

An Exploratory Study of DevOps Approach and Engagement : From the Perspective of Bangladesh IT Industries

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Declaration of Candidate

This is to certify that the work presented in this thesis is the outcome of the analysis and experiments carried out by Mahir Ashraf Emad, H. M. Raihan Evan, Anirban Tasfin Azad under the supervision of Shohel Ahmed, Assistant Professor, Department of Computer Science and Engineering (CSE), Islamic University of Technology (IUT), Dhaka, Bangladesh. It is also declared that neither of this thesis nor any part of this thesis has been submitted anywhere else for any degree or diploma. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references is given.



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The thesis titled, “**An Exploratory Study of DevOps Approach and Engagement : From the Perspective of Bangladesh IT Industries**” submitted by Mahir Ashraf Emad , H. M. Raihan Evan, Anirban Tasfin Azad of Academic Year 2020-21 has been found as satisfactory and accepted.

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List of Abbreviations

GLT	Generalized Locally Toeplitz
TET	Tabular Enhancement Toeplitz
FGD	Focus Group Discussion
CI	Continuous Integration
CD	Continuous Delivery
SRS	Stratified Random Sampling
CTM	Cross Tabulation Method
SDLC	Software Development Life Cycle

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Abstract

On-Time Delivery (OTD) with high quality is the key success factor for Software development organizations. To increase the ability to meet the OTD with high quality, software organizations start practicing DevOps. And the rate of adopting DevOps is highly observed in the regions where the IT industry is already developed. Still, there is a clear demand of analyzing the DevOps culture to understand the formulation and vision of continuous quality product delivery of Software organizations in a region like Bangladesh where the IT sector is rapidly expanding. In order to explore this, we conduct our current study using both empirical study and statistical analysis based on semi-structured interviews and surveys. We conduct our survey on 9 different Bangladeshi software organizations ranging in size from small to large. It is discovered that most of the organizations follow a traditional approach, rather than having an established DevOps team. A large number of developers are accountable for the DevOps pipeline and the surveyed organizations in this region had a positive mentality about adopting DevOps.

Chapter 1

Introduction

1.1 Overview

In recent years, the software industry has shifted its focus to market trends and well-maintained projects. And, because software businesses are focused on the development of long-term projects and applications, resource management and the production of faster and more efficient deliverables are critical. Furthermore, with the introduction of cloud platforms and microservice architecture, these requirements were destined to be met. DevOps has become quite a term in this scenario as a solution. It was proposed with the goal of bridging the workload gap between development and operations. Organizations that can deliver software frequently and early have quite a better chance of competing in the market [1]. DevOps claims to enable technical firms to compete with the IT industry's greater frequency software product releases. It's also been described as an organizational strategy for building empathy and cross-functional collaboration [2, 3].

Figure 1.1 gives an overview of the four different phases of a software development lifecycle starting with Planning, Developing, Testing, Product Deployment, Operations, Monitoring. These phases run simultaneously to build a superior quality software with on time seamless delivery. Each phase has an inter-dependent association technique that merges the work done into the DevOps pipeline. Here the pipeline term refers to the set of techniques of automated processes and technologies that enable developers and operations professionals to collaborate on developing and delivering code in a production environment. DevOps has been modifying actions and products to meet the current market needs, as users are increasingly interested in feature-rich and fast-updating Enterprise level software. As a result, faster deliverables and better-optimized products are produced.

Despite all of the hype, the concept of DevOps has been widely defined by technol-

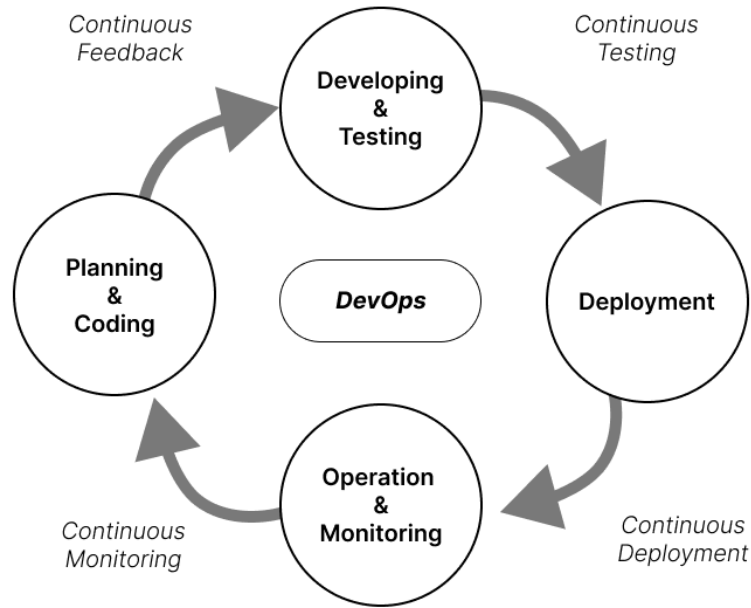


Figure 1.1: DevOps working structure

ogy experts and practitioners alike. More crucially, the techniques and their usefulness vary depending on the industry. It is obvious that it cannot be ignored as a technology because it encompasses a far greater responsibility. When it comes to Bangladeshi industries, we've observed a significant increase in advanced technology culture. Using new goods, learning new technology stacks, and even adopting new processes, to name a few examples. As a result, the term "DevOps" comes to mind. We get into this move in depth in this report. We discuss the knowledge of DevOps that Bangladesh's software firms have and how they are adapting to it. Our purpose for these reports is to collect data from the ground up to a major organizational level.

1.2 Problem statement

We want to find out the current scenario and knowledge gap of Bangladeshi IT industry professionals regarding the usage of DevOps. Analyzing and verifying the practice/usage of DevOps in the Information and Technology sectors of Bangladesh is a must because DevOps related research is still not conducted here. DevOps is still evolving and there are no specific definitions of it. DevOps can facilitate the on time delivery of product without changing the quality but still many companies are using agile and lean software methodologies as an umbrella to show DevOps a practice. So, this needs to be identified, what are the constraints which are restraining the companies from adopting DevOps. DevOps is getting a huge demand in the countries where the IT sector is already developed but in regions like Bangladesh where the IT sector is

developing, agile and traditional methods are still used and quite famous here. This needs to be found out what are the reasons behind these, the benefits (improved software delivery performance) and challenges that these firms face, as well as the DevOps team structure they used during their DevOps transition. This research will aid practitioners and scholars in better understanding DevOps changes and the circumstances in which they were implemented to fill out the scopes which still need to be discovered. Also, in turn, should help to reinforce the evidence surrounding DevOps and assist practitioners in making more educated judgments about the return on investment when using DevOps.

1.3 Motivation and scope of Research

As evidenced by the growing number of scientific articles published on the subject, DevOps has become a focus of active scientific research. Many firms appear to be interested in this innovative approach to development and operations management [4]. This is an exploratory study to find out the statistics of the organizations using devops in a formalized way along with the facts associated with devops adoption as well as the barriers/challenges. We summarized and covered a few papers in our area of interest, which we used to develop our issue statements. We came up with four specific study objectives after it was completed, which we used to pursue our semi structured empirical study. The main goals of our research will be to answer these questions. As a result, we'll do more investigation to find answers to these questions in the upcoming chapters.

RQ1 - How do professionals describe DevOps as a practice?

RQ2 - What are the different DevOps approaches according to IT Experts (procedures and operations) ?

RQ3 - What are the individual processes that are implemented and for what purposes?

RQ4 - What are the company cultures inclining to DevOps practices?

These research questionnaires are then split and expanded based on the primary rationales to create generic survey questionnaires. The survey's main goal would be to look into the responses based on preliminary analysis and discover metrics relevant to our research issue. Our expected outcomes for generating a conclusion would be the investigated results of these research questions.

1.4 Research Challenges

There are already some current contributions to DevOps knowledge that are essentially technical in nature, focused on many of the tools that are linked with it. As a result, most of the information appears to be directly correlated to Computer Science as an academic discipline. In addition, there is a lack of empirical study on what DevOps adoption means for an IT firm. DevOps adoption is not considered a fundamental culture to carry out all product development related operations, especially in a south-asian region like Bangladesh. Rather, in most IT organizations, the major focus is on developing a specific product using legacy technologies in the traditional fashion. The majority of the practitioners stated that infrastructural dependencies are a major roadblock to implementing DevOps as a formal approach. Other important problems, such as a lack of skilled/experienced staff and cost, are also considered to be significant barriers to DevOps adoption. The issue for researchers is to determine the current state of DevOps in practice and to educate the next generation of software engineers on DevOps ideas and practices [5].

1.5 Thesis Outline

The first chapter of the thesis introduces DevOps and lays out the research aim. In chapter 2, there is a literature review that offers an explanation of DevOps, its life cycle, and why it is significant in the IT industry of Bangladesh. Chapter 3 covers the research methodology and precedes the literature review in order to give the methodological approach.

