent and understandable. The security process could cover wide range of issues including code review, restrictions for access, management configuration etc. Our respondents from company D stated that *"DevOps teams should work with security teams so that a secured application can be produced with good policies, tools under collaboration"*.

5 Discussion

5.1 Key findings

This study addresses two aspects of DevOps. Firstly, the perceived challenges by industry professionals and, secondly, risks mitigation for DevOps. From the survey and interviews with professionals, we have got an initial list of DevOps practical challenges faced by organizations. Though these challenges are not universal. These are professionals own view regarding challenges they face while working in companies.

Miscommunication between Dev and Ops teams is a major issue for DevOps process success. Some of the DevOps professionals reported that there is a lack of team coordination while working in a team [2, 3, 22, 27]. When there is a lack of communication that make DevOps adoption process unsuccessful [2, 22]. This is one of the biggest challenges in terms of performance and quick releases [4]. Respondents told that rapid release increases the chance of better performance with less time [4].

According to the respondents we have got an idea that DevOps implementation in a company for the first time is very risky and difficult, which might lead unsuccessful DevOps implementation. The changes were perceived to be always difficult. The change process creates confusion among employees and many times it is difficult for the employees to adopt and accept new changes. This new change is challenging and time consuming too [3, 22].

Lack of focus or differences in development is another challenge for DevOps practices. Many times devlopers faced that there is a lack of focus in the development process. They are not sure of what they are doing, there could be miscommunication with team members. There could be misconceptions between development teams and operations team members. Due to these reasons differences occur in the development process [2, 4, 22, 27].

Test and production environment is a challenge too. Testing and production environment is very crucial for the production process. It is very important to have a good testing for the code and the production environment should support the testing process. When there is poor integration that hampers the testing process. Due to that reason the test set ups should be proper so that the rest of the process can work well [15].

Poorly defined functional and technical requirements are another challenge faced by professionals. When DevOps engineers are working on a project, there are always some technical requirements and functional requirements. Before start working on a specific task the technical requirements should be clearly defined to teams so that there is no confusion about the task. When the requirements are not defined clearly then that become a challenge for the team to work on functional and technical requirements for the end product [10, 11, 19].

DevOps pipeline is a set of automated processes and tools which helps the developers and operations professionals for collaboration so that the codes can be build and deployed to the production environment. Sometimes the professionals faces pipeline execution problems. In a pipelines there are several process like CI/CD, continuous testing (CT), continuous deployment, continuous monitoring, continuous feedback, continuous operations, develop and build. When there is an execution problem in the pipeline that become a challenge for the developers [14].

Choosing the right tools for DevOps operations is another challenge for companies. There are several tools that are used for DevOps and the company chooses the tools based on their needs and requirements for the project. Finding or choosing the right tools is often challenging for companies. While there a plethor of tools [c.f. 1], according to the respondents sometimes the company chooses tools which are not effective and make the process even slower [4].

People challenges and siloed thinking is also a vital challenge for DevOps prctices. Sometimes people challenge is not easy to figure out. There are still siloed thinking among people and teams while working together in an organization[31]. Debugging challenges due to remote execution is also a challenge for professionals. Due to remote work most of the DevOps engineers faced debugging challenges. They said that it was difficult when they were not working from office, they could not get support for many technical issues and other issues which could have been easier to handle if they could work from office [15]. Knowledge sharing is another challenging issues for DevOps process. Knowledge sharing can be hard and team members have to be careful not to overwhelm other members [33].

There are also clear positive impacts for using DevOps in companies. From respondents we observed that in previously software developers worked in the companies and there were no DevOps practices in the organization. Gradually the developers got to know how the implementation works for DevOps operations, how the actual level of testing should be done and how to configure the CI/CD pipelines. In previous time, developers used to do many operations manually and after implementation of DevOps most of the operations become automated.

Previously developers needed to prepare infrastructure for the sales engineer which were mostly manual. The previous process used by developers used to take lot of time. It was not easy to figure out how this works or doing many manual testing for the development phases. But when the developers introduced to DevOps, they found that there are quite many things which are simple and they can do it very effectively and that could save a lot of time for the software development process. Good knowledge on DevOps is perceived to be really important, and which will benefit DevOps engineers to deliver the product in time.

5.2 Research limitations

There are some limitations of our research. First, the data was collected through an open-invitation online survey. It was not easy to get complete responses for the open-ended questionnaire. Due to the short response time, the number of received responses remained low. If we could get a good number of responses, this could reveal more information on the topic.

Second, we could take some interviews of the DevOps professionals that provided richer data and many new angles were discovered. The time for the interview was short. For future work we plan to conduct more interviews with the respondents. Third, DevOps is a specific domain. Identifying specific respondents was a real challenge. Researchers contacted many individuals personally to set up the interviews. Moreover DevOps is a progressing practice for many companies. Due to this reason finding respondents was difficult which is considered as one of the major limitations for this research.

Fourth, according to our observation some respondents had a lack of knowledge on DevOps. Some of the respondents were new to the company and had little idea about DevOps culture, some respondents were explaining how DevOps are communicated among teams and still the misconceptions are present in the process. They were unable to answer some managerial, cultural and organizational questions. Fifth, in our research there could be response bias and selection bias. The answers we have received from the respondents were not specific. There could be some bindings and confidential issues regarding information sharing. Moreover this study could connect the DevOps model with empirical support. To discover more we need to do more research so that components of the CSF model, see [3], align with the challenges. However, more work is needed to both develop the model further as well as empirically validate its components.

5.3 Future reserach

According to our findings from the literature review we got some topics which need more study in the DevOps domain. These topics could be a great opportunity for future research agenda for critical success factors of DevOps.

Research model for identifying challenges Based on our literature review we have got several factors for future work in this domain. A new model could be developed for DevOps challenges along with the critical success factors. This new model could be used as a guiding framework for investigating various challenges in the organization.

Combining DevOps and AI for better performance Artificial intelligence (AI) has potential which could combine DevOps for better performance. DevOps efficiency would increase more for using AI in the software development life cycle. When AI is involved with DevOps then that will increase quick development and the operation cycle performance will increase at the same time. This will provide a good experience for the users with new features of AI implementation with DevOps. This will trigger the machine learning algorithms to gather data from various sources for the DevOps system [5]. This could be a great future research agenda which will facilitate various models developed with AI and DevOps.

Theory-based approach According to our literature we have observed that very few studies were conducted for theoretical frameworks for critical success factors and challenges. From our literature review we have seen that there is a lack of theoretical papers that discuss DevOps success factors along with challenges.

Combining Blockchain and DevOps challenges The combination of Blockchain technology and DevOps Challenges has a great potential for future research agenda. DevOps helps to increase number of software releases and blockchain could help storing highly sensitive and private information for the project, industry, and product

needs. Most of the time sharing sensitive files and records are challenging issues due to data sharing. In this situation use of Blockchain technology along with DevOps could be a key solution to this problem. This is a new research area and there could be many possibilities to explore blockchain and DevOps operations.

6 Conclusions

DevOps is an organizational culture which helps the development teams and operations teams to operate smoothly for software development life cycle. DevOps challenges have a strong impact on companies performance. Solving those could help the companies to improve their culture and support the future challenges for DevOps practices. We got the perspectice and view of DevOps professionals through open-ended questionnaires and in-depth interviews with the professionals. We have listed several challenges which they face for DevOps implementation and DevOps adoption process. This research will be helpful for future research agenda and investigate more on DevOps domain.

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