Challenges in Implementing Continuous Delivery Process

A Systematic Literature Review

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Abstract— **Even though several successful attempts were made in implementing continuous delivery(CD), there were few cases that faced many challenges in implementing it. This made the topic interesting and motivated us to choose for conducting this SLR. This paper focuses on the challenges faced by the enterprises and the enhancements required to coordinate and manage customer involvement in continuous delivery. This SLR was done by identifying 7 research papers after applying the inclusion and exclusion studies. We count on that the presented literature will address the challenges faced in CD.**

Keywords— Continuous Delivery, Software Development, Challenges, Customer Involvement, Challenges.

I. INTRODUCTION

A. Context

Continuous Delivery is an agile software development methodology which creates software that are available for release at any time of the development, ensuring us with reasonable outcomes. This method requires support from strong engineering discipline i.e. system must be finely tuned and comprehensively governed by automation, with proper monitoring and testing[1]. With the help of CD valuable software can be developed in short cycles. Even though CD is gaining attention in software industry, there is no common overview regarding the topic where customers are playing vital role in its development[2]. CD helps an organization for efficiently and quickly improving its service and staying a step ahead of the competition which are the stepping stones of success for any existing or upcoming organizations[3].

B. Background

CD is becoming popular among many enterprises where they have started adopting CD but industries that still have not adopted the practice at large and those who have started implementing CD found it challenging [4]. This has led to a dilemma whether a better strategy is to roll out or existing methodologies are sufficient when put into use.

C. Objectives

This research paper is based on Continuous Delivery which emphasizes on the challenges faced in adopting CD and ensuring reliability in CD. Another objective of this paper is the effect customer involvement has on CD.

D. Methods

Firstly, problem domain was identified and then a search string was formed based on the domain. In the beginning, SLR's which are in the given problem domain were analyzed. This was done as analysis of SLRs under current domain will give apt ideas for a Research paper. Three SLRs were found in our search where two of them followed the Kitchenham's guidelines. So, we ensured that we followed Kitchenham's guidelines. Then other articles, research papers and conference papers were searched.

E. Results

With this research, we would like to gain knowledge on the problems in adopting CD and propose some notable enhancements to the coordination and management of customer involvement in CD.

F. Conclusions

While adopting new or different strategies, there will be initial hiccups in implementing it, so by overcoming these problems, adoption of CD can be a successful one. This methodology will contribute in clinching the gap between the user and the developer.

This SLR was planned as follows, where next section of this SLR consists of review questions. Then it is followed by the Review Methodology, with the help of the subsections in review methodology, following sections Included and Excluded studies and Results could be described. Next section consists of the Limitations and followed by the Conclusions which were drafted from the results and the last section consists of References.

II. REVIEW QUESTIONS

RQ1) What are the challenges faced in implementing Continuous Delivery(CD) process?

RQ1 is framed to obtain the state of art of the present challenges faced in implementing CD. Addressing these challenges may help the practitioners to adopt continuous delivery process effectively.

RQ2) What enhancements can be made to coordinate and manage customer involvement in CD?

The main motivation of RQ2 is that while addressing the challenges in RQ1 for adopting continuous delivery, we identified customer involvement as one of the key challenge. Finding enhancements for managing the customers can significantly improve the continuous delivery process.

III. REVIEW METHODOLOGY

A. Pilot Study

For the preliminary analysis of our research a pilot study was designed to plan the research protocol as illustrated in figure 1. This figure depicts the various steps which were followed while conducting the research. A systematic literature review was conducted following the guidelines of Kitchenham [5]. This study was conducted with an
objective of gathering all the evidence related to our research questions. Initially, a literature review was conducted which led us to the problem area, from which research question 1(RQ1) was formulated for addressing the challenges in CD. Many papers were examined where the main discussing was regarding the adoption problems but we could find a SLR which helped us formulating research question 2(RQ2).