The results of a focus group and questionnaire survey on the concept, adoption, and practices of DevOps are presented in Chapter 4. Chapter 5 presents an overview of the findings generated from qualitative data acquired over a fourteen-month period from a number of IT organizations. The threats to validity are discussed in Chapter 6 and compared to the data analysis and findings part before concluding with a summary of the theoretical and methodological contributions made by this study. Finally, in 7, The overall conclusion along with some statistical discussion is added.

Chapter 2

Background Study and Literature review

2.1 DevOps Definition

Formerly, there were two distinct IT departments "Development" and "Operations" which were clearly segregated and, for the most part, pursued different objectives. Based on this history, the software development unit might be said to be in charge of the programming and creation of new software programs. IT operations, on the other hand, are the procedures and services managed by an organization's IT department, which includes administrative processes as well as hardware and software support. These multiple steps of a software lifecycle used to be independent, and IT operations would normally only work on a project when Development had declared it ready on their end, where each department would conduct their own jobs with minimum interaction of the other department. It emerged as a response to the growing need for high-quality software to be developed and deployed quickly within web development organizations. Companies are applying agile and lean software development strategies in their operations to increase the pace of their software development process and improve the quality of their software [4]. It's a management method aimed at reducing the time between software production and deployment while maintaining high quality [6].

2.2 DevOps Process/ Implementation

DevOps was originally defined as a collection of concepts that pushed for closer collaboration between developers and operators in order to eliminate the friction associated with new software releases [7]. To be implemented for an organizational entity, this concept must be developed through a series of steps. In Figure 2.1 it is shown that Culture organization, continuous integration and deployment process development, containerization, tool integration, alignment with the testing team, and overall performance monitoring are among these steps [8].

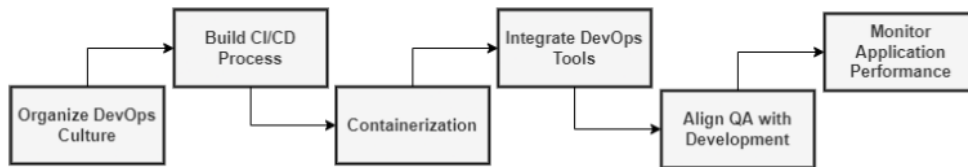


Figure 2.1: DevOps Process Steps

- **Organization Culture:** From the top-level job to the bottom-level staff hierarchy, a successful DevOps transformation fosters effective communication amongst cross-functional teams. A dedicated manager oversees and maintains the DevOps implementation process in an appropriate way. Personnel with a big role start the DevOps implementation with appropriate DevOps Strategies.
- **CI/CD Process Buildup:** Various software teams, such as testing, operations, and design teams, work together to gain a better knowledge of each other's responsibilities in order to speed up the software development life cycle and raise the quality of the program. Developers may securely create new codes while also ensuring that current ones are of high quality. Continuous testing is used throughout the delivery pipeline, with the primary purpose of keeping the release duration to a minimum.
- **Containerization:** Containerization is a type of virtualization in which applications run in separate user environments, known as containers, while sharing the same operating system. A containerized software or application can be transported and executed reliably in any environment and on any infrastructure, regardless of the operating system used in that environment or infrastructure.
- **Tools integration:** To efficiently streamline the project life cycle process, suitable DevOps tools are used to automate the Company's Infrastructure. Following the Containerization process, the software applications in the container must be managed using proper automation tools. Jenkins, Selenium, Ansible, and Kubernetes are used to automate the building, testing, and deployment of new builds in large organizations.
- **Align QA and Development:** Following a few best practices ensures that there are no post-release defects and ensures that the QA and development processes are perfectly aligned. To avoid bugs after the release, development and testing are done simultaneously. While the software is still being developed, there are some best practices for running automated tests on a regular basis. If any bugs are discovered, developers strive to fix them before publishing the next build.
- **Monitor Performance:** Application performance monitoring gives DevOps teams

visibility into all performance concerns, such as poor response times, runtime failures, and so on. Performance monitoring enables the early detection, prioritization, and isolation of application problems before they are discovered by end users, as well as the rapid identification of the errors' main causes.

2.3 DevOps Usage/Adoption

DevOps is a relatively new term that refers to best practices for a comprehensive and efficient software engineering process. For both the business sector and the scientific community, DevOps has become a significant phenomenon in software engineering [5, 6]. It is utilized as a formal technique in most international technologically advanced countries to successfully develop good quality software in a shorter length of time. Amazon, Google, Facebook are just a few examples of successful firms whose DevOps techniques have been documented in a variety of publications [9]. Businesses benefit from this information, but it is difficult for most of them to match these top companies and implement the practices they disclose. There are some annual assessments on measuring the state of DevOps, such as those produced by DORA (DevOps Research & Assessment Association) and Puppet , which examine data from survey questionnaires completed by over 30,000 technical professionals worldwide [9]. "Puppet Lab" examined their own survey and discovered that the number of teams utilizing DevOps has risen from 16 percent in 2014 to 27 percent in 2017, according to industry standards for IT automation [10].

Automation, collaborative culture, continuous measurement, quality assurance, and a variety of other categories all play a role in DevOps adoption [11, 12]. The collaborative culture is the most important aspect of DevOps adoption. Among these, some of the categories are termed as "DevOps enablers". In general, this approach makes it easier to comprehend the complex set of aspects that make up DevOps adoption, allowing it to be more direct and reduce the danger of focusing on the wrong things. As it's already known that the essential category for DevOps adoption is collaborative culture [13]. The goal of a collaborative culture is to break down barriers between development and operational teams and activities. As a result, operational duties such as product deployment/release, infrastructure management, and monitoring should be considered user 's daily activity. The development team no longer needs to wait for the production of one software or version of a software in a staging environment as a result of cultivating a collaborative culture. Everyone should understand how this is done, and with the help of the operations staff, it can be done on a daily basis. If a task can be completed by the development team and the teams have mutual trust, the

work is naturally incorporated into the development process. Therefore, a complete life cycle of DevOps adoption can take place in subsequent IT firms according to their cultural activities.

2.4 DevOps in Bangladesh

Bangladesh is a developing country with a strong technological base. According to UNCTAD, the average annual growth rate of Bangladesh's software development industry has been over 40% for the past five years, and this trend is expected to continue. Fast-growing IT companies are always evolving by incorporating all of the essential processes and tools in order to deliver a higher-quality product faster. The use of approaches such as Agile, Scrum, and DevOps is significantly impacting software production and delivery speed, particularly in the private sector. All of these insights reflect a significant shift from the initial phase to the ongoing phase, which statistically leads to a significant accomplishment and greater revenue. The IT business of a country is one of the most promising areas, and many organizations with physically reliant infrastructure have been shown to be interested in moving to online and cloud native technical innovations, especially after the *Covid-19* epidemic. As a result, the components and methodologies that promote this advancement procedure are being investigated for adoption in Bangladesh's IT industry's infrastructure backbone for future improvement. From a brief introduction, DevOps is one of the methodologies that is now being embraced in Bangladesh. The more current trends are introduced to academics, the more likely new technology will be adopted. This increased use of new technologies is expected to alter the IT industry's existing performance.

In Bangladesh's IT industry, DevOps is an emerging buzzword. Dedicated teams are forming in well-structured major corporations in particular. DevOps Engineer, DevOps enthusiast, Release coordinator, Cloud architect, and more responsibilities are being assigned to practitioners. Roles and duties are shifting in some ways to keep up with the production pipeline and team configurations. Most firms in Bangladesh continue to employ agile approaches and traditional development practices because DevOps is still relatively new [14]. However, some constraints such as insufficient infrastructure, project and resource constraints, high demand for skilled/experts in this domain, lack of understanding sophisticated DevOps concepts, and difficulties in automation-deployment-monitoring are some of the most significant challenges in Bangladesh's IT culture when adopting DevOps. By taking into account these roadblocks, software practitioners can determine the best paths to DevOps adoption by avoiding the issues that industrial researchers have assumed and surveyed.

Chapter 3

Methodology/ Proposed Approach

3.1 Mixed Method Empirical Study

The approach that we have chosen is mixed-method empirical research, in which we collected and analyzed data using both qualitative and quantitative methodologies [15]. In qualitative research, data obtained by the researcher from first-hand observation, interviews, questionnaires, focus groups, participant-observation, recordings made in natural settings, documents, case studies, and artifacts. The data are generally non numerical. So, it is mainly dependent on the observation of the researcher. On the other hand, Quantitative research is a research strategy that focuses on quantifying the collection and analysis of data. It is formed from a deductive approach where emphasis is placed on the testing of theory, shaped by empiricist and positivist philosophies. So, Quantitative research mainly focuses on quantifying the data and analyzing it.

As a result, we benefited from both qualitative and quantitative research which gave us a broad set of techniques and methods to conduct our surveys. Figure 3.1 shows how specific methods are taken based on different factors related to our paper. Then, We managed to differentiate the data collection methods. For qualitative research we conducted primary interviews (face to face) and for quantitative research we conducted research through questionnaires.

Analyzing the qualitative data and the quantitative data is very different. From figure 3.1 we see that, while we used thematic analysis (which is described in the latter section), purpose sampling and data formulation (for qualitative study), we cross-tabulate and used graphs-charts for quantitative research. Getting the theme from the participants' responses and analyzing the observations gave us a detailed overview of the result. But we needed to select in which form we have to represent our findings.

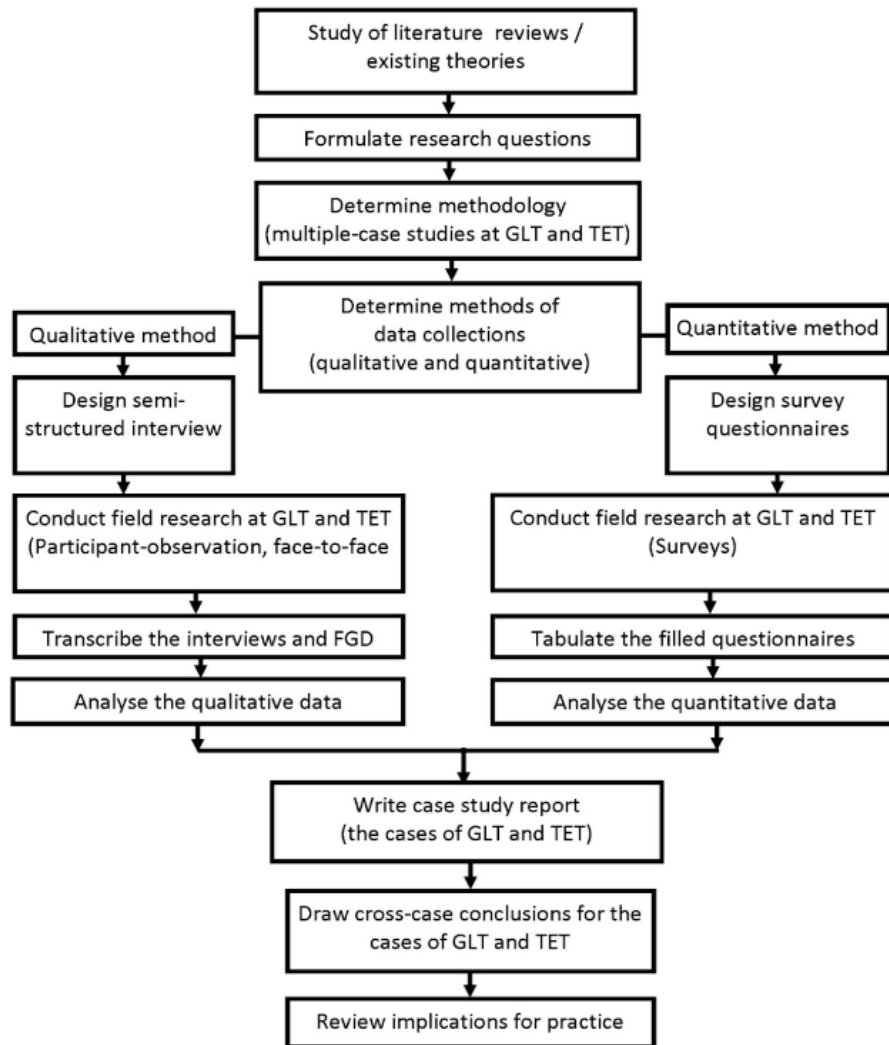


Figure 3.1: Mixed Method empirical study

Figure 3.2 shows the stages in mixed method research. The main objective is to evaluate the qualitative and quantitative data altogether. As both of the data collection and analysis procedures are quite different and diverse.

We had to manually identify the factors and the findings affecting the factors. Then after analyzing the data from both qualitative and quantitative research, we managed to merge the data depending on the segments in our question rationale. Figure 3.2 also indicates the how to select RQs based on emphasis and the challenge in both research methods that affect the research and both kinds of flaws which need to be managed must be taken care of. Like in qualitative research we need to take care of data sampling from observation which can be a huge pitfall for this kind of research. Also, in quantitative research, we need to take care of weak articulation, flawed data etc. to analyze the data collection perfectly.

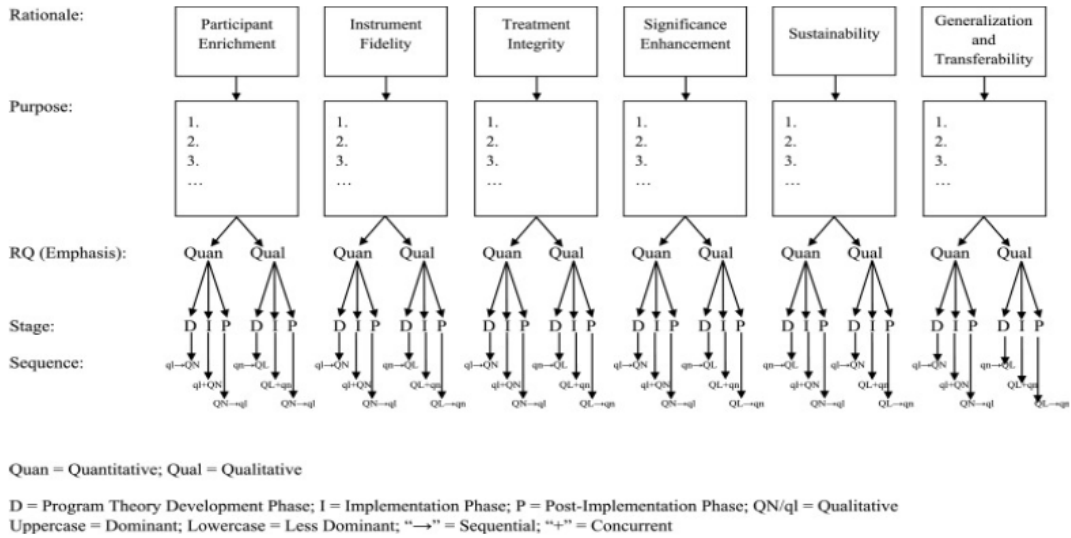


Figure 3.2: Stages of mixed method research

3.2 Data rationale

Analyzing the current situation and methods, we created our questionnaires for covering findings as much as we can for our research. Data rationale in tables 3.1 and 3.2 show why and for what purpose each question is selected respectively.

Table 3.1: Rationales for question(1)

Questions	Rationale
1. How long have you been working in your organization?	Quantitative question for organization state analysis. The participants should be working enough days, to at least be aware about the company DevOps culture.
2(a). Is there any dedicated DevOps team in your organization?	Helps to how DevOps is conducted .
2(b). (If no) Then How your organization do DevOps related works?	To check Which else models are popular.
3. Your Experience with DevOps	To figure out if the participants knows the basics of DevOps.
4. How do you describe yourself as a DevOps expert?	To measure the expertise level of the employees/survey participants
5. How do you define/refer to DevOps as?	Visualize the relative perspective of the participants, to see how they judge DevOps as an entity.
6. Total how many people works in your organization? (Approximate)	To measure company size/scale company according to usage
7. What is the type of your organization?	Just to get to know which kind of org normally focuses on which aspects
8. Which sectors your organization focuses mostly?	Key focus of the organization
9. What is the current Architecture of your company?	To know about how the company work process is done which will help to verify if it is effective or not
10. What Architecture do you prefer in your company?	Preferable architectural opinion

Table 3.2: Rationales for question(2)

