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# REQUIREMENTS ENGINEERING CHALLENGES IN OPEN-SOURCE SOFTWARE DEVELOPMENT: A MULTIVOCAL LITERATURE REVIEW PROTOCOL WITH PRELIMINARY RESULTS

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**Article Info**



**Abstract**

*In the dynamic landscape of software development, open source software (OSS) has acquired traction due to its collaborative and transparent nature. In OSS, source code of the software is accessible to users under a copyright license. The license allows the users to examine, improve, alter and distribute the software either in modified or unmodified form. Richard Stallman, programmer at MIT, presented the idea of making source code freely accessible in the year 1983, from an ideological movement. Users must accept the conditions of a license before the use of OSS. Requirement engineering (RE) is the process of gathering requirements statements, along with the documentation and analysis for a project. Requirements that are insufficient, unclear, inconsistent, and incomplete, may adversely affect software development. In OSS, requirements emerge through online conversations, as well as discussions evolve continually in different online forums and emails. Requirements' gathering is a complex process and its practitioners may face different challenges while practicing it. A Multivocal literature review (MLR) will be conducted to find out challenges, success factors, and practices/solutions for the identified challenges in RE process of OSS. This research will help academic researcher, OSS practitioners and managers to improve RE process, leading to more efficient, effective and successful software applications.*

**Keywords:** *Open source software (OSS), Requirement Engineering (RE), Multivocal Literature Review (MLR).*

## Introduction

Open source software developers (OSSD) make the source code accessible to those who want to study that code, reproduce it, learn from it, change it, or share itwith others [1]. OSS code is usually kept in a public repositoryand shared with community [2]. Users must accept the conditions of a license before the use of OSS. OSS promotes involvement from a community of developers, customers and contributors by granting unrestricted use of its source code [3]. In order to promote community collective intelligence and high quality software development, new ideas can be discovered and exchanged. Software developers from different backgrounds can share their opinions, ideas and views [2].

Requirements engineering (RE) has always been considered as an essential process in the software engineering (SE) process. RE is concerned with the systematic and disciplined application of methodologies, technologies, and scientific approaches for gathering requirements [3]. The requirements for OSS can be determined by brain-storming, ranked by stakeholders, and posted online for public discussion. In OSS requirements emerge through online conversations, as well as discussions evolve continually in different online forums and emails [4].

In conventional software engineering the requirements can be elicited, examined, defined, and managed under central control of an administrative body. The OSS community does not followprescriptive models and standards for software engineering [5]. Being base of software development, the RE process have number of difficulties within each of the sub-processes [6]. Requirements that are insufficient, unclear,inconsistent, and incomplete may adversely affect software development [7].

## 1. Background

Many systematic literature reviews and mapping studies have been conducted to investigate different aspects of open source software development. These studies included analyzing community engagement and participation in OSS as well as examining the differences between open source and traditional development activities.

Jaison et al. [8] reported how OSS developers actually practice RE activities and what are their opinions about it. The RE process by OSS developers do not match their opinions about it.

Javed et al. [9] reported that errors concerned to RE arise frequently during software development life cycle (SDLC). An industrial survey that was conducted in 12 software development companies revealed that 48 percent are RE related errors in SDLC. Kiran et al. [10] investigated requirement elicitation process in OSS projects, examining how requirement elicitation process is carried out through a literature review.

Björn et al. [11] provided an overview of the OSS requirements management procedure. OSSD differ from traditional software development since OSS has informal requirements, planning, analysis and design, and is performed by one developer or few numbers of developers. Paula et al. [12] examines and assesses the forum-based techniques used by vendor-based OSS projects to gather and prioritize requirements. The requirements phase generally consists of elicitation, analysis, specification, validation and management

activities, which can be executed either sequentially or iteratively, depending on the software development lifecycle.

While the previous related work highlight various features of OSS development, yet none of the above-mentioned research works systematically investigated RE process in OSS projects. An MLR aiming at RE process in OSS development providing a complete understanding of the challenges, success factors and practices associated with requirements engineering process in OSS project would fill this gap.