B. Search Strategy

A well formulated Keyword driven search approach was used to identify references. Selection of right choices of database from the databases available is considered to play vital role, where databases like Scopus, IEEE, Inspec, ACM etc. are claimed to be the largest database of abstract and citations[5]. We selected Scopus as database to aid the search strategy as it is a valid source for finding information about present and ongoing research in computer science and related areas. Moreover, this database is updated and facilitates filters to narrow the search. Figure-1 consists a flowchart that describes the steps followed in conducting SLR.
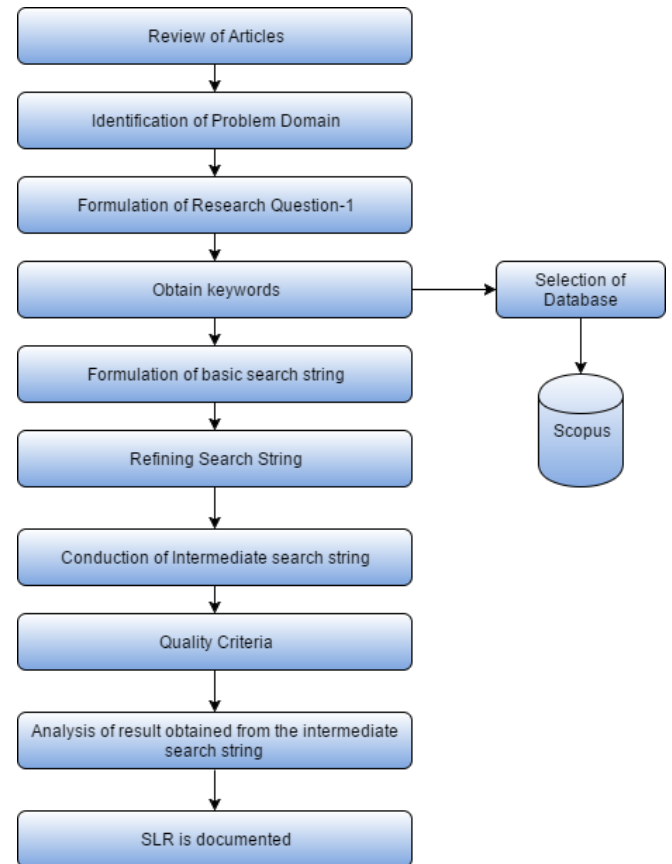

Fig 1: Steps for conducting SLR

C. Refining Research Questions and Search Strings

After conducting a preliminary study on 'Continuous Delivery', we identified the importance of this software engineering approach and the various challenges associated with its implementation. There were few primary studies that motivated us to gather evidence based on the challenges or issues associated with continuous delivery faced by the software practitioners. Additional reading led us to recognize the importance of coordinating and managing customer involvement in CD, which is also one of the key challenges identified. This enabled the refinement of our research questions.

A document search was initiated in the scopus database using the field "Article title, Abstract, Keywords". The initial search string of "Continuous Delivery" where the subject area was limited to computer science retrieved 1,411 results. Further the search string was modified to (TITLE-ABS-KEY (continuous AND delivery) AND TITLE-ABS-KEY(software AND engineering)) AND (LIMIT-TO (SUBJAREA , "COMP")), which resulted in 122 hits. 2 papers were selected from the list. The final search string that was formulated depending on the research question is as shown below:

(TITLE-ABS-KEY (continuous AND delivery) AND TITLE-ABS-KEY (software AND

engineering) AND TITLE-ABS-KEY (challenge))

Additionally, on limiting the subject area to computer science 31 results were retrieved. We identified 5 papers pertinent to our research after reading full text, in addition to 2 papers selected initially. Thus, a total of 7 papers are reliable to answer our research questions.

D. Include and Exclude Criteria

The final list of 7 references are obtained after applying the following inclusion and exclusion criteria.

Inclusion criteria

1. Research articles written in English.
2. Research articles whose source type is Conference Proceedings and Journals.
3. Research articles available in full-text.
4. Research articles published between 2010-2017, as before 2010 Continuous Delivery approach was not introduced.
5. Research articles related to the research questions.
6. Research articles with existing cases of CD implementation.

Exclusion criteria

1. Research articles that talk about agile practices and release engineering.
2. Research articles that focus on continuous integration and not on continuous delivery.

3. Research articles that are copies of same problem domain.
4. Research articles which weren't discussing anything new other than the existing definitions.
5. Research articles that are not available to access.
6. After a detailed study of the titles and abstracts, articles not relevant to the research are excluded.

E. Quality Criteria

The following questions (quality checklists) were framed to assess the quality of the primary studies as per the guidelines of Kitchenham[5]. For this purpose, four stages of empirical study namely: design, conduct, analysis, conclusion are considered where the problems of bias and validity can occur.

QC1: Was the study related to the research questions?

QC2: Are the data collection methods adequately described?

QC3: Were the basic data adequately described?

QC4: Do the conclusions reflect the results of the study?

The quality assessment criteria of the selected studies can be represented by table-2 where the quality questions are answered on a scale of YES or NO. Since article 1 and 3 answer at least RQ1, we have selected them though they do not satisfy quality criteria

Quality checklists	Article[1]	Article[3]	Article[6]	Article[4]	Article[7]	Article[2]	Article[8]
QC1	YES	YES	YES	YES	YES	YES	YES
QC2	NO	YES	YES	YES	YES	YES	YES
QC3	YES	NO	YES	YES	YES	YES	YES
QC4	NO	YES	YES	YES	YES	YES	YES

Table 1: Quality Criteria

F. Data Extraction

This process is used to address the problem areas which were identified through the initial findings of our research. For addressing these questions, Data extraction forms were framed to extract data from the list of selected articles. Furthermore, questions related to the problem domain and problem areas were included in the data extraction form created, which will lead to the information required to address the review questions.