Questions	Rationale
11. In your opinion, what is most important in the earliest stages of a DevOps initiative?	Based on opinion
12. Did your company adopt Continuous Delivery?	As continuous delivery is known to be an effective part of DevOps culture, knowing whether the company adopted it or not will provide with critical data.
13. (If Yes) How much do you think your responsibility has changed after your organization adopted Continuous Delivery practices?	Before and after adopting Continuous Delivery a developers role may change. this will give up the new scopes of a workplace which acknowledged DevOps.
14. On a scale of 1 to 5 what would you rate the collaboration between team members that has increased in your organization since the adoption of Continuous Development?	what is the perspective of developers about DevOps in their work and if they think DevOps is beneficial or not
15. How important do you think DevOps is for SDLC?	To gather the usage and statistics of different DevOps tools across the workplaces.
16. Which continuous delivery tools do you use?	As version control helps to get back to previous work which helps to track the work and process that's why it is needed to identify the process of it
17. Do you version control your software builds?	As version control helps to get back to previous work which helps to track the work and process that's why it is needed to identify the process of it
18. How frequently your team works on deployment?	Measuring the frequency of deployment process and plot it to devops practice
19. How Continuous Integration is conducted in your organization?	Measuring the way of CI conducting process and plot it to devops practice
20. In your opinion, how Test Automation impacts DevOps?	Based on opinion
21. How Test Automation is conducted in case of development life cycle?	Based on opinion
22. How Test Data is managed in your Organization?	Based on opinion
23. How Continuous Delivery is conducted?	Based on opinion
24. How Customer Feedback is conducted in your organization?	Customer feedback can call upon different new requirements. These can be queried from the perspectives of DevOps practices to distribute efforts.
25. What kinds of Customers your company deals with?	To categorize customer sector with DevOps usage
26. How Monitoring is conducted?	This can bring out certain flaws which can be later utilized by DevOps practices to get efficient results
27. Does your organization conduct System Health Checks?	To know whether system checks are performed or not
28. (If Yes) How System Health Checks is conducted?	Knowing about the process of health checks
29. How do you visualize work progress using collaborative tools? (eg. Kanban board, Jira etc.)	To know whether they perform any selective tools for enhancing productive communication & interactivity with intangible results
31. How is the Collaboration between inter teams?	helps to know the process integrity and how the work is done if it is collaborated or not
30. What is the learning culture in the Organization?	To learn about how the DevOps culture makes us quantify the impact.

3.3 Semi-structured Interview

After selecting our question rationale we conducted semi-structured interviews. While a structured interview has a rigorous set of questions which does not allow one to divert, a semi-structured interview is open, allowing new ideas to be brought up during the interview as a result of what the interviewee says. In a semi-structured interview, the interviewer usually has a framework of issues to examine. As interviewers, probes allowed us to ask respondents to explain, add to, clarify, or qualify their responses, addressing richness, depth of answer, comprehensiveness, and honesty, which are all hallmarks of good interviewing. When using semi-structured interviews, researchers must pay close attention to the replies of their participants in order to spot fresh avenues of inquiry. For this study, semi-structured interviews were used to examine and explain participant replies. This helped participants return to the interview's main topic. Probes for elaboration and clarity were crucial. As a result, it's the best tool for this research. For qualitative research, we employed these methodologies.

Phase 1 - We conducted the interview in 3 companies where 6 practitioners participated and interviews lasted for about more or less 30 minutes. As given in table 3.3, each company has more than 300 employees working currently. We used a purposive sampling method [16, 17]. When we were analyzing our study questions, we only wanted to talk to people who had worked for companies that were implementing DevOps/CD methods or who were participating in DevOps/CD-related projects [18]. After finding out our research objective, a meeting was held where a variety of professionals were present. For our focus groups Junior developer, Senior developer, team lead, manager, DevOps Engineer were predetermined. So, during the interviews we tried to address them specifically [15].

Table 3.3: Summary of interviewees

Companies	3
Number of employees for each company	>300
Team working strategy	co-location
Number of interviews(role)	3 (DevOps Engineer/Team Lead), 1 Junior developer

They gave us a full overview of the projects and their working procedure in their companies. Some follow up questions have been asked based on their responses and they also asked us about our suggestions about using DevOps and how they can develop and start this in their companies. From our current research and recent scenarios we provided them with some steps and tools which could be used for their primary execu-

tion of DevOps adoption.

To conduct successful qualitative research, we ensured the accuracy of our data. This is more difficult to do than with quantitative research. As we migrate qualitative data from the source to our published material, it's possible to lose essential information and significance. As a result, transcribing is an important tool for maintaining integrity and relaying information in an unbiased manner that is valuable to readers and provides context to the journal or research. Interviews, as we've seen, are critical for obtaining less quantified data from direct sources. They enable us to share relatable experiences and opinions, as well as directly cite key contributors. We were able to prevent exaggeration and keep the integrity of its content thanks to a large amount of qualitative data from interviewees.

Table 3.4: Interview Statistics

Organization	Business	Interview Setting	Interviewee Role
Banglalink	Telecommunication	On location meeting	DevOps Engineer
Transcom Ltd.	Consumer products, Electronics, Newspaper etc.	On location meeting	1. DevOps Team Lead 2. Junior Developer
Bangla Lamps	Electronics, Bulbs	On location meeting	DevOps Team Lead

We made sure that our participants are relevant to our study and not a single practitioner is irrelevant to research objectives which helped us get enough information about our results which were the main focus of our objectives.

Table 3.4 shows the statistics of face to face interviews. We contacted 3 companies for conducting interviews. To collect and save the data we used mobile recording during the interviews. In Parallel, we took notes and asked questions from the documents we created for the questionnaires. Then we organized the data after each interview session and made a summary to identify strong points for the findings. The next crucial step is Transcription. When done manually, this is a time-consuming and difficult operation that can take hours, days, or even months to complete. There are also plenty of problems to be aware of while manually transcribing, since it might be difficult to pick up words spoken in a thick accent or in a hushed tone.

As the meeting was on-site we could easily observe the answers and the thinking process of the participants which helped to avoid biases. Senior members from each company came to our interview session and they gave a variety of ideas and methods they used over the years. Then we used segmentation to verify the results and also used spreadsheets for data compilation. At last, we structured the objectives to write down the findings of each interview session and analyze the relationship between other factors obtained from different interviews.

Common Inclusion/Exclusion Criteria

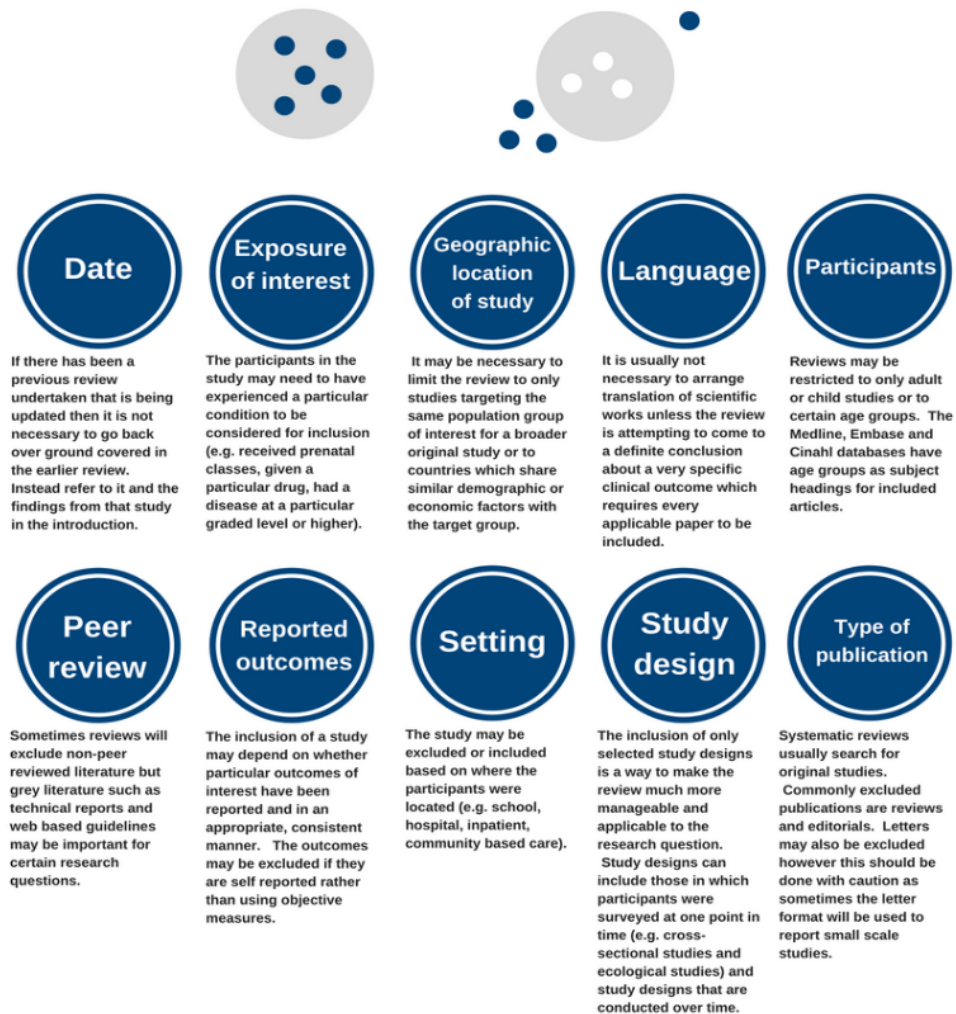


Figure 3.3: Data Inclusion and Exclusion criteria

Phase-2 : Figure 3.3 shows how the interview steps were followed. In this phase we focused on data inclusion and exclusion, we targeted the impacts and findings which were more important to our research[9]. So, as some of the interview follow-up questions were too open ended, we took the specific answers by classifying the sources with different attributes. During the interviews, we took notes and we also recorded using a voice recorder to make a session summary for each interview. We strictly maintained the privacy policy of each company and took verbal and written consent of every participant before conducting the interviews. After classifying the actual data which we needed for the research we finalized our data collection and passed them to the analysis steps for the interviews.

3.4 Survey

Phase-1 : To assess and quantify survey findings from qualitative results, we used Kitchenham and Pfleeger criteria for our Pilot survey [19]. We used surveys on six firms with a total of 20 practitioners to acquire secondary data. From December 2020 to January 2022, the survey was conducted. For which we designed questionnaires within that time frame and conducted online surveys to obtain data efficiently [15]. We began our questionnaires with demographic questions (name, role, email, etc.) and then divided them into sections such as general information, corporate architecture, continuous delivery, product & processing procedure, and management & monitoring. Table 3.5 shows how each questions satisfy individual research questions. These segments contain certain questions to answer in order to define the DevOps process and significant conclusions. There were 18 multiple choice questions, 8 checkboxes, and 4 textbook questions in our poll. Depending on the respondents' degree of experience, not all questions were required. We added several predicted answers according to the studied literature [5, 20–22] to the option after evaluating the DevOps field, which assisted them in selecting the correct answer. We also asked open-ended questions to get as many different responses as possible.

Table 3.5: Survey Questions structured

Question	RQ1	RQ2	RQ3	RQ4	Question	RQ1	RQ2	RQ3	RQ4
1				✓	16		✓	✓	
2(a)		✓		✓	17		✓		
2(b)			✓	✓	18			✓	✓
3	✓				19		✓	✓	
4	✓				20			✓	
5	✓				21	✓	✓	✓	
6				✓	22		✓		
7				✓	23		✓	✓	
8			✓		24			✓	
9		✓			25				✓
10		✓			26		✓	✓	
11	✓	✓	✓		27		✓		
12			✓		28			✓	
13		✓	✓		29		✓	✓	
14		✓	✓		30	✓	✓		
15	✓	✓			31				✓

Phase-2 : Following the completion of our questionnaires, we contacted various orga-

nizations across the country who have been wanting to use DevOps in their projects. We sent our questionnaires through email after contacting high-ranking authorities. We made sure that all of the attendees had at least some DevOps experience and understanding. Because the survey was more technical in nature, we double-checked the responses depending on the participant's degree of competence to ensure that the data was accurate. Up until the responses were available they were double checked to verify the authenticity.

3.5 Data Analysis

We used two methods to examine the survey data. We applied descriptive statistics to analyze the responses gathered on the Likert scale and closed-ended questions [23]. For the open-ended questions, where the results were in qualitative data, We used a process called conceived thematic analysis [18, 24]. Individual responses of participants, Researcher presence during the interviews and understanding the point view of each practitioner are strictly analyzed to avoid the biases [24].

In our case the Quantitative datas were statistically evaluated, either individually or filtered among two or more questions. Datas were translated on by ordinal and nominal scales [25] due option changes between the survey. They were put into Likert values later on and given a result according to it. Further the relevant questions that could be grouped were analyzed together to create a mixed result. The qualitative questions were made into themes and done a thematic analysis [17, 18, 26]. Open-ended questions and fully descriptive questions were manually formalized into necessary wanted information.

3.5.1 Thematic Analysis

For the open ended descriptive questions, we apply thematic analysis. It is a flexible and recursive method to qualitative data that can reveal important insights into people's ideas, perspectives, and lived experiences [15]. Within qualitative data, it focuses on detecting, evaluating, and interpreting patterns of meaning (or "themes"). Most other qualitative analytic approaches, such as grounded theory, discourse analysis, narrative analysis, and interpretative phenomenological analysis, can be described as methodologies or theoretically informed frameworks for research. Thematic analysis is often thought of as a method or technique, in contrast to the majority of other qualitative analytic approaches, which can be described as methodologies or theoretically informed frameworks for research.

First, we familiarize ourselves with the data in order to execute thematic analysis. We transcribed our data ourselves if it was in the form of audio files. We write down thoughts and memoranda on potential codes to build after going through the transcripts and actively examining meanings and patterns that occur across our data set. As a result, to keep track of the codes, we established a codebook [18]. We go over our data again and again, looking for noteworthy extracts and assigning them the relevant codes. After that, we group together all the excerpts associated with a particular code. Sorting the codes into prospective themes now that we have a set of beginning codes.

The main objective is to evaluate and improve our topics as we had our initial collection. Ascertain that each theme is distinct and has sufficient facts to support it. We considered combining comparable themes and deleting topics that don't have enough data to support them and checked how our concepts may be combined into a story. The last stage in telling the story of our data is writing the narrative. We have thoroughly considered our themes, and then it is the opportunity to inform our audience on the veracity of our research. We made sure that our narrative offers a cohesive tale about our data, and uses vivid data quotes to support our claims. Our story should go beyond just providing our statistics; it should also contain our own interpretative analysis and a defense of the statements we make. We ensured whether a topic had enough evidence to support it or not.

3.5.2 Cross Tabulation Method

Cross tabulation reports show the association between two or more survey items when examining survey answer data. A thorough comparison of how different groups of respondents responded to certain questions is supplied to survey administrators. It helped us analyze the data at a granular level [15]. Typically, survey findings are provided as aggregate data tables that display the total replies to all of the survey's questions. Cross tabulations are data tables that show not only the overall results of a set of respondents, but also the results of subgroups that have been defined. We were dealing with data sets that were both overwhelming and perplexing. It can be difficult to extract information from them in order to make business judgments. Cross tabulation decreases the chances of making mistakes while interpreting the data, resulting in more efficient use of time.

From the excel sheet and data table, we analyzed factors based on the results and objectives we want to focus on. Like we saw the collaboration between teams regarding the fact that if they are in small groups, different individual groups, same role or not etc. We had 5 major segments in our survey and we first identified some factors which

are related to each other and we want to create a relationship between them. After that, for each segment we merged some questions based on factors we want to work on. We generated results from it and calculated the difference from the actual and expected output, which we hypothesized in the early stages.

We quantified the results from our survey and then used them as variables to label them as different factors. The variables used in the cross tabulation made us describe the relationships between them. We created charts and graphs separately after analyzing each result gathered from this method.

3.6 Formalizing Finding

In the findings section, each topic is discussed in depth, with emphasis on the frequency and existence of the themes in the data, as well as what they signify, and examples from the data provided as supporting evidence. Then we highlighted the major points and discussed how the analysis addresses the research question. Each subject is generally addressed in turn in the results or findings section [27]. We explain how frequently the themes appear and what they represent, using data samples as proof. Finally, our conclusion summarizes the important points and demonstrates how the study addressed our research topic. It must, however, be used with caution in order to avoid allowing subjectivity to taint or distort the results. Researchers' observations can create biases to interpret the understandings of the responses so, thematic analysis not only focused on the replies of the participants but also their perspective and thoughts during the interviews.

Chapter 4

Analysis of of the dataset & Result

4.1 Overview

According to the proposed approach in chapter 3 a cross tabulation technique has been applied to the resulting data set. By this we mean, holding one field's value we check out one or more different fields and their frequency range. Those ranges afterwards were compared to each other to find patterns or deviation. These patterns were thoroughly analyzed and explained. For the techniques of preferability a few questions which support the format have been translated and calculated in the Likert scale. They have been considered with a marginal variance in mind, resulting in a plausible verdict. The rest of the data has been secured from frequency based pie charts with and without multiple selection. Thereby, we can give a proper estimation of the responses and their weights. And the impact factors of each aspect could be identified and put into perspective.

4.2 DevOps Usage and Definitive factors

We discovered which people identify DevOps as what by looking at practitioners and the roles they play in their firms. We can observe that developers generally use these three terms to describe it: **Process, Strategy, and Movement**. It is referred to as: **Process & Methodology** by DevOps Engineers. While this is a very subjective reasoning, This cannot be explained why practitioners conceptualized it as any one of them. The survey's participants are all private businesses that employ version control. About 54% of respondents have a dedicated DevOps team, and 73% have chosen continuous delivery. It is noteworthy that almost all the dedicated DevOps teams have adopted Continuous delivery. Around 73 percent of bigger organizations utilize the data they get from monitoring to drive their business goals. However, if a firm has a dedicated DevOps staff, this percentage jumps to 100%.

4.2.1 Priority factorization

We can see how crucial DevOps is to the entire SDLC process from question fifteen. The significance is then converted into numbers. From 1 to 5, the importance scale goes from unimportant to highly important. We estimated them as Likert values from their mean averages as a result of this method. During the course of the survey, this computation was discussed several times. And has been discovered to be as high as 4.62 and as low as 4.41. And the Likert scale score at the conclusion of 26 replies is 4.46 out of 5. As a result, we may conclude that the value stays close to 4.5 with a tiny variance of 0.4. As a result, it might be regarded highly crucial for any SDLC for a big portion of the consumers. According to the 26 replies to the Likert Scale in question 14, the Likert value of the team cooperation enhancement with CI/CD was around 3.65. Even so the variance has been approximately 1.15 which means the enhancements are not consistent across the perspectives of practitioners.

