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A Novel Blockchain-Based Scientific Publishing System

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Abstract: The scientific publishing industry is dominated by a few publishers that use centralized systems, which decrease the quality of studies and make the publication process longer. Traditional publication systems generally have high publication costs, slow and biased review processes, copyrights held by publishers, lack of rewards for contributors, lack of connection among researchers, etc. Accordingly, we propose a decentralized blockchain-based scientific publication platform to eliminate the traditional publication system deficiencies. The proposed system uses Ethereum smart contracts to accelerate the publication process and abate the biased evaluation process while reducing the publication cost. The proposed model also improves the quality of scientific studies by adding new features to the publication process. The proposed system increases the number of publishers, makes the publication process fully traceable, and makes scientific papers globally available to anyone with a small fee. In addition, the system provides journals with decentralized models and integrates scientific papers with related data or datasets. The editors, reviewers, and cited authors are also rewarded. The proposed system has been implemented using Ethereum Virtual Machine (EVM), which consists of a front-end, middleware, and back-end. When an author submits a manuscript for evaluation, the system automatically finds the most appropriate editors and reviewers for related fields. After the publication process finishes, editors, reviewers, cited authors, and other contributors are rewarded as a system token-based cryptocurrency.

Keywords: scientific publishing system; publication challenges; blockchain; Ethereum; smart contract; online learning; knowledge sharing

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1. Introduction

A scientific publication is a written and published report describing the details and results of original research based on scientific writing rules. In other words, the current scientific publishing system makes research available to the scientific community in a journal or other source document form where the original research results can be referenced. In this case, other authors can repeat experiments and examine the outcomes [1]. Scientists publish their research and result in summaries, theses, conference reports, and articles to announce their work to a wide range of audiences. However, these publications do not always meet the current publication criteria. Moreover, even if a scientific article passes all tests, it will not be exploited efficiently if it is published on the wrong platform.

Many problems cause the quality of scientific articles to decrease, slow the publication process and cause the publications not to be published in the right place [2,3] in the current publication system. Sometimes, research reports that are not good enough can pass the tests, be accepted and, thus, become valid publications. In another situation, incorrect

or nonexpert reviewers may be appointed for publication evaluation, which causes the article not to be evaluated correctly. At the same time, the number of scientific publishers is not very large. Therefore, the evaluation process of publications takes a very long time. There are many problems such as these in the scientific publication process. To address these problems, blockchain-based systems have begun to be developed [4]. In this study, a blockchain-based method using decentralized Ethereum smart contracts is proposed to contribute to the solution of all these problems.

The proposed model first addresses the problem of scientific researchers' inability to choose the right journal for their publication. When selecting a journal, researchers have to consider many parameters, such as the field of research, the evaluation time of the journal, and the acceptance rate. However, it takes too much time to conduct a study that includes each of these, or researchers ignore some parameters. This causes research to be published in nonfield journals or to take longer than expected. This problem can be solved by parameter filtering and article listing methods used by the proposed system. Secondly, our model, by ensuring that appropriate reviewers and editors are assigned, eliminates assigning out-of-field reviewers problems. In addition, the system prevents the biased evaluation process by eliminating the reviewers in the same institution and region. In addition, one of the biggest problems in the publication process is the evaluation part, which takes extreme time. The proposed new model also contributes to this problem. In this context, if a nonaccepted article is considered for a different journal, the research is directed to another journal by submitting it for the approval of the authors. The reviewers in the referred journal can see the previous reviews and can refer to them instead of making a review from scratch. In addition, if the reviewers do not accept the evaluation request in two days, the request is sent to the appropriate reviewers. If a reviewer completes the evaluation in a shorter time than requested, it is added to the reviewer's success score. As this period increases, the success score given to the reviewer decreases. Thanks to these criteria and approaches, the evaluation process speeds up considerably. Finally, a contribution has been made to increase the quality of evaluation of both research and reviews. The proposed system also considers the number of citations of researchers and the successful evaluation scores of the reviewers. Fees are paid periodically to highly cited researchers and reviewers who completed the evaluation process successfully. This encourages researchers to publish higher-quality articles and reviewers to evaluate the scientific articles precisely and fast.

Ethereum is an open-source protocol, or more accurately it is a blockchain-based operating system (software platform), which is public and accounts with chain modeling. The structure of Ethereum uses Solidity software language and is developed with different certificates, which has enabled the placement and operation of code pieces called smart contracts on Ethereum [5,6]. In summary, the smart contract is the realization of the purpose of the agreement autonomously, without the additional discretion of the parties, if the contractual terms agreed upon by the parties are fulfilled [7–9]. In scientific publishing platforms, decentralized alternative studies are still in development, despite the many functions they promise. Despite suggestions such as review proposals using cryptocurrencies, voting [10], insurance [11], and storage of publications, no exact success has yet been demonstrated [12]. Accordingly, we propose a new model that uses blockchain technology and Ethereum smart contracts to create an effective decentralized scientific publishing platform. We compare traditional publication platforms and Ethereum-based smart contracts in Figure 1.