Data Extraction Questions	DE1): What are the objectives of the study?	DE2): What research method is used in the study?	DE3): What continuous delivery challenges are addressed in the study?	DE4:) What solutions are proposed to overcome the challenges?	DE5:) What are the keywords used in the study?
Article[1]	Motivating software practitioners to deploy frequently	Case study	Challenges with build systems, automated test	Clear and transparent communication, automating	Not specified

	by sharing industrial experiences of CD.		suites, customer enablement, internal communication	deployment process, fast and reliable tests	
Article[3]	Motivating researchers and practitioners to adopt CD	Case study	Organizational, technical and process challenges.	Restructuring the organization, defining active API, building active plug-in ecosystem.	Continuous delivery, continuous delivery pipeline, software process
Article[6]	Implementing continuous delivery in the context of architecture	Case study	Challenges in terms of ASRs (Architecturally Significant Requirements), increased cost	Use of comprehensive ASRs list and customized templates to help architects.	Software architecture, continuous delivery, continuous integration.
Article[4]	To survey the problems faced while adopting CD and solutions to it.	Systematic Literature Review	Build and system design challenges, Integration and testing challenges, release, human and organizational	System modularization, test parallelization, separate release processes, top management strategy.	Continuous integration, continuous deployment, continuous delivery
Article[7]	To analyze challenges and benefits of continuous delivery in B2B domain	Case study	Technical, Procedural and customer challenges	Not elicited.	Continuous delivery, development process, B2B domain, case study
Article[2]	Exploring the state of art of customer involvement in continuous delivery.	Systematic Literature Review	Customer behavior, data management, communication, transparency, customer profile challenges	Proper requirements elicitation, good communication and relationship with customers.	Customer involvement, customer feedback, continuous delivery
Article[8]	Overcoming challenges of continuous delivery using concepts of Application Lifecycle Management.	experimentation	Collaboration, automation and process oriented challenges.	Integrated management, process standardization, usage of tools	Continuous delivery, process quality, application lifecycle management.

Table 2: Data Extraction Form

G. Assessment and Training

Assessment of the primary studies is done based on the filters the database facilitated like field, publishing year, subject area, author name, document type and language. Training is necessary to check the relevance of the primary studies to the objective of research and intended results that are presented. In the research papers, we focused on their observations and implementation problems rather considering their perspective.

H. Validation of protocol

Validating the research protocol is very critical in any systematic review. We used peer-review method to evaluate the protocol. We individually conducted the protocol and repeated it for several times. On

comparing the results, we identified same search results. Thus, the extracted references suggest that the search was adequate.

Additionally, the internal consistencies of the protocol are checked by confirming to the appropriateness to which the search string was derived and data extracted answer the research questions[5].

IV. INCLUDED AND EXCLUDED STUDIES

After developing the initial search string, 122 results were acquired for which we applied many filters like articles written in English were chosen, articles of source type conference papers and journals were selected, and articles published after 2004 were considered as prior to that less evidence was available. After applying this inclusion criteria, we selected 2 articles. Subsequently, search string was refined and filters were applied to minimize the results to 31. About 5 articles were selected from these and a total of 7 articles were used for study. Studies related to agile practices were excluded as continuous delivery and agile development are two different approaches. Furthermore, we identified that studies will be excluded at different stages in the review for different reasons. We represent this by a flowchart as shown in figure-2.
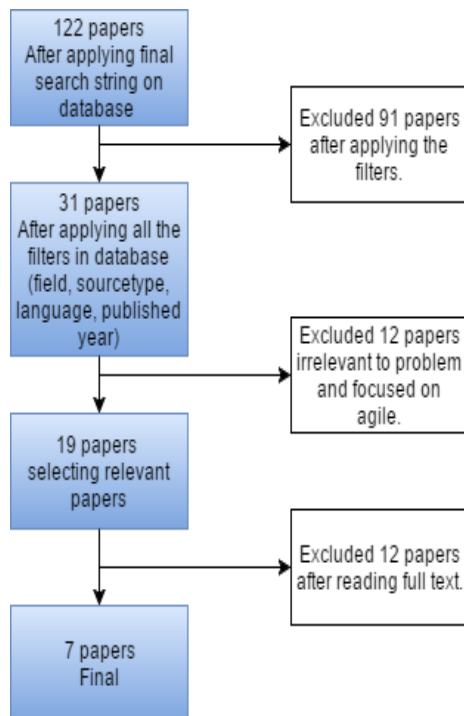

Fig 2: Inclusion and Exclusion studies Flowchart

V. RESULTS

Articles which were shortlisted with the help of inclusion and excluded studies were analyzed for data required to complete this and following sections.

A. Overview of Studies

A total of 7 articles were chosen for writing the results. As, Continuous delivery is a new methodology which was introduced in 2010[4], so papers earlier than 2010 weren't considered. So, selected articles are from 2010-2017, as it takes time for any methodology to become popular among the enterprises, we considered papers from 2010 to be useful for the SLR. In the following table, the year of article publication and the research method was already mentioned in the data extraction process.

References	Years
Article[7]	2015
Article[1]	2013
Article[3]	2015
Article[8]	2015
Article[4]	2017
Article[9]	2016
Article[2]	2016

B. Results for Review Questions

RQ1) What are the challenges faced in implementing Continuous Delivery(CD) process?

A company must consider the central aspects of CD in order to move along with its competitors[7]. Reference[7] identifies that challenges can be divided into technical, procedural and challenges related to the customer in the B2B environment, where advantages of CD matched their issues and could solve their problems. Reference[1] states that the process must be clear and transparently communicated to every individual involved with the project. Investing heavily in automation, as manual steps are error prone, due to this change delivery can be made faster and we need to have confidence in CD which isn't free and easy where it will result in best engineering discipline and speed. Reference[3] classifies the challenges to process, technical and organizational challenges. Reference[8] states that implementation of CD and application lifestyle management is something more than installation of tools and automation of tasks. It depends on the

effective collaboration of people involved in it. Reference[4] states few themes, in which problems occurred in CD were listed in it and then by the usage of supported causal chains which states the problems, which may be caused by other themes and implementation of the required solution for the cause. Reference[9] claims that lead times and release cycle metrics doesn't give clear idea about the development. In DevOps practice measuring and monitoring production systems is central capability.

RQ2) What enhancements can be made to coordinate and manage customer involvement in CD?

For building a successful software product and service, customer involvement and an understanding of customer requirement and behavior while developing a project is must[2]. Reference[2] states customer involvement benefits both developers and end users, requirements and behaviors during the development process are essential. Customer misperception, customers' unwillingness to receive continuous updates, forming the right feedback methods, determining from whom and in which format the feedback should be collected and they had found less evidence on its implications. Requirements Engineering research can enlighten CD studies with it is established body of knowledge. Reference[9] states that collaborative working practices were perceived as important criteria by customer and development organization. Customers weren't seeing the benefits of faster delivery and the reduced risk of failures but they were focusing on productivity, quality and collaboration. So, they need to keep in mind that different customers require different methods. It claims that metrics can be used as a tool for communication.

VI. DISCUSSION

Until the introduction of CD as a new software development methodology, there were many enterprises looking for an alternative which helps them in every aspect of the delivery problems they were facing. Even though it is a new methodology, it has become popular in its sector. But the initial complications which are common with a new methodology, is making many enterprises wait for implementing it. The problems and the challenges in bringing the changes were discussed with an empirical evidence with the help of literature. By conducting this research, our major goal was to increase our knowledge on CD by gaining knowledge on its implementation issues and even enhance coordination and management of customer involvement in CD. Here are the major findings of the research:

    1. Of the process, technical and organizational challenges faced in implementing CD, organizational challenges pose a greater threat in comparison.

2. By considering customer requirements and valuing their suggestions or feedback and metrics can be used as a tool for communication.

With the present literature, an exact solution for the implementation issues wasn't described. So, it is required to tackle the issues faced. In all the papers, content wasn't clear where some sections of the report were keenly observed to draw correct conclusions and the articles used were qualitative which were related to the problem areas.

VII. LIMITATIONS

The Following validity threats were examined while conducting the study:

1. Few articles were excluded that are not available in full texts, though they were relevant to research questions.

2. Since Scopus was the only bibliographic database for our research, we might have overlooked some papers in Scopus or other articles which were more informative and relevant to our problem domain.

3. Researcher's bias: Since the data extraction process and the search strategy was performed by two researchers, there is a possibility of researcher's bias. However, any such differences were reviewed, rectified and commonly agreed. A proper inclusion and exclusion criteria was used to nullify this bias.

VIII. CONCLUSION

With the help of our study we could address the challenges faced in the adoption of continuous delivery. With this SLR, we identified that there are some technical, process and organizational challenges in the implementation of CD, as our review focused on the challenges faced in the implementation of CD and even the software professionals who act as customers where their involvement plays a crucial role in developing CD. CD helped in the timely delivery of product to its customers. Through this SLR, it was identified that enterprises were facing some inconvenience in the system design as there aren't too many solutions for it. This is a major issue which requires an immediate looking. So we expect with our further studies on the topic, these issues can be mitigated.

IX. REFERENCES

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