## 2. Research Methodology

A Multi-vocal literature review (MLR) will be conducted in order to access all the available literature. MLR is a systematic research approach which includes academic literature (journal and conference papers) as wellas gray literature like, articles, reports, videos, blog post and white papers [12]. It is important to conduct MLR, as primary studies, particularly in the field of SE, as developers extensively utilize grey literature as the most common way to disseminate guidance, knowledge, and practices on new methodologies and skill-driven advancements.

## 3. Research Questions

The main aim of this research study is to improve the RE process in OSSD, leading to more efficient, effective, and successful software applications. The aim will be achieved by achieving the following objectives:

**i.** Identification of key challenges and success factors in Requirements Engineeringprocess of OSSD, based on literature review.

**ii.** Identification of solutions and practices, from literature, for addressing the identified challenges and for implementation of the identified success factors. key

Open-source software projects often involve contributions from multiple developers and volunteers. This can result in a lack of clear and consistent requirements,making it difficult to define the scope and goals of the project. The requirements engineering process presents unique challenges, as practices often deviate from conventional software engineering approaches.

There is no effective documentationof requirements which is crucial for open-source community.

In order to bridge the gap, we have posed the following research questions:

RQ1: What are the critical challenges, as identified in the literature in RE process of OSSD?

RQ2: What are the critical success factors, as identified in the literature in RE process of OSSD?

RQ3: What are the practices/solutions, as identified in the literature to be adopted for implementation of success factors and addressing the challenges in RE process of OSSD?

## 4. Constructing Search String

Relevant to our research questions following search terms are constructed by following [14-15] guidelines.

Population: Open source software/ Requirement Engineering.

Intervention: Challenges/success

factors/practices in RE process of OSS

Outcome of relevance: To improve RE process in OSSD.

Experimental design: All

published/unpublished research papers relevant to RE process of OSS i.e. case studies, empirical studies, theoretical studies and experts' opinions etc.

Now we can formulate our research questions using the terms above, as follows:

**RQ1:** [What are the challenges] **INTERVENTION** faced by

[Open Source Software developers] **POPULATION**

[To improve RE process in OSS] "**OUTCOME OF RELEVANCE**"

**RQ2:** [What are the success factors] **INTERVENTION** faced by

[Open Source Software developers] **POPULATION**

[To improve RE process in OSS] **OUTCOME OF RELEVANCE**

**RQ3:** [What are the solutions] **INTERVENTION**

[Open Source Software developers] **POPULATION**

[To improve RE process in OSS] **OUTCOME OF RELEVANCE**

### 4.2. Search Strategy

The main objective of this phase is to describe the search and assessment strategies used to classify the primary research studies. These strategies enable a thorough exploration of both published (White literature) and unpublished (Grey literature) sources, which provide answers to address the research questions (RQs) at hand.

### 4.3 Trial Search

A trial search mean applying the search term to different online resources. Search query will be applied to different digital libraries of ACM, Springer Link, IEEE Xplore, Science Direct and Wiley Online Library [16-17].

("Open source Software" OR OSS OR "Free Software" OR "Libre Software") AND ("Requirements Engineering" OR "Requirements Analysis" OR "Requirements gathering") AND ("success factor" OR "Key Factor" OR "Positive Factor" OR Barrier OR challenge OR hurdle OR difficult OR problem OR inhabited OR limitation OR Feature OR Factor OR Element OR Risk OR Threat OR Practice OR Solution OR "implementation initiative" OR Technique OR Opportunity OR Result OR Direction OR Procedure OR Outcome OR Pattern)

Search string was altered to fulfill the required format of various digital libraries.

### 4.4 Identifying Search Term

First, we will divide the RQs into different search terms for the selection of “population”, “intervention” and “relevant outcome”.

Next, we will find out alternative spellings and synonyms for the search terms previously find out.

In the next step, we will validate the keywords by searching them in relevant publications.

We will use Boolean Operators ‘OR’ and ‘AND’ to concatenate the alternate and major terms respectively.

The implementation of the above-mentioned plan produced the following results.

***Result for (a):***

RQ1: Challenges, Open Source Software, Requirement Engineering

RQ2: Success Factors, Open Source Software, Requirement Engineering

RQ3: Solution, Challenges, Open Source Software, Requirement Engineering

***Result for (b):***

Challenge(s): (Challenge OR Hurdle OR Barrier OR Risk OR Feature OR Threat OR Element)

Solution(s): (Solution OR Result OR Practice OR Opportunity OR Outcome OR Technique OR Procedure OR Pattern OR Direction)

Open Source Software: ("Open source Software" OR OSS OR "Free Software" OR "Libre Software")

***Result for (c):***

(Challenges in Open Source Software, Success Factors in Open Source Software, Solutions/ Practices for challenges in Open Source Software)

***Result for (d):***

(Challenge OR Hurdle OR Risk OR Barrier OR Feature OR Factor OR Threat OR Element OR Practice OR Solution OR Result OR Technique OR Opportunity

OR Outcome OR Direction OR Procedure OR Pattern) AND ("Open Source Software" OR "OSS") AND ("Requirements Engineering").

### 4.5 Search String Breakup

Some databases and libraries, such as Science Direct, has limit on the length of search strings. So we will divide our search string into smaller substrings and will perform separate searches for each of the string.

Substrings:

**Search string 1:**

("Open source Software" OR OSS OR "Libre Software") AND ("Requirements Engineering" OR "Requirements Analysis") AND ("success factor" OR "Key Factor" OR Result OR Pattern OR "Positive Factor" OR challenge)

**Search string 2:**

("Open source Software" OR "Free Software") AND ("Requirements Engineering" OR "Requirements gathering") AND (Barrier OR hurdle OR difficult OR problem OR inhabited)

**Search string 3:**

("Open source Software" OR OSS) AND ("Requirements Engineering" OR "Requirements Analysis") AND (limitation OR Risk OR Factor OR Feature OR Pattern OR Element)

**Search string 4:**

("Open source Software" OR "Libre software") AND ("Requirements Engineering" OR "Requirements Analysis") AND (Threat OR Practice OR Solution OR Direction OR "implementation initiative")

### 5. 5. Resources to be searched

**To select the relevant literature we will divide it into two further sub-steps i.e. search for white literature and search for Gray literature (GL) resources.**

### 5.1. Automatic Search (Digital Database)

We have selected the following digital libraries/databases/search engine for identifying white literature.

1) Springer-Link (http://www.springerlink.com)
2) Wiley Online (https://onlinelibrary.wiley.com)
3) IEEE Xplore: (http://ieeexplore.ieee.org)
4) Science-Direct (www.sciencedirect.com)
5) ACM Portal (http://dl.acm.org)

We have included these digital databases/libraries primarily because it offers us the opportunity to access their contents, which align with the services provided by our institution. Also, these databases/libraries cover

a wide range of impactful full-text journals and conference proceedings, providing comprehensive coverage of the field of software engineering as a whole [14].

### 5.2. Snowballing

As per the guidelines outlined by Kitchenham and Charters [14] for Systematic Literature Reviews (SLRs), both forward & backward snowballing techniques will be used in order to maximize the inclusion of all appropriate resources.

### 5.3. Resources to be searched for Gray Literature (GL)

To select resources for gray literature, we have followed the search strategy as suggested by Felderer et.al in their MLR guidelines [18]. This approach includes an advance search on 'GOOGLE' by applying search string and digital database 'ProQuest Dissertations and Thesis Global' to select related master's and PhD thesis.

1) Google Search engine (https://www.google.com/)
2) 'ProQuest Dissertations and Thesis Global' database to identify relevant Ph.D. and master theses (https://www.proquest.com/)

## 6. Primary Selection

To perform Initial selection for the research study, we examine the titles, abstracts and keywords of research papers. The aim of this process is to select only those articles that are relevant to our research topic and research questions. When the initial selection process is

complete, a comprehensive review of the full text will be conducted, considering the inclusion and exclusion criteria defined below. In cases of uncertainty whether to include or exclude a particular article, it will be referred to a secondary reviewer for further evaluation and its selection.

### 6.1. Inclusion Criteria

To determine which article will be used for data extraction, we have defined specific criteria based on our search term. We will only select formal and informal research papers that are related to RE process of OSS, and are written and published in English language. Our focus will be specifically on studies that:

1) Articles that discuss the requirement engineering process of OSS.
2) Articles that describe the challenges faced by OSS developers while practicing requirement engineering process.
3) Studies that discuss success factors faced by OSS developers while practicing RE process.
4) Studies that discuss the practices/solutions of challenges related to RE process in OSS.
5) All available online published and unpublished gray literature will be included.

### 6.2. Exclusion Criteria

To maintain quality in our research study, we have set a clear criterion for the exclusion, discussed in the section below: The criterion is defined below:

1) Research work that doesn't address our research questions or objectives.
2) Research study that fails to define the challenges/success factors/practices in RE process of OSS.
3) A study that doesn't meet the inclusion criteria listed above.
4) Identical articles found in different search engines and libraries were recognized and excluded from final list of papers.
5) Publications that are not in English language.

### 6.3. Data Extraction Process

Initially data will be extracted by the primary reviewer and the secondary reviewer will be administering an inter-rater reliability test.

### 6.4. Data Extraction Review Process

Primary reviewer will take the responsibility for extracting the data. In case of any confusion during the process of data extraction, the secondary reviewer will be contacted for further guidance.

The secondary researcher will review a set of studies that have been previously examined by the primary researcher to verify the extracted data.

### 1. Data Synthesis

The finally extracted data will be summarized into tables, based on our three RQs. These tables will contain columns for S.No, challenge, success factors, practice names, its frequencies, and their percentages. Furthermore, the data will also be shown in diagrammatical form. For each challenge, there will be a separate table to show the practices to tackle that particular challenge.

To ensure the validity of the data synthesis, the extracted themes will be cross-checked with the secondary researcher, who possesses significant expertise in the field of software engineering.

Significant revisions to the protocol will be employed based on the feedback and reviews received.

The revised edition of the protocol will serve as the foundation for the review. If any additional modifications are necessary, we will update the protocol and adjust the version number accordingly.

### 2. Preliminary Results

The MLR protocol is presently in the phase of execution. We obtained results of some of the above mentioned sections of our protocol. By applying the search strategy on designated digital repositories, a cumulative total of 2070 papers were identified including published and unpublished resources. Subsequently, the search queries were executed to extract relevant research articles from online digital libraries, databases and websites, utilizing inclusion and exclusion criteria. The selection process was performed in two phases. In the first phase, a preliminary screening of the title and abstract was conducted, resulting in the identification of 125 research articles that satisfied the selection criteria shown in table 3. In the second phase a more comprehensive study of the full text of the research papers that passed the initial

screening was conducted. For the Multi-vocal literature review, following the application of the criteria for inclusion and exclusion a total of 47 relevant articles were ultimately finalized to answer the research questions.

**Table 1. Information to be extracted**

| S.No | Information to be extracted |
|---|---|
| **1.** | S. No |
| **2.** | Paper-ID |
| **3.** | Date of Review |
| **4.** | Title |
| **5.** | Authors |
| **6.** | References |
| **7.** | Database |
| **8.** | Methodology |
| **9.** | Sample Population |
| **10.** | Target Population |
| **11.** | Publication Quality Description |
| **12.** | Goal of the paper |
| **13.** | Country/Location of Analysis |
| **14.** | Publication Year |
| **15.** | Challenges faced during the RE process of OSSD |
| **16.** | Success factors faced during the RE process of OSSD |
| **17.** | Practices/solution for challenges faced during RE process of OSSD |

**Table 2. Search results**

| Name of libraries | Search Result | Primary Selecti | Final Selectio |
|---|---|---|---|
| **ACM** | 601 | 18 | 08 |
| **IEEE Xplore** | 108 | 31 | 14 |
| **Springer Link** | 136 | 24 | 10 |
| **Wiley Online** | 188 | 11 | 01 |
| **Science Direct** | 927 | 07 | 02 |
| **Gray Literature** | 110 | 34 | 10 |
| **Snowballing** | | | 02 |
| **Total** | **2070** | **125** | **47** |

## 3. Conclusion

Diverse research has illuminated the open source software. However, a comprehensive multi vocal literature review (MLR) analyzing the challenges, success factors and practices in RE process of OSSD has not been

conducted. This research article outline our research strategy via MLR protocol. The MLR protocol has been developed and is presently being executed, yielding preliminary findings for the final selection.

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