The proposed model is based on the Ethereum Virtual Machine and consists of three basic components. These components are front-end, middleware, and back-end. Firstly, the author sends a new article to the system that lists the journals most suitable for the article. It also assigns more than one editor to the submitted paper. The appointed editors make a preliminary decision. However, the system defines the reviewers. The selected editors and reviewers are automatically chosen by the Ethereum-based smart contracts system, with the points determined according to the research fields. Afterward, the article is forwarded to the selected reviewers. When the evaluation process is completed; every person who

contributes to this process, such as those who are in the pre-evaluation process; editors, reviewers, and the owners of the cited article receives the payment in cryptocurrency. In addition, the proposed system aims to increase the quality of scientific studies with new features. The process of the system and its features are listed below:

- The article information is entered into the system, and the system lists the appropriate journals by evaluating metrics, such as journal area, acceptance period, and acceptance rate;
- Appropriate editors and reviewers are appointed by the system. Owners of the publications referenced in the article and individuals from the same institution and region, cannot be editors or reviewers for related articles;
- After completing the evaluation process, the reviewers and editors comment on the article even if it is not accepted. If the article is suitable for a different journal, the same editor and reviewers can evaluate the paper according to the journal. If there is no need for re-evaluation, the article can be published directly in a different journal;
- If the article is accepted after the evaluation process, the first version of the article is published in the journal. There are two versions of the published article. Other authors can improve the quality of the paper by contributing to the first version and receiving an award;
- After the article is published, the authors can be paid tokens according to the number of citations they receive at 6 month intervals;
- Reviewers with successful evaluation scores can also be given more tokens as a reward.



Figure 1. (**a**) Traditional publication system; (**b**) Ethereum smart-contract-based publication system.

Thanks to the proposed system, a fast, efficient, and impartial broadcasting process is provided. With this system, monopolization in the broadcasting process is also prevented. Articles are published publicly for a small fee so that everyone can benefit from scientific contributions while reducing the cost of publication. The existence of such a system can make a significant contribution to both the publishing world and scientific literature.

The rest of the article is organized as follows. Section 2 first explains the preliminary information on the scientific publication systems and then provides state-of-the-art studies in the field. Section 3 clarifies the methodology of the proposed method. Section 4 discusses the results and evaluates the current publication systems. Section 5 lists the limitations of the proposed systems. Finally, Section 6 presents the conclusion and future research directions.

2. Related Work

To clearly define the problem and explain the solutions, we first present how the current scientific publishing system works in detail. Then, what kind of challenges the current system faces are listed, and how blockchain technology can decrease the current deficiencies is presented. Finally, the state-of-the-art methods related to blockchain-based scientific publishing systems in the literature are reviewed.

2.1. Scientific Publication System

Scientific publishing is one of the most profitable industries in which its annual profits can compete with the big technology companies. The scientific publishing industry is

dominated by a few publishers that did not update their publishing systems to adapt to the new technological developments [13]. Moreover, the traditional publication system has several problems, which decrease the quality of scientific papers and decelerate the publication process. These problems are high publication costs, slow and biased review process, copyrights held by publishers, lack of rewards for contributors, lack of connection among researchers, etc. On the other hand, the blockchain-based publishing system is proposed to eliminate the deficiencies of the current traditional publishing system and advance the quality of scientific studies. The platforms such as Orvium, ARTiFACTS, Everipedia, and Steem have started to provide knowledge sharing for scientific publication systems [13,14].

2.1.1. How the Traditional Publishing System Works

Data sharing among scientists has become easier with the increasing use of the Internet. Reputed publishers, such as Black & Wiley, Elsevier, Springer, and Taylor & Francis, use these technological developments in computer-based systems and knowledge sharing to make more profit and reputation in the publishing industry. However, they could not show the same success in enhancing the quality of scientific studies and sharing information among the researchers. The limitations of the current traditional publication system have a direct effect on regular human life because scientific developments lead to technological developments [13]. The general view of the scientific review process for the current traditional publishing system can be summarized in Figure 2. In the current publishing system, the publication process can be summarized as the following (Figure 2).

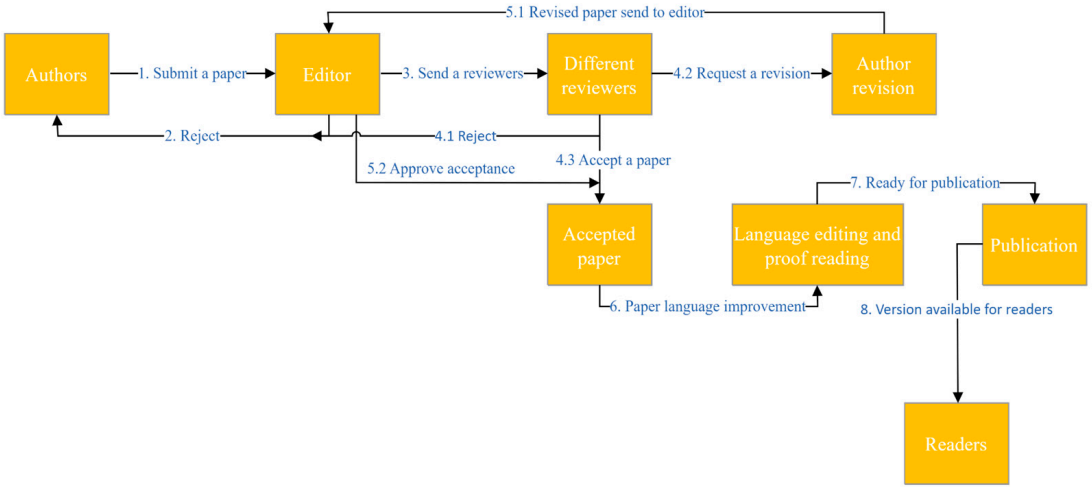


Figure 2. General view of the traditional publishing process.

0. The authors search for a suitable journal;
1. Authors submit for the selected journal;
2. The editor checks the paper and decides to reject the paper directly;
3. Editor assigns reviewers;
4. Reviewers check the paper and decide to reject, require revision, or accept;
5. Revised paper sent to the editor, and the accepted paper approved by the editor;
6. Accepted paper sent to the publication stage for language editing and proofreading;
7. The ready paper is put into the publishing queue and if the journal requires an article processing charge (APC), the authors pay the APC fee;
8. The paper is published and accessible to readers (in this stage, some journals require a subscription fee).

In the traditional publication system, the publishing process from author to journal and from journal to publishing takes approximately six to twelve months. Sometimes, this process can even take more time. This lengthy process delays the publication time and

becomes troublesome for most authors. This publication process time may vary based on the publishing company and publication types (open access or not), but the general delay process continues. Further, the current publishing systems face several other challenges during the publishing process. Even though a few preprint platforms are trying to eliminate the deficiencies of the existing traditional publication system, it is not enough, and most of the preprint platforms are not being used by many scientists. These challenges can be listed as the following:

Challenge 1—Difficult to set-up a new journal: Most of the journals are owned by only a few publishers. Because of this, there are various constraints to creating new journals and keeping these journals alive among the big publishers. Moreover, there are many different criteria to increase the related journal index, which makes it challenging to create new thriving journals.

Challenge 2—Difficult to find an appropriate journal: Finding the right journal for a study takes a lot of time. Most journal finders are not working decently to find the right journal, resulting in delays in scientific studies.

Challenge 3—No rewards for authors and contributors: It is hard to find appropriate editors, reviewers for specific domain knowledge, and other contributors to the paper. This problem arises because most journals do not pay the article contributors for their valuable contributions during the evaluation process. In addition, the authors, who contribute to the specific field and get many citations, do not earn rewards for their effort. The lack of a reward system discourages everyone who wants to contribute to world science.

Challenge 4—Biased review process (lack of transparency): The review process is biased and not transparent. Most of the time, journals cannot find appropriate reviewers having deep knowledge in related fields because the reviewers who have domain knowledge into related specific subjects want to receive rewards for their valuable evaluation. Since journals are not paying reviewers, finding appropriate reviewers becomes so challenging. This situation extends the time of the reviewing process, as well as raising issues concerning transparency. Even though some publishers claim that transparent peer review is being adopted, there are still some concerns regarding this issue.

Challenge 5—Copyright ownership held by publisher: In traditional publishing systems, even though all the works have been conducted by authors, the copyright is held by journal publishers, which provides the right to the publisher to copy the work and use research data freely. In some open access modes, the copyright may be owned by the authors paying high costs, which causes the issue.

Challenge 6—Lack of reusability: There are not enough connections and data sharing among researchers. When scientists claim new ideas, they start from scratch instead of adding new features to the existing works most of the time. This is because there is no information sharing among researchers. In addition, most scientists could not perform experiments conducted by different scientists [15]. Current publishers do not encourage scientists to share their data with other researchers, which results in time consumption for similar studies.

Challenge 7—Not enough integration between data and its results: Journals usually do not require and encourage scientists to link the data used during the experiment and their results. This case prevents scientific verification and reduces data sharing among researchers. Although some data repositories have been set-up (e.g., IEEE Dataport, Mendeley Data, and Code Ocean), there is still the problem that most of the authors do not publish their data on those platforms.

Challenge 8—Difficult to eliminate plagiarism: In the current publication systems, eliminating plagiarism relies on plagiarism checker programs, such as iThenticate, Grammarly, and CopyScape. These programs work regarding the predefined list properties, which can be easily evaded by paper writers.

Challenge 9—High cost: Most journals require a high publication fee from the authors to publish their works. This discourages scientists from working hard and pursuing new ideas to publish. On the other hand, journal publishers request subscription fees from

institutions and universities without doing the hard work. Publishers demand money when authors publish the article and a subscription fee to see other scientific studies.

Challenge 10—Long publication time: After authors finish their work, it takes approximately six to twelve months, even longer in some cases, to publish the papers. Such a long time discourages scientists from publishing new articles. Even researchers forget about their work details when they receive evaluation results from journals. Even though a few preprint platforms are available and free to use, it is not fully practical for use by authors.

2.1.2. How Blockchain-Based Publishing System Works

Blockchain is a new decentralized and distributed ledger consisting of a series of blocks [16]. Blockchain technology provides a proof-of-work model and transparency across the distributed network, which makes the overall system trustworthy [17]. A smart contract is a computer program that relies on the agreement between two entities and runs on the Ethereum blockchain [18,19]. Blockchain and smart contract technologies jointly provide novel infrastructure, which allows a decentralized trustworthy environment.

Recently, blockchain with smart contracts is used to solve various problems in several areas, such as the retail market, delivery system, automated financial system, secure internet of things devices, detecting malware, and securing cloud computing applications. It has also started to be used in scientific publishing platforms as well. The blockchain-based scientific publishing system brings many advantages over the traditional publishing system. To the best of our knowledge, only a few platforms, such as Orvium, ARTiFACTS, Everipedia, and Steem, have started sharing knowledge with researchers. In addition, only a few scientific papers proposed a blockchain-based scientific publishing system idea. As far as we know, our paper is the most detailed paper that explains the blockchain-based publishing system.

The blockchain-based scientific publishing system is still in the early stages, and the platform details are not yet explicit in the literature. Thus, our proposed platform will be one of the most extensive scientific studies in this context. Accordingly, we present the proposed system in detail in Section 3. Smart contracts (Ethereum-based automatic computer code blocks) are used for many transactions to make the process work with less human intervention in blockchain-based systems in many cases. Likewise, we would like to automate almost the whole process to reduce the biased peer-review process while increasing the paper quality and decreasing the costs and publication time. We can summarize these processes in the proposed system as the following: First, the author submits an article through a web application of the platform; then, the platform automatically proves authorship and adds it to the blockchain system. In this process, the system cuts down a small percentage of payment as a cryptocurrency from the authors by using smart contracts as well. In this stage, the first version of the paper is also available for readers. The platform also provides a list of appropriate journals for related articles, the author only needs to pick one from the list. After the journal is selected, the system assigns editors for articles as well as provides a list of reviewers for editors to decide from. The editors only need to select the reviewers from the available list. After the reviewers decide on the paper, the necessary updating request is sent to the authors. Finally, after proper editing takes place, the paper is published, and the last version of the paper is available to the public with a small fee, which is paid as cryptocurrency. In the later version of our system, we plan to make the system work as much without any editors and reviewers as possible. In this case, the whole process will automatize, and the editors, as well as reviewers, may only check the system decision.

2.1.3. Comparison of Traditional versus Blockchain-Based Publishing System

Even though the blockchain-based publishing system does not solve the publication process completely, it has several advantages over the traditional publishing system in many aspects. We think that a generally less biased publication process and lower publishing cost rewards all contributors, as authors hold copyright, etc. The comparisons of traditional

versus blockchain-based scientific publishing systems can be summarized in Table 1 based on previous studies [2,4,13,20–24]. It can be seen from Table 1 that there are some differences between blockchain-based publishing systems and traditional-based publishing systems in many aspects.

Table 1. Comparisons of traditional versus blockchain-based scientific publishing system.

Comparison Parameter	Traditional Publishing System	Blockchain-Based Publishing System
Time to publish	long	short
Time to access the article	generally long	short
Publishing cost	generally high	low
Access cost	generally high	low
Reward	no	yes
System support	low	high
Copyright ownership	generally publisher	authors
Link data with the article	generally low	generally high
Knowledge sharing	generally low	generally high
Biased evaluation	generally high	generally low
The score for editors and reviewers	no	yes

2.2. State-of-the-Art-Studies on Scientific Publishing System

As far as we know, there are not many studies proposed in the literature related to blockchain-based scientific publishing systems. The blockchain-based scientific publishing system methods are provided in research articles [15,20–23,25,26]. We discuss each related article based on the proposed method, main idea, and advantages–disadvantages.

Mackey et al. proposed a blockchain model that uses shared governance for scientific publication processes [20]. The suggested blockchain-based model validated inclusion using a DAO (decentralized autonomous organization). The DAO used the organization rule performed by smart contracts. The DAO consists of reviewers, editors, related scientists in the field, and publishers for managing and controlling the proposed framework. The model consists of front-end, back-end, and Ethereum Network. The front-end was embedded in current publication interfaces, which have MetaMask to store users' sign-in transactions and wallet information. The front-end used NodeJS to access the chain database, which is located in the back-end. The back-end communicated with Ethereum Network using the Ethereum JavaScript API. The Ethereum Network has smart contracts which are performed for publication management workflows. The paper claimed that the proposed framework enhanced the integrity and transparency of the scientific publishing system. The presented blockchain-based scientific publishing system is adapted from a similar framework in the literature. In addition, the proposed framework was not implemented and tested. To improve the paper quality, the proposed framework should be implemented and tested in active collaboration with the current scientific publishers.

An open peer-review system was proposed by Choi [21], which uses Hyperledger Fabric based on private blockchain. In the proposed system, the authors and reviewers were in the center position. The system provided a reviewer recommendation module. According to the reviewer recommendation module, colleagues, as well as co-authors, cannot be reviewers for related papers. Wang et al. presented a decentralized publication platform called PubChain [22]. To show the effectiveness of the presented system, the prototype was implemented using blockchain. The authors claimed that the proposed platform has several advantages over the centralized publication platforms. Daraghmi et al. suggested a blockchain-based editorial management system called TimedChain [23]. TimedChain provides an effective way to access manuscripts from submission to publication. To control

the transactions and provide the security, smart contracts and encryption techniques were used. The reviewed papers [21–23] are valuable because they created a starting point for a decentralized publication system, but it is not clear how whole components work properly.

According to Schaufelbühl et al., the traditional scientific publishing system is handled by just a few publishers, which makes the publication process inefficient [25]. To make the scientific publication system more efficient, they proposed a blockchain-based scientific publishing platform called EUREKA. The EUREKA provided ownership rights for article owners and rewarded editors and reviewers who contributed to a paper. The proposed system was implemented on the Ethereum blockchain, which consists of a front-end and a back-end. The front-end and back-end components communicate via a REST API to perform necessary jobs in the background. The article has many deficiencies, including the poor presentation of a proposed framework and not providing enough information on how the proposed framework exactly worked. In addition, the proposed framework performance and limitations were not discussed sufficiently as well.

A blockchain-based scientific publication platform, called Eureka, was presented by Niya et al. [15]. The authors stated in the paper that the Eureka platform incentive model increased the quality of scientific studies. The proposed platform consisted of three major components: front-end, back-end, and smart contracts. The front-end Daap (decentralized application) was used as an interface to interact directly with the Ethereum blockchain. The back-end interacts with the front-end to check contracts and update the dashboard when needed. The smart contracts bind Eureka to the Ethereum decentralized blockchain platform. When a new paper is submitted, the time stamp is added to a blockchain, and then the review is processed and added to the smart contract. To improve the quality of the paper, the contributions were paid as token-based cryptocurrency. Even though the proposed framework improved the traditional scientific publishing system, it did not clearly define how this process will be handled with different journals and make the blockchain process trustworthy. In addition, the implementation was carried out on a test case and was not tested in a real-world scenario.

Stojmenova Duh et al. introduced a blockchain-based decentralized scholarly communication model that relies on strategic game-playing by researchers [26]. According to the paper, the academic world puts a lot of pressure on researchers to rapidly publish scientific papers. However, this pressure decreases the quality of research papers. Moreover, the review process is not transparent and is biased, which causes a decrease in the quality of scholarly communication. The strategy behind the proposed model is to introduce new ideas rather than publish scientific studies in a short period. In the presented model, smart contracts were used to provide a modifiable continuous peer-reviewing process for research papers. When authors submit the research contents to the blockchain-based platform, the content subset is hashed and added into the blockchain system to guarantee authorship. Users who contribute to the paper's contents earn system tokens. This incentive reward system enhances the overall paper quality. There are some drawbacks in the paper, which need to be addressed. The proposed idea was not presented fluently, and the contributions of the paper are not clear. The implementation of the idea was not provided elaborately, and the algorithms of the proposed system were not mentioned as well. Moreover, the limitations of the proposed idea were not discussed at all.

2.3. Evaluation of Blockchain-Based State-of-the-Art Studies on Scientific Publishing Methods

Since the idea of blockchain-based publishing systems is quite new, there are no numerous research papers published in this field. The articles evaluated in the literature reviews suffer from many aspects, which can be seen in [15,20–23,25,26]. For instance, in the study [20], the proposed blockchain-based system was adopted from a similar framework from the literature, so the novelty was limited. In the study [25], the proposed framework was poorly presented, and not enough information was provided on how the proposed system exactly works. In the study [15], the whole process will be handled with different journals, and making the blockchain process more trustworthy was not presented.

In the study [26], the proposed idea was not presented fluently, and the contributions were ambiguous. The deficiencies mostly seen in current blockchain-based state-of-the-art studies can be listed as follows:

1. They do not clearly discuss the problem;
2. The proposed framework was poorly presented;
3. It was not clear how the proposed framework exactly work;
4. Only 1 or 2 papers had a test case and implementation;
5. The implementation details of the methods were not well presented;
6. The limitations of the proposed methods were not given.

The proposed method explains the challenges of the current system and makes necessary contributions in each step to make the system work better. In addition, we added extra features to the idea of a blockchain-based scientific publishing system to make the publication process fast and more efficient. The details of the proposed system are given in the following section.

3. Proposed Method

This section is divided into two subsections, namely, design and implementation.

3.1. Design

In our proposed model, in all transactions, the smart contracts perform smart decisions automatically during the publication process. In other words, we would like to automate almost the whole process to decrease the biased peer-review process while increasing the paper quality and decreasing the cost and publication time. Figure 3 presents our proposed blockchain-based publication platform.

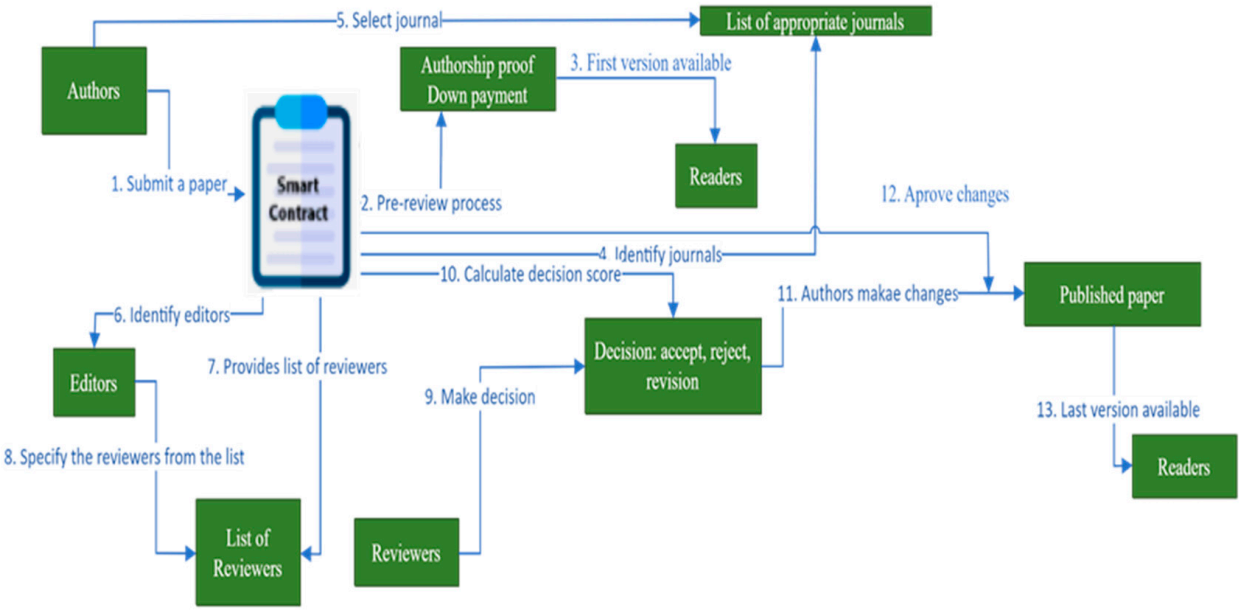


Figure 3. The proposed blockchain-based publishing system.

A user (or author) should have a wallet to keep Scientific Journal Platform (SJP) tokens for a submission process. In other words, users need to have enough balance to continue their submissions. Surely, users can access the system with their wallet number and be able to own tokens if needed. After the users obtain enough tokens and pass the balance check via the system, they can submit their manuscripts. As soon as the manuscript is submitted, the responsible editor checks its eligibility in terms of scope, journal format, and plagiarism detection (iThenticate report). If the manuscript passes the precheck conducted, the editor selects the reviewers from the list provided by the smart contracts. To accelerate the review process, more reward is provided based on the reviewers' performances.

In the proposed model, the number of reviewers can be declared based on the user's request. The user can determine the number of reviewers concerning the cost of the review. The system generally selects more than needed reviewers for specified time intervals. The system automatically selects different reviewers after some time, if the previously chosen reviewers are not available. Moreover, the reviewers who accept and finish the review on time or before will be rewarded more to decrease the reviewing process time.

When a reviewer completes the review, she submits the review via a smart contract to the SJP. The reviewer can prefer to fill out the review form on the website or upload a review document. After the reviewer completes the task in time, the editors and smart contracts evaluate the quality of the review to prevent fake reviews. The smart contracts can check the review time and apply a late fee to force the reviewers to complete the submissions on time. Accordingly, based on the quality of the review, the editor and the smart contracts provide a rate for the review. If the paper is rejected for a related journal, the author can select a different journal from the journal list. In this process, all the reviewer's comments and editors' decisions will be available to the current journal editors. Based on the journal quality, the paper can be accepted with revision (in this case no re-evaluation) or may be sent to the new reviewers. In the later version of our system, we plan to make the system work as without any editors and reviewers as possible. In this case, the whole process will automatize, and the editors and reviewers may only check the decision of the smart contract.

Our proposed blockchain-based publishing model accelerates the publication process while decreasing the publication time and cost. The time and cost will be less because we accelerate the publication process by automating most of the process using smart contracts, also by providing more rewards when reviewers finish their job faster. The publication cost will also diminish because it will require less human intervention. Moreover, all parties who support and contribute to the paper (editors, reviewers, cited authors, etc.) receive some amount of SJP token-based cryptocurrency. The smart contracts are included in the review process to reduce the biased evaluation process as well. The novelty of our blockchain-based scientific publishing system can be summarized as follows:

1. The authors hold copyright;
2. Reasonable publication cost;
3. Reasonable access cost;
4. Speeding up the publishing process;
5. To link the article with its data;
6. The reward for all contributors;
7. Authors vote for editors and reviewers;
8. No need to resubmit for rejected article;
9. Easier to create new journals;
10. Link journals to a social platform for more contributions and transparency.

3.2. Implementation

As seen in Figure 4, our method has three main components: front-end, back-end, and smart contracts to connect Scientific Journal Platform (SJP) tokens to the Ethereum blockchain. In this section, we present details of these components.

3.2.1. Front-End

We implemented a decentralized application (DApp) to interact with the Ethereum blockchain. An user interface API is created using Asp.Net with the C# programming language. Accordingly, we integrated Dapp browsers that use the MetaMask extension to provide a way for the user to submit their manuscript to the smart contract. Unlike the Eureka scientific publishing platform, SJP accepts manuscripts as files rather than URLs [15].

Registration Module: In our proposed framework, we ask the user to use their Metamask account for registration. Since the Metamask ID is unique for each user, we do

not need to obtain another user ID. Then, we ask for related information, such as name, surname, e-mail address, country, password with password checker, and fields.

Login Module: when a user creates an account in the system, they can directly sign in to the system using a Metamask account.

Article Submission and Article Status Modules: If the user is an author and would like to submit an article, they navigate to the article submission module. In this module, the user fills related fields, uploads the manuscript, and then submits it to the system. Finally, the system navigates them to the payment module. In the article status module, the author can check the status of the article after completing the submission.

Payment Module: In this module, the author pays the amount with the Scientific Journal Platform (SJP) token, which we present in Section 3.2.3 in detail, by connecting their Metamask Account.

Reviewer Assignment Module: There is also a manager, in other words an editor, in the system. The manager is responsible for assigning the submitted article to the corresponding reviewers. The manager selects an article from the article list, then assigns the reviewers after filling in related fields on the module. Then, an information e-mail is sent to the reviewers.

Review Submission Module: On the reviewer side, the reviewer submits their comments after evaluating the submitted paper. Definitely, we provide an option for the reviewer to submit their comment as a file.

3.2.2. Back-End

In SJP, we use a SQL database to keep related documents and information. The front-end communicates with the database via REST API JSON protocols. In addition, we run our local tests on an open-source platform called Ganache, which enables us to test our smart contracts without any cost [27]. We manage the database and interact with the Ganache using a Node.js application.

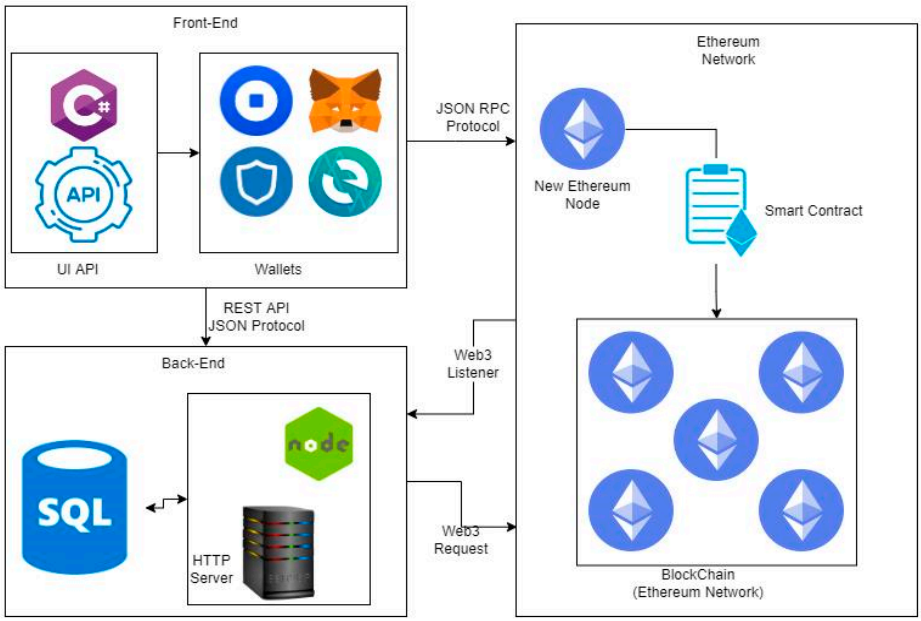


Figure 4. Proposed blockchain-based publishing system Scientific Journal Platform.

3.2.3. Smart Contracts and Scientific Journal Platform (SJP) Token

A user can submit a paper by using a web browser that has the MetaMask extension. Such web browsers provide the ability to access the Dapp by using the standard web3.js JavaScript API that enables the generic JSON RPC specification for providing an interface for the RPC methods.

Accordingly, we implemented a Scientific Journal Platform (SJP) token, which contains the ERC-20 standard and all substandards that are used for integrating smart contracts on the Ethereum blockchain [28]. We implement the transfer via a call for a transfer (called transfer() and transferFrom(), respectively) functions based on the ERC-677 token [29,30]. For both functions, specific parameters, such as an address to, address from, and token units, can be provided to the functions as parameters. The functions are provided in Figure 5.

```
function transfer(address to, uint tokens) public returns (bool success) {
        balances[msg.sender] = safeSub(balances[msg.sender], tokens);
        balances[to] = safeAdd(balances[to], tokens);
        emit Transfer(msg.sender, to, tokens);
        return true;
    }

    function transferFrom(address from, address to, uint tokens) public returns (bool
success) {
        balances[from] = safeSub(balances[from], tokens);
        allowed[from][msg.sender] = safeSub(allowed[from][msg.sender], tokens);
        balances[to] = safeAdd(balances[to], tokens);
        emit Transfer(from, to, tokens);
        return true;
    }
```

Figure 5. Transfer() and transferFrom() functions.

In addition, the SJP token contract assures whether a user has enough balance or not. In addition, it allows the user to transfer SJP tokens and pay transaction costs using SJP tokens. These processes are conducted using the implemented balanceOf(), totalSupply(), allowance(), and approve() functions that are provided in Figure 6.

```
        function totalSupply() public view returns (uint) {
                return _totalSupply  - balances[address(0)];
            }
            function balanceOf(address tokenOwner) public view returns (uint balance) {
                return balances[tokenOwner];
            }
            function allowance(address tokenOwner, address spender) public view returns
(uint remaining) {
                return allowed[tokenOwner][spender];
            }
            function approve(address spender, uint tokens) public returns (bool success)
{
                allowed[msg.sender][spender] = tokens;
                emit Approval(msg.sender, spender, tokens);
                return true;
            }
```

Figure 6. TotalSupply, balanceOf, allowance, and approve functions.

4. Evaluation and Discussion

For many years, the scientific publication system has faced many problems. Due to the limited number of scientific publishers, evaluations take a long time, are possibly biased, and the article published in a journal in the wrong field are just a few examples of these problems. With the developed method in this study, it has been tried to avoid or reduce these problems to the minimum extent. In this context, a blockchain-based method based on Ethereum smart contracts has been proposed. The features of this developed method, contributions, and results provided to this field thanks to these features are listed as follows:

- **Listing the appropriate journal for article publication:** During the listing of the appropriate journal, filters such as the area of the journals, the average publication time, and the average article acceptance rate were used. In this way, the possibility of

publishing the articles in the wrong journal outside the scope of the field is prevented. In addition, an appropriate journal list accelerated the publication process.

- **The most suitable editors and reviewers are appