Jurnal ELTIKOM :
Jurnal Teknik Elektro, Teknologi Informasi dan Komputer

Vol. 7, Issue 1, June 2023, page. 38-49
ISSN 2598-3245 (Print), ISSN 2598-3288 (Online)
DOI: http://doi.org/10.31961/eltikom.v7i1.725
Available online at http://eltikom.poliban.ac.id

A SYSTEMATIC LITERATURE REVIEW ON BLOCKCHAIN TECHNOLOGY IN SOFTWARE ENGINEERING

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Received: 9 March 2023 – Revised: 18 April 2023 – Accepted: 8 May 2023

ABSTRACT

Blockchain technology is gaining increasing interest among software developers as a distributed and decentralized ledger for tracking the origin of digital assets. However, the application of blockchain in software engineering requires further attention. In this study, we aim to address the current challenges and explore the need for specialized blockchain practices in software engineering. Through a systematic literature review, we identify the various applications of blockchain technology in software engineering. Additionally, we conduct a thorough analysis of existing obstacles and propose potential solutions. Gathering and evaluating requirements using blockchain-based requirements engineering approaches will enhance the quality and reliability of data in software development projects. This, in turn, will improve the overall quality and dependability of software, as well as increase user interest and productivity.

***Keywords**: blockchain in software engineering, blockchain for a distributed system, systematic literature review.*

I. INTRODUCTION

BLOCKCHAIN technology is defined a decentralized, distributed ledger that documents the origin of a digital item. This ledger is to enable decentralized transaction management [1]. Starting from Bitcoin [2] , the pioneering decentralized cryptocurrency, to Ethereum [3] with its smart contract capabilities, and the emerging permissioned blockchain [4], blockchain technology has experienced rapid evolution. Due to its fundamental architecture, blockchain data cannot be manipulated, making it a real industry disruptor. Blockchain is a cutting-edge and innovative technology that offers scalability, transparency, and risk reduction for a wide range of applications [5]. Lately, many firms have been drawn to blockchain technology owing to its inherent value. Many sectors, including financial applications, supply chain management [6], and healthcare [7], have investigated the use of this innovative technology.

Blockchain technology has established trust between participants in collaborative software development [8], [9] as well as the traditional industries that might benefit from using it. Examples of alternative platforms are GitHub [10], [11], Travis CI [12], [13], and care loud-based package management [14], [15]. Porru [16] highlighted the necessity for blockchain-specific software engineering approaches and created the phrase blockchain-oriented software engineering (BOSE). The importance of collaboration between software engineering and cutting-edge technologies like machine learning and blockchain technology was also emphasized by Demi [17]. Moreover, they found that smart contracts may automate a variety of software engineering processes, such as the approval process,

TABLE 1
SUMMARY OF SELECTED LITERATURE ON BLOCKCHAIN TECHNOLOGY IN SOFTWARE ENGINEERING REVIEWS AT LARGE.

Reference	Goal	Research questions
Demi et al. [17]	The purpose of this research is to offer a thorough review of how blockchain technology has been used in Software Engineering.	Blockchain platforms are utilized to create SE applications, blockchain use in studies is on the rise, and blockchain has a positive impact on the SE environment, according to published research.
Lone et al. [20]	Evaluation of blockchain-based smart contracts used for Internet and IoT security.	Various security measures based on smart contracts, especially for IoT; the benefits of smart contracts for resolving security and vulnerability concerns in the Internet of Things; the usage of blockchain as a platform for smart contract-based security solutions on the Internet of Things; and evidence confirming the utility and appropriateness of smart contracts.
Batwa et al. [6]	Examining the discovered gap between BCT and trust theories within the framework of SCM.	In papers that addressed supply chain management and blockchain technology, trust was operationalized and examined in two ways: How does blockchain technology affect trust in supply chain management.

remuneration for software engineers, and compliance adherence, which often need human thinking. Software engineers are increasingly interested in blockchain technologies, and as a result, numerous software projects based on different blockchain implementations are emerging and developing rapidly [18], [19].

Previous systematic literature reviews [6], [17], [20] focused on blockchain-based applications, such as sustainable supply chain management [21]. In their study, the function of blockchain technology in environmentally friendly supply chain management is examined. Moreover, Chang [22] clarifies the interaction link between stakeholders and the blockchain's evolutionary growth in healthcare settings. Further study on v code metrics for code optimization is recommended by their findings. The two previous studies address issues about the more general use of blockchain technology, but they do not particularly look at how it may be used to enhance software engineering enterprises. They need to have paid more attention to how blockchain technology may advance software engineering.

To the best of our knowledge, there seems to be relatively little research on the use of blockchain in software engineering. Systematic mapping is the closest related research [17], [23]. Their studies covered the uses of blockchain in software engineering as well as the benefits that this cutting-edge technology may bring to the sector.

Many examples of evaluation of blockchain technology are found in the field of software engineering research (summarized in Table 1). Demi [17] conducted a rigorous mapping study on software engineering applications made feasible by blockchain technology. By providing a comprehensive overview of the software engineering applications made feasible by blockchain technology, their study was focused on enhancing our knowledge of blockchain-oriented software engineering. As the writers undertook a rigorous mapping investigation, they discovered ten major studies.

A thorough, comprehensive assessment of the literature tries to address or minimize the research gap by compiling the evidence on blockchain in software engineering. While the evaluations indicate the growth of blockchain-related research in software engineering, additional information regarding the approach, tools, and difficulties is still required. Table 1 lists various studies that specifically address blockchain technology in software engineering. The use of blockchain in software engineering has gained significant attention and interest. However, the benefits it offers, particularly in terms of reducing software requirements, have become particularly relevant in this research. This study aims to identify the advantages of blockchain technology in software engineering through a comprehensive literature review. The contribution focuses on energizing, exposing, and researching the need for new blockchain techniques with a focus on software engineering. The latter speaks to the fields of software engineering where blockchain was first introduced. Finally, we present the key findings of this study, which aim to highlight potential areas for future research in software engineering.

II. RESEARCH METHOD

In conducting our study, we followed the recommendations provided by Kitchenham [24]–[27]. The

TABLE 2
SEARCH SOURCES.

Electronic databases	IEEE Xplore SpringerLink Mendeley ScienceDirect MDPI Research Gate
Searched items	Journal and conference papers
Search applied on	Whole text—to ensure that we don't overlook any articles with titles or abstracts that don't include our search terms but are nevertheless relevant to the review object.
Language	English
Publication period	From January 2012 to November 2021

fundamental procedures of our systematic review, such as preparation, execution, and dissemination of the results, were then covered [28].

A. *Review of objectives and research questions*

Studying the significance of blockchain in software requirements is crucial given the growing usage of blockchain in software development. The management of requirements [29], [30], and traceability [31]–[33] faces various challenges, including limited trust in existing tools, integration issues with diverse systems, manual effort, lack of motivation, and confidentiality constraints that hinder seamless traceability across organizational boundaries. For the responsible management and traceability of requirements in cross-organizational software projects, a blockchain-based method has been suggested in this area. Therefore, the primary objective of this study is to enhance understanding of blockchain practices in software requirements and identify the challenges encountered by teams during requirement engineering in such contexts. We also considered how blockchain may enhance the immutability, trust, visibility, and traceability of requirements across the whole software development lifecycle (SDLC). The following study questions were developed in order to accomplish these objectives.
1) RQ1. How can blockchain help improve the requirement engineering process?
2) RQ2. What method can use in blockchain-oriented requirement engineering?

B. *Search strategy*

The investigation was conducted using the Kitchenham study [24] as a reference. We developed a thorough search strategy after deciding on our goals and research questions in order to thoroughly review all important empirical data related to the goal of this study. The technique included setting up the search area, which comprised both printed proceedings and internet resources, as shown in Table 2. Initially, the articles were retrieved from electronic databases, and subsequently, a snowballing approach [34], [35], was employed to identify additional relevant research by examining the references of the retrieved articles. The recovered publications were then subjected to two distinct applications of the inclusion and exclusion criteria, each involving a different number of researchers.

C. *Search criteria*

C1 and C2, which are divided into two portions for the sake of this evaluation, are the search criteria.
- C1 is a string made up of keywords related to blockchain technology, such as *blockchain*, *decentralization*, *distributed system*, *ledger*, *bitcoin*, and *cryptocurrencies*;
- C2 is a string of keywords related to software engineering, such as *requirements engineering*, *computer science*, and *requirements traceability*.

The search criterion for a Boolean expression may be C1 AND C2, for instance. This is a screenshot of the database search that was conducted.

Blockchain AND (“decentralization” OR “distributed system” OR “ledger” OR “bitcoin” OR “cryptocurrencies”) AND (“software engineering” OR “computer science” OR “requirements traceability”)

We carefully built the search term in each database based on the search tools it offered. Each database search was regarded as a learning and testing exercise.

TABLE 3
SEVERAL IDENTIFIED STUDIES DURING THE DISTINCT ROUNDS OF OUR SYSTEMATIC SEARCH.

Database	Retrieve	Round 1		Round 2	
		Include	Exclude	Include	Exclude
IEEE	127	47	80	6	74
Mendeley	511	51	460	2	49
Springer Link	1441	74	1367	0	74
Science Direct	370	10	360	0	10
MDPI	491	1	490	1	0
Research Gate	30	1	12	1	0
Total	2970	194	2776	10	207

D. Inclusion and exclusion criteria

The following inclusion and exclusion criteria were used to decide which studies should be included: eligibility standards (I1) the research is published in a peer-reviewed journal; (I2) It is conducted in English; (I3) it is relevant to the search phrases used; (I4) it is an empirical research article, an experience report, or a workshop paper; and (I5) the study is published between January 2012 and November 2021.

Exclusion criteria: (E1) studies that do not focus explicitly on blockchain in software engineering but only refer to blockchain as an application; (E2) studies that do not discuss requirement engineering in blockchain; and (E3) studies that do not meet inclusion criteria.

E. Study search and selection

The selected electronic databases were searched using the defined search strategy, and the relevant studies were retrieved. As shown in Table 3, our initial search yielded a total of 2970 studies. It is important to note that we focused on databases that publish peer-reviewed publications (I1). Using the inclusion criteria, one of the researchers thoroughly examined the study titles and abstracts. Most of the studies that were identified met the inclusion criteria I2, I3, and I5. However, a significant portion of the search results were later excluded as the search engines were unable to search the entire content of the papers using the provided search strings. The second researcher (one of the co-authors) then assessed the pre-selected publications in Round 2 using the exclusion criteria (E1, E2, and E3). After this first classification, there were still 194 prospective research topics. In addition, when the articles were obtained, we checked to make sure they were not arguments, editorials, comments, tutorials, prefaces, or presentations (I4). We conducted a face-to-face consensus session to go through the agreements and disagreements brought up by the researchers in their assessments. Based on the established exclusion criteria for the publications where an agreement was not achieved, the researchers reviewed the whole article and decided which studies to include. Ten studies were omitted from the 194 that had been pre-selected after the inclusion criteria had been applied because they had not covered any of the subjects covered by our inquiry (E1 to E3). Four discussed approaches, frameworks, and models for software engineering's use of blockchain technology. One of them spoke about using blockchain technology to manage requirements responsibly and track them throughout the software development life cycle. Therefore, 10 studies make up our final list (see the two rightmost columns in Table 3).

F. Data extraction

We followed a data extraction procedure based on the recommendations provided by Kitchenham [24] and Triandini [28] to extract relevant information from the ten selected primary studies that align with our research objectives. The data extraction process involved the following steps: We developed a form to systematically document the concepts, theories, contributions, and conclusions from the eight research papers. The use of this format ensures a higher level of interpretation during subsequent analysis. The following data were extracted from each publication: (i) review date; (ii) title; (iii) authors; (iv) reference; (v) database; (vi) relevance to the theme, i.e., blockchain for requirements engineering issues, challenges, practices, models, methods, techniques; (vii) methodology (interview, case study, report, survey); (viii) future work; (ix) limitations; (x) country/location of the analysis; and (xi) year of publication.

G. Methodological quality assessment

The key papers included for this systematic review were assessed for methodological quality using Guyatt's original quality criteria [36]. The criteria were later used by Dyba [37] to evaluate the effectiveness of empirical research pertaining to software development processes. These quality standards

TABLE 4
QUALITY CRITERIA FOR STUDY SELECTION.

Criteria	Response grading	Grade obtained
(C1) Is the research aim/objective clearly defined?	{1}(Yes)	10 studies, 90%
(C2) Is the context of research well addressed?	{1}(Yes)	10 studies, 90%
(C3) Are the findings clearly stated?	{1}(Yes)	10 studies, 90%
(C4) Based on the findings, how valuable is the research?	>80% = 1, <20% = 0, in-between = 0	

TABLE 5
STUDIES ARE DISTRIBUTED IN ACCORDANCE WITH THE PUBLICATION CHANNEL.

Publication Source	Type	Number
International Conference for Convergence in Technology	Conference	1
International Workshop on Blockchain Oriented Software Engineering (IWBOSE)	Conference	1
International Conference on Software Engineering: New Ideas and Emerging Results (ICSE-NIER)	Conference	1
IEEE International Conference on Software Analysis, Evolution and Reengineering	Conference	1
Computer Standards and Interfaces	Journal	1
Future Internet	Journal	1
IEEE Access	Conference	2
RTU Press	Journal	1
Sustainability (Switzerland)	Journal	1

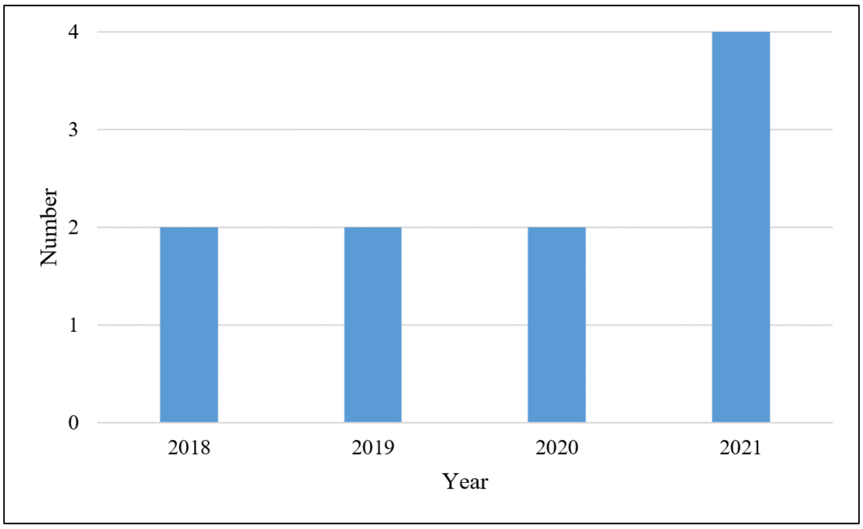

Fig. 1. Year-wise distribution of selected studies.

(shown in Table 4) comprise tests that determine how much a study is acceptable and will broaden the scope of the investigation. The breadth, dependability, and significance of the research are part of the criteria [38]. We chose these standards because I they may be used to evaluate the significance of synthesis findings and guide interpretation [24] and (ii) the quality metrics associated with these standards have previously been used in a number of recent systematic reviews [37].

The quality assessment criteria indicated in Table 4 were used to evaluate each study. We classified and rated the studies more correctly by using an ordinal scale based on our quality evaluation criteria (Table 4) rather than a binary scale. The first criterion (C1) included assessing each study's objective. 90% of the studies gave a favorable response to this question. The second criteria (C2) assessed the extent to which the research setting was covered and explained. 90% of the studies had good answers to this question. The third criteria (C3) asked if each research had a clear description of its results. 90% of the studies gave a favorable response to this question. The heuristic ratings for the quality metrics were created by the same researchers previously stated (C4).

III. RESULT AND DISCUSSION

A. *Overview of studies*

As previously mentioned, we identified the sources from which the papers were published. The distribution of these sources is presented in Table 5. Out of the total studies, 40% (4 studies) were published in journals, while 60% (6 studies) were published in conferences. Based on our findings in Table 5, it appears that the studies are evenly distributed across the different publication venues. There

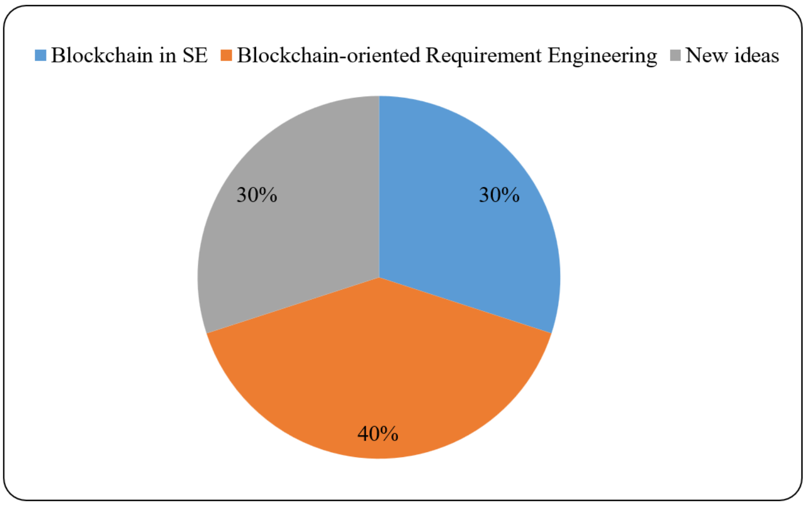

Fig. 2. Categorization of study basis.

Fig. 3. Geographical distribution of the chosen studies' authors.

are one or two articles published by each of the publishing sources. This suggests that writers focusing on requirement engineering in the context of blockchains do not show a particular preference for any specific source.

Considering the years of publication, we only discovered noteworthy papers connected to our study subject prior to 2018. Together with the topics of interest in our inquiry, the distribution of peer-reviewed publications produced between 2018 and 2021 is provided (see Fig. 1 and 2, respectively). Two studies [39], [40] are from 2018. Two studies [41], [42] are from 2019. Two studies [43], [44] are from 2020. Furthermore, four studies [45]–[48] are from 2021.

Considering the topics covered by the research, Fig. 2 shows that 40% of the studies focus on blockchain-focused requirement engineering, 30% explore recently proposed concepts in other approaches, and the remaining 30% investigate the use of blockchain in software engineering.

In the majority of the 10 studies we reviewed, we observed that the co-authors represented multiple countries within a single study. However, it is challenging to attribute authorship to specific regions for each research paper. When examining the individual locations of the authors, we can observe that most of them are from Europe and Asia (refer to Fig. 3). Furthermore, it is noticeable that there are fewer studies on blockchain-focused requirement engineering from Asian nations, and none from American or African nations.

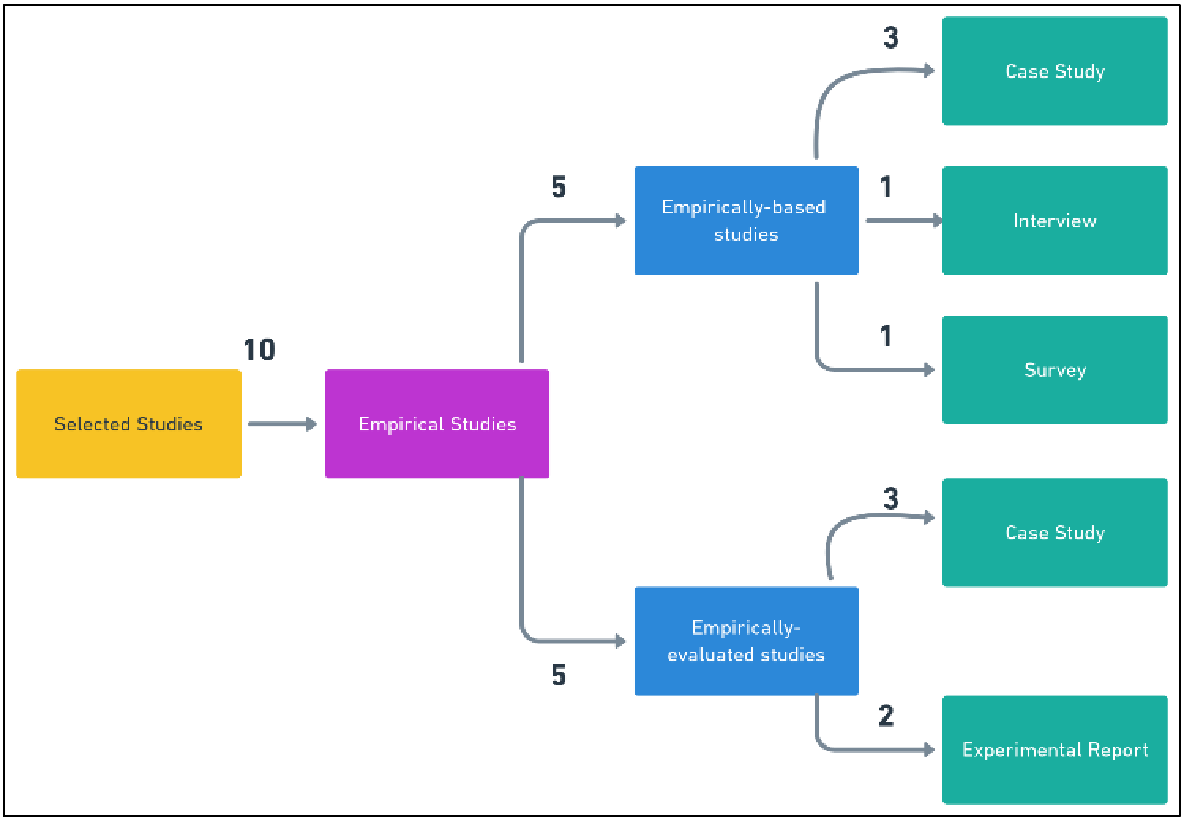

Fig. 4. Distributions of research studies depending on research methodology includes.

The research methodologies used in the 10 selected papers are shown in Fig. 4. First, we discovered that most of the studies are exploratory. Among the 10 papers in the empirical subset of this category, several of them have undergone empirical appraisal. The remaining papers have employed qualitative research techniques, such as surveys and interviews, and are considered exploratory, based on an empirical foundation. Out of the 5 papers in this category, we found that 40% (2 out of 5) of the "empirically based" research included experiments and interviews as sub-methods. The remaining 60% of the studies did not disclose the specific sub-methods used in their case studies. For the sake of this study, we refer to a search technique that is used as part of the search process as a "sub-mature approach." For instance, a case study may involve interviews and surveys to gather data. Surveys and interviews are regarded as sub-research methodologies. Additional research techniques used in empirical studies include ethnography (1), observation (1), focus groups (1), surveys (1), and interviews (1) (with grounded theory as a sub-method for data processing) (1). The research techniques mentioned by the authors of several studies include ethnography and observation.

B. (RQ1) How can blockchain help improve the requirement engineering process?

The three procedures that we identified to enhance the requirement engineering process are described below, along with the unique potential challenges associated with each approach. It is important to note that the list provided below is comprehensive and represents the collective findings of the 10 studies.

1) Requirement Negotiation

Software projects can benefit from improvements in the quality of requirement engineering processes, which ultimately leads to high-quality software projects [49], [50]. Requirement engineering employs various techniques and procedures [48], [51], to establish well-defined specifications. However, the process of working out the details can be challenging and time-consuming. Despite the use of strategies and algorithms to simplify and streamline the process, there is still room for improvement in enhancing the quality of software projects in various areas.

Several industries and applications are using blockchain technology to enhance quality [52], [53], safety [54], [55], dependability [56], [57], and speed [58], [59]. Therefore, in the field of requirements engineering, we may utilize the blockchain to gather more exact requirements and produce better software projects. Blockchain-focused requirements engineering will raise the caliber and dependability of software initiatives [60], [61]. The success rate of linked software projects should increase as a result of applying this technique in requirements engineering.

The use of a blockchain-based platform in requirements engineering will enhance the methodological and operational processes of requirements negotiation. Developers, the management team, and other interested parties will be able to finish the process on time and under budget if the requirements negotiation procedure is enhanced.

2) Requirement Traceability

A blockchain structure's data blocks include time stamps on them [62], [63]. As each block is encrypted using a hash technique, data input is impermanent and impossible to alter without the agreement of the majority of nodes in the network. They are becoming unchangeable and irrevocable. The shared ledger is unchangeable because each modification, no matter how little, results in a new hash that can be quickly identified.

The ability to demonstrate that the data has not been altered, both by the data supplier and the receiver, has a significant positive impact on financial transactions and audits. This capability enhances the confidence in the Blockchain system. However, the immutability of Blockchain also brings about significant challenges and difficulties, and in recent times, some individuals have started to question its benefits. The immutability attribute of blockchains might make it difficult to utilize them in particular applications. Only by fulfilling this legal responsibility may blockchain or healthcare delivery and application be created.

By applying the supply chain mindset to the context of SDLC, which involves various value creation activities, it is possible to enhance the traceability of requirements through the properties and principles of blockchain. This approach ensures the integrity and immutability of requirement traceability data, transfers the responsibility for requirements management and traceability from the requirements engineer, and encourages stakeholders to create and validate traceability data. Additionally, it provides visibility to customers, allowing them to check the status of their needs and detect any inconsistencies or faults at any time.

C. (RQ2) What method can use in blockchain-oriented requirement engineering?

This study aims to enhance the existing knowledge on requirement traceability by exploring frameworks built on blockchain technology as a novel solution. Design science research is considered the most suitable method for organizations interested in requirement traceability. To ensure the generalizability of the results, three distinct data creation strategies will be employed.

The study employs two main approaches. First, a systematic mapping and systematic literature review (SLR) comprehensively examine the existing literature on requirement engineering, requirement traceability, and blockchain in software engineering. This process follows established standards for systematic mapping and SLRs in software engineering. Second, an analysis of the relationship between standards and practices aids in the development of the framework. The framework is evaluated through a combination of artificial experiments and naturalistic approaches, including qualitative methods such as interviews and focus groups, documentation analysis, and quantitative methods.

The study employs a thematic coding analysis to extract the themes utilized to further enhance the framework from the qualitative data analysis. The authors assert that blockchain can boost requirements' immutability, trustworthiness, visibility, and traceability throughout the software development cycle, even though this study is still in progress in this area (SDLC).

D. Discussion

The geographical location of the authors is a significant factor that has been emphasized in the analysis of our ten chosen research. It has been observed that European nations, including Norway, Italy, the Netherlands, Belgium, Spain, and Cyprus, accounted for approximately two-thirds of all contributions. Asian nations such as Pakistan, Saudi Arabia, and India also made contributions. However, due to the uneven distribution of authors across geographic areas, the empirical data presented by the ten research studies cannot be considered generalizable. It is challenging to predict the similarity in outcomes when blockchain-oriented requirement engineering is implemented in European or Asian enterprises, as most of the data available is derived from empirical studies conducted in European and Asian organizations. Organizations worldwide have distinct organizational cultures, national cultures, and social conventions [62]. Therefore, we anticipate that the conclusions drawn from our review may differ from any potential findings mentioned in empirical studies, considering the diverse contexts and factors at play in different regions.

Consequently, we expect our review's findings to show that many organizations in America are still adopting requirement engineering methods and are in maturation. Meanwhile, there is a need to study blockchain-oriented requirement engineering in American countries. Since each place has a distinct culture, it is advised that scholars perform more empirical studies on American companies to present the results from these various locations. Moreover, this provides a way to compare how requirement engineering for blockchains is being implemented in various parts of the world.

Requirement engineering, which has lagged in recent years, has gained attention with the introduction of blockchain-focused approaches in the software business. By managing requirements, one would also anticipate the compensations and flexibility of requirement engineering approaches. Therefore, this encourages the industry to adopt blockchain-focused requirement engineering techniques, particularly for large-scale distributed projects. Active industry involvement is crucial for the successful implementation of research findings. In order to fully benefit from research focused on blockchain-oriented requirement engineering, the industry should actively participate and collaborate in pursuing shared research objectives.

Moreover, it is important to put existing research models and structures created for managing blockchain-driven requirements engineering to use in real-world scenarios to show their efficacy and performance. To support the requirements engineering process for the blockchain-oriented requirements engineering approach, models and procedures for common business tools should be created. To make the usage of these tools easier and more convenient, flexible porting help tools should be created.

For the design and development of successful software projects, requirements engineering is one of the most important components. It talks about creating evidence that is tailored to the requirements of the client, making accurate time and budget estimates, and satisfying those objectives. Each project's real narrative includes a software system that is dependent on how well requirements engineering is done. Furthermore, an important aspect that needs to be addressed is the issue of requirement consistency. While requirements may need to be collected from multiple sources, it is crucial to ensure that they are synchronized and aligned with each other.

As a result, blockchain technology is widely used in many applications and organizations. This is because of its reliability, security, and consistency. Consequently, the topic of blockchain requirements engineering is studied in order to raise the caliber and dependability of software projects, lower their failure rate, and make the verification and ease of the engineering process requirements. Blockchain is a distributed ledger system that offers an unchangeable record of transactions and is safe. As blockchain is a decentralized online global database, all stakeholders can understand its logic.

Our findings show that although academics have concentrated on advancing several fields of expertise in blockchain-oriented requirements engineering, they have neglected to examine the overall effects of blockchain on software testing and maintenance. A study of this kind might make it easier for software companies to develop blockchain use cases and for software experts to assess them. Our findings suggest that there is currently a lack of research on the utilization of blockchain-oriented requirements engineering in organizational settings. This could be attributed to the limited exploration of blockchain in software engineering at this early stage and unresolved technological challenges. Further research in the form of concepts and prototypes is needed to encourage developers to incorporate blockchain features into blockchain-focused software architecture and unlock tangible benefits.

IV. CONCLUSION

The thorough overview of the literature on the methods and difficulties of blockchain-oriented requirement engineering is presented in this study. The search and categorization of all existing and accessible material on blockchain-oriented requirement engineering for this study were done in accordance with the established principles for systematic literature reviews. The 2970 original publications in well-known electronic research databases underwent a multistage filtering procedure with independent confirmation, and ten pertinent pieces were removed. On the basis of the research questions, these papers were then evaluated for the quality of the evidence they provided, further analyzed, and grouped into the following thematic groups: I commonly used practices of blockchain-oriented requirement engineering; (ii) requirements engineering challenges addressed by blockchain; and (iii) real-world challenges of blockchain-oriented requirement engineering. The results of our study provide industry and academic practitioners new perspectives for future work on blockchain-focused requirement engineering.

We have established that further study is necessary to understand the effect and uses of blockchain-oriented requirement engineering in the actual world. Requirement negotiation and requirement traceability are two potential aspects of blockchain-oriented requirement engineering that can empower businesses in the sector to leverage this flexible yet time-constrained approach. Our analysis of papers on blockchain-focused requirement engineering reveals that this discipline is still in its infancy and requires further empirical testing of methods in real-world applications. Our findings indicate that while most empirical studies focus on managing blockchain software development methodologies, relatively few studies pay attention to blockchain-specific techniques for requirement engineering. The analysis demonstrates that some of the drawbacks of conventional requirement engineering techniques may be made up for by blockchain-focused requirement engineering procedures. Blockchain-based methods for requirement engineering enable authorized users, such as partners and customers, to access and verify an auditable history of requirements. The authors argue that blockchain has the potential to surpass traditional requirement engineering approaches by enhancing the immutability, trustworthiness, visibility, and traceability of requirements throughout the software development lifecycle (SDLC). However, it is important to note that this research is still ongoing. The analysis revealed that the primary objective of most exploratory studies was to gain a deeper understanding of the subject. However, there is a limited number of studies that utilize empirical data from real-world industrial examples, highlighting the need for further attention in this area. Four studies focused on proposing new theories and approaches, emphasizing the importance of integrating Blockchain-focused requirement engineering approaches into existing infrastructure frameworks and models used in global software engineering. The advantages and limitations of utilizing blockchain-oriented requirement engineering were discussed, along with best practices for their implementation, providing practitioners with valuable insights for managing requirements using blockchain-oriented approaches.

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