Question 20 has a different approach, with one of the alternatives having a negative effect factor. However, none of the practitioners double-checked it. As a consequence, we may disregard it and focus solely on the positive aspects.

The translations were carried out in the following manner:

0 = Has no impacts

1 = Somewhat impacts positively

2 = Improves Performance

Positively the calculated impact was $F(26) = 1.65$ and can be labeled near “Improves performance”

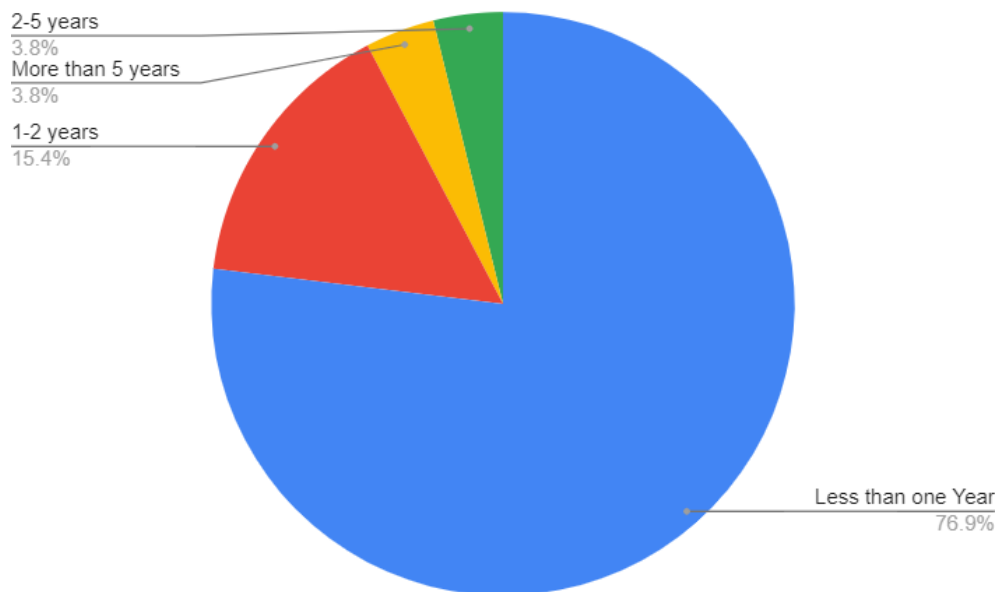


Figure 4.1: Practitioners experience with DevOps

4.2.2 Participants Level of Experience

We may get a quick overview of the practitioners' experiences by looking at questions 1 and 3. On a global scale, 66 percent of persons have some industrial experience, having worked for a few years. However, we can see from figure 4.1 that 77% of them have little or no DevOps experience. Filtering out the inexperienced professionals in cross tabulation, we see that 64.7% of those experienced industry professionals have been working with DevOps for less than a year, and 23.5% have been working with it for one to two years. The rest of them have a good understanding of DevOps.

It is common among DevOps practitioners with several years of expertise that their teams either work individually or wish to work separately. Another certain finding of cross tabulations is that, the members who opinionated that automated tests are a little bit of importance, are seen to have test phases separated from their development phase. We can say that a different testing team is available for those companies.

4.2.3 Hypothesis

The question number 11 has a unique formation providing the order of importance among the aspects of DevOps. These aspect were given in the survey question as options. And the respondents could order them according to their importance. According to our literary studies we thought of a hypothesis of the order. Iterative process identification being rank #1, Communication architecture being rank #2 and Tools and techniques being rank #3. The results turned out to be

Communication architecture - 7 votes

Usage of tools and techniques - 6 votes

Iterative process identification - 13 votes

This has indeed aligned with our null hypothesis.

Finally, 33% of organizations undertake a situational health check after the system health check, based on customer feedback. The majority of people take precautions by using third-party network operations (20%) or assessing rate of change (40 percent).

4.3 Thematic analysis

We've included a few qualitative questions in our semi-structured survey methodologies as previously mentioned. Our Fully Qualitative questions are 2(b) and 19. The Quantitative questions are 5, 8, 16, 21, 23, 25 and have a customized option to answer on their own.

The second question, as per answers previously, approximately 53.8% people do not have dedicated teams for DevOps. The later question was to reiterate which alter-

nate people are responsible for the works related to DevOps. This was ultimately not answered by 28.6% of those practitioners. Figure 4.2 shows that rather than personalized trained professionals, developers are heavily involved in DevOps efforts.

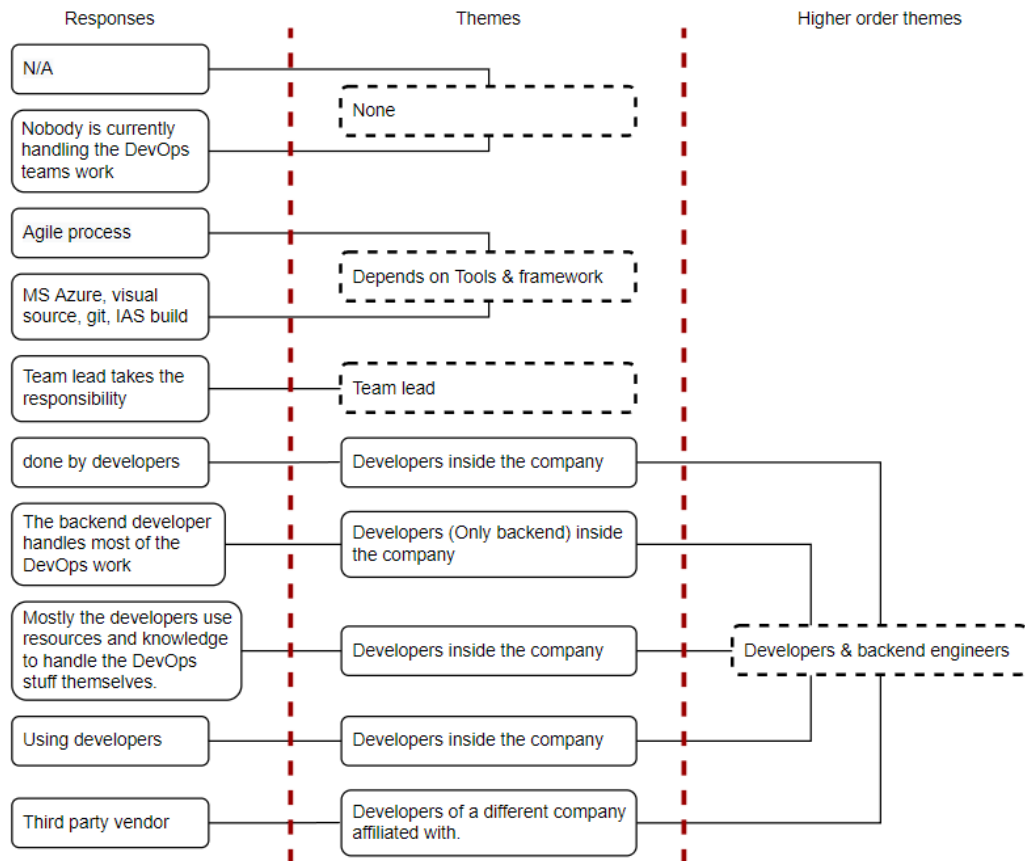


Figure 4.2: Alternates for DevOps teams

The following qualitative question is question 19. There it is asked, how Continuous Integration is carried out at their company. We can observe from the figure 4.3 that just a few people really run automated tests. After a successful automated test, the integration command in the build module is triggered. Aside from that, four answers to the use of tools and frameworks have been recorded. In this case, an IAAS stage and queue technique is significant.

Now, coming to the open ended questions, in survey question 5 the terminologies by which DevOps could be defined were asked, but everyone seemed to be answering between the given options. So, It's accepted as an inclusive answer. Later on it was necessary to gather the companies working sectors. To figure out which of the product types that are in high necessity of a CI/CD cycle. Some new sectors could be recognized except our given options.

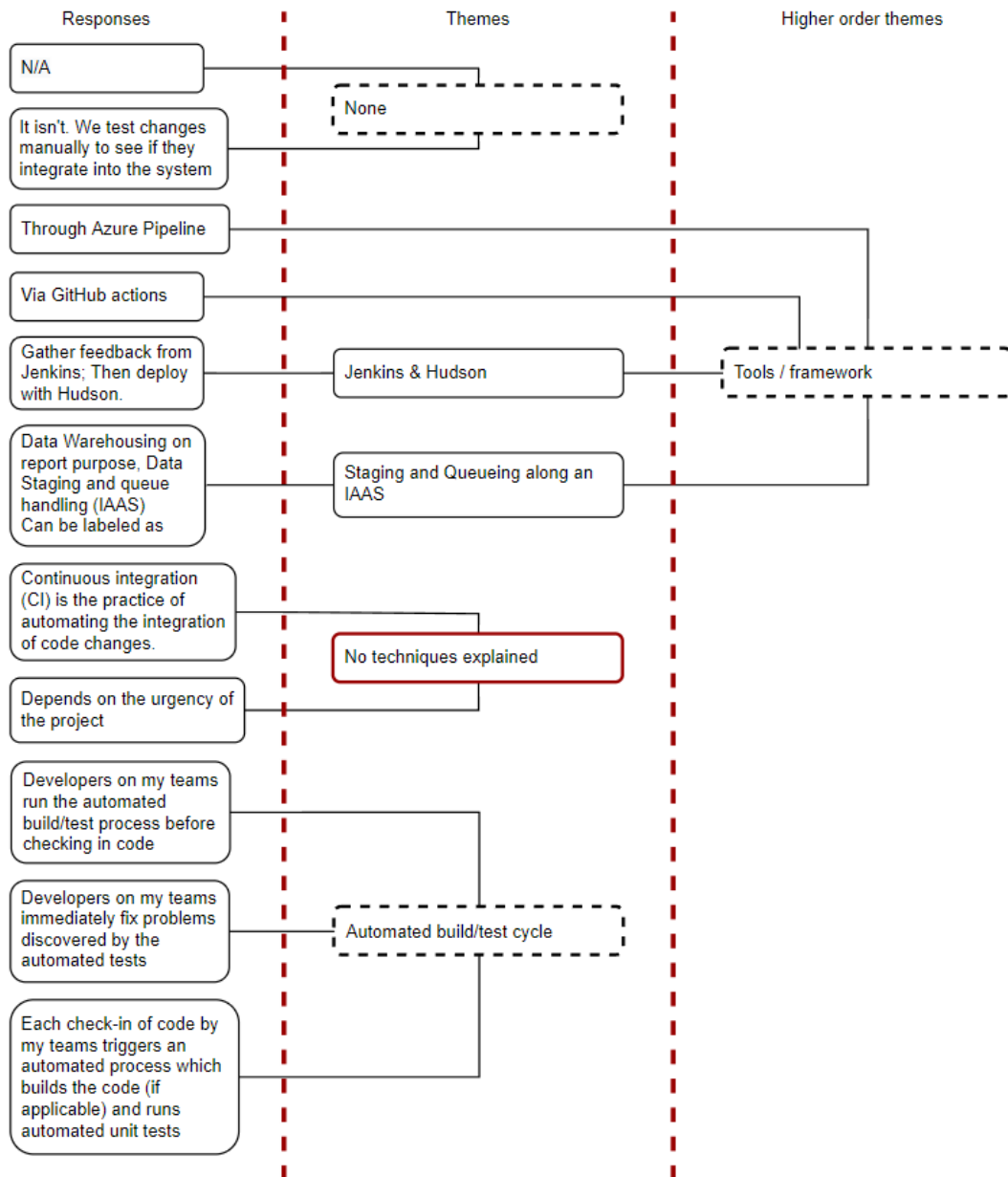


Figure 4.3: Thematic Analysis on Continuous Integration methods

These new sectors being,

- a) ERP b) Agriculture c) Project Management consultancy

Aside from that, we got a few unclear results that do not quite fall into certain sectors. like, Web Application Development & cloud. The tools however were quite an important equipment, and preference across the practitioners were vital. Here we learn about a few new tools like,

- a) Tekton
- b) GitOps

- c) Vegacloud
- d) Hudson

Automated testing and how it is conducted was formulated as an open ended question. We find out that 11.5 percent of the companies are not in use of automated testing techniques which can be seen from the figure 4.4. Only one open ended response “On every CI pipeline trigger” can be accepted as a valid technique. Other responses are recorded inclusively in between the given options. The new responses we get are shown in figure 4.4.

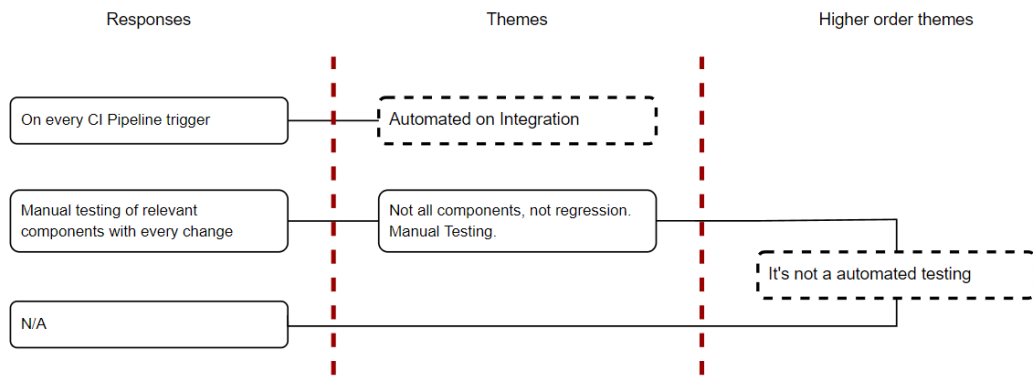


Figure 4.4: Thematic Analysis on automated testing methods

The 23rd survey question asks about how continuous delivery is conducted. Two of the instances were found to have an outside answer, both of them having the answer as not doing any kind of continuous delivery.

- a) We have not adopted CD yet
- b) N/A

However, they did not make it clear which sort of delivery; more importantly which frequency they maintain to deliver their product. Then regarding which kind of customer’s demand they focus on (Survey Question 25) one qualitative answer was found. Which assures that customers demand do indeed change in between development process. Shown in figure 4.5.

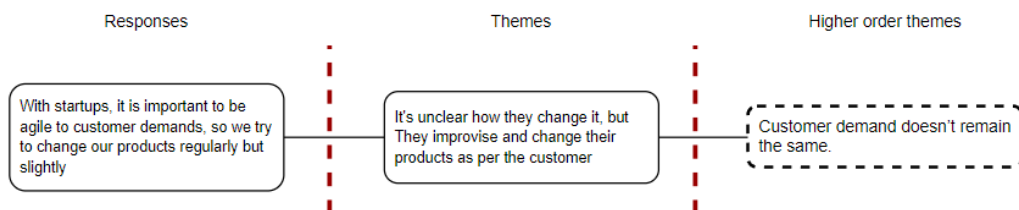


Figure 4.5: Customer Demands

Chapter 5

Findings

After the in depth statistical analysis of the response dataset we now comment and discuss about the things we found noteworthy of attention. Here we have presented them in terms of the Research Questions we have set in the beginning of our research [26]. But firstly let's start with the practitioners and their attributes.

5.1 DevOps personnel in Bangladesh

The private companies which we have approached and could find a relevant level of working culture around the flow of DevOps were mildly underwhelming. Even the larger IT companies spanning from 200 to 300 people there are rarely a DevOps team. Solitary non-team work that a company relies on to just a single employee is a massive threat to the future operations of an industry. Most of the companies are a bit unaware of which process of continuous development to trigger next resulting in a quite unplanned way of adopting a DevOps culture in a company. The next thing that could be mentioned about the practitioners is that the responsibilities they are in, enveloped around any processes of DevOps, are not what they are recognized for. We can put in this way that mostly Developers and Testers are working the tools and processes to formulate the Continuous flow. This has been clear by the roles they have mentioned they are in their company if not, the roles they acknowledged that does their CI/CD. Looking at this predominantly new market and industry towards DevOps its safe to say that it is a very early surge of shifting and adopting to DevOps.

5.2 Professionals Describing DevOps (RQ1)

As a very controversial topic of this time there are bound to be a few mismatches when it comes to the definition that the general mass of practitioners have.[15] However according to the analysis we can say that Strategy and process has been the most acknowledged keywords to refer to DevOps as. Regarding the highly important topics

Table 5.1: Hypothesis on the importance order of DevOps aspects

HYPOTHESIS: The most important to carry out any existing or new work in a DevOps environment is to Define the processes, workflows and feedback loops. The next thing would be the Communication architecture of the teams, and finally to learn and work through the tools, frameworks and their techniques.

that are affiliated with DevOps we have had an hypothesis of our own which was supposedly to be followed in the IT companies and their employees. And by analysis we can come to a conclusion that it is indeed what the respondents are following in their DevOps culture.

5.3 DevOps approaches (RQ2)

The workflow that each and every team has mentioned are mostly related to the guidelines of the SDLC. This puts us in the Idea that the approach is to define processes from the beginning of the development process[5]. Although the preferences of the collaboration in the functional team remain something to debate, most of them value the community collaboration of a function. We can say that the period of learning new approaches and implementing them is a well-known thing in the public eye. Within it one or more continuous methods (ie. CI, CT or CD) is adopted and researched upon to authenticate its viability [27]. Respondents were keen to learn about the technologies they may use to align their current DevOps process during our survey discussions. Monitoring and health checks are highly rated among the companies having precautionary methods for issues.

5.4 Individual Implemented processes (RQ3)

It has been very clear that not much of the DevOps team has encapsulated the full DevOps workflow culture in their projects. And sure enough they have come with the processes that they find their company can appreciate.

In figure 5.1 we can see that whichever companies have accepted continuous development and how their working cultures change. A significant level of collaboration while a moderate change in workplace responsibility can be reported. For which the personnel's seems to be eager in a full DevOps pipeline. Following are the current info on how the companies are inhabited with the processes.

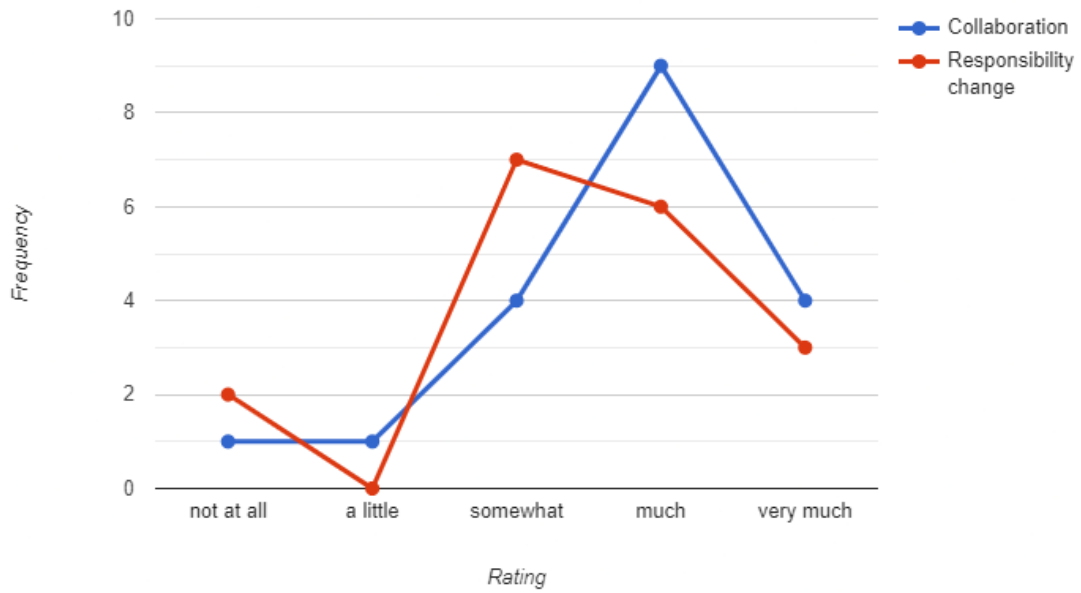


Figure 5.1: Collaboration and responsibility change line chart

On the table 5.2 we see each individual processes and the affirmation percentage indicates the percentage of companies that has adopted it. It should be noted that businesses have employed one or more procedures. So, the affirmation value is inclusive for multiple companies.

Table 5.2: Individual Processes & their usage

Processes	Affirmation	Description
Continuous Development	85-94%	Most of the practitioners agree to be in a continuous development environment. This umbrella term could be followed by the next few processes.
Continuous Integration	72.8%	A variety of methodologies have been clarified, with the majority of them indicating the presence of an existing CI system. However, a few of them were unclear, thus it can only be inferred that they integrated their systems using a tool or an automated Build/test cycle.

Automated Testing	50%	We can see from the data that testing automation is not something that every organization has implemented. With a few exceptions, the ratio is about 1:1. Following the Integrations is a common test phase automation behavior. Now, from 5.2 we have had the knowledge that Developers are involved mostly in continuous workflow. As a result, having a separate testing team has kept the people in this company unaware of the usefulness of automated testing.
Continuous Deployment	73.1%	Practitioners report a rising necessity for re-iteration of subsequent deployments before each delivery stage. As a result, a large number of teams have been evaluating continuous deployment and even claim to have boosted team efficiency (Likert value: 3.65)
Monitoring/ Operations	96.2%	Monitoring is a highly done process. Nonetheless, about 56% of the companies actually evaluate their monitoring findings to review their processes.

5.5 Company Culture(RQ4)

As previously stated, DevOps procedures are frequently managed by individual developers. As a result, many businesses lack a specialized DevOps crew. If we dig a little deeper, we can observe that the rates of collaboration have been quite high. And, because all of the businesses are private, the delivery of products to clients is mostly based on demand. 65.4% of the companies have been seen to even take regular customer feedback, while 19% at least share feedback report to the team. Customers modify their requirements, which is accepted by the majority of businesses that improvise to meet those changes.

Chapter 6

Threats to validity

Internal : Internal validity is challenged by participant prejudice and inaccuracies. The first internal validity danger is the risk of survey participant selection bias. Our research concentrated on industry projects, the majority of which are proprietary. As a result, we chose the participants based on their experience and background. At the very beginning of the study procedure, we established our criteria for choosing participants. We did this by looking at each participant's public profiles and professional history. To eliminate biases, we made sure that the participants had a variety of positions (eg. DevOps Engineer, Project Lead, Developers etc.). Before beginning the interview, the questions were addressed to assist them understand and develop appropriate answers [18].

The presence of researchers throughout the interview process might influence and prejudice responses [24]. Participants may have misread the questions since they were asked from the researcher's perspective. As a result, we asked follow-up questions and explained each topic in depth to ensure that participants understood the scenario and provided accurate answers.

External validity: All of the organizations we contacted and surveyed were private. Though our goal was to interview both private and public firms, we discovered that relatively few public companies use DevOps and also there were some limitations and regulations in place to do interviews with government entities. The range of roles played by participants in presenting DevOps viewpoints from multiple perspectives, however, has contradicted the generalizability of our findings.

Construct: Another limitation of our study might be the appropriateness and applicability of the questions asked in interviews and questionnaires, which were generally closed-ended. As a result, the replies' richness may be impacted. Closed-ended questions, on the other hand, seemed to have more advantages than disadvantages: they are

dynamic and responsive. Thus, during conducting pilot interviews we improved our questions by taking feedback from the participants. As a result, we were able to conduct interviews with conversations with the respondents and obtain rich and in-depth feedback using semi-structured interviews.

We used two different data collection methods [15] which enabled us to derive the research findings and reduce biases. The survey questionnaires which we developed and improved by constant feedback from the interviewees, helped us to avoid negative impact and alleviate the subjective points of view of the practitioners. As one of the limitations of qualitative study is that, results and findings are dependent on researchers point of view and on how they interpret the data. So, after one author analyzed the data, we separately analyzed each response to avoid the ambiguity.

Reliability: To guarantee consistency, we employed an interview process and kept a database for the groups we interviewed [28]. The most important and primary step was to follow the interview protocol (eg. privacy questions, data collection methods, preparing the meetings, taking consent etc.). We strictly abide by all the protocols throughout the research. On the other hand, from audio recording, interview documents, coding structure, notes to statistics we maintained a database from the beginning. Due to confidentiality, The database is privately secured and not available to the public.

Chapter 7

Discussion & Conclusion

This paper covered a plethora of IT companies to collect a knowledge base. After a thorough understanding of the DevOps architecture from our background studies, the segmented questions and their responses were analyzed according to stratified random sampling. We've demonstrated the meaning of the term DevOps, how it's applied by practitioners, and how it's accepted topologically. It is shown that in this region mostly Developers are responsible for handling DevOps pipeline. And that a designated DevOps team can manifest a better vision on this path. A pretty much high usability on each individual process and an eager demographic makes the IT companies of Bangladesh a very good candidate for following DevOps architecture.

In two ways, this work contributes to DevOps research. First, it summarizes what has been written in scholarly literature about DevOps. This research can be used by researchers to acquire a broad overview of the academic literature and to locate literature to investigate further. Secondly, the report outlines the findings of our interviews with nine IT organizations about their DevOps practices. This can be used as a starting point for researchers looking into DevOps in practice. Organizations can compare their DevOps techniques to the methodologies of the nine companies we spoke with. We defined DevOps as the interplay of development and operations at the individual, team, and departmental levels. We've compiled a collection of top-level codes derived from research and interviews that enterprises can use to assess their own DevOps adoption. This study exhibits a scope based on a limited examination of industry practices. As a result, there is still room for improvement in terms of the obtained industrial data in order to increase statistical viability. A global comparison of this maneuvered data can reveal significant development for Bangladesh's IT industry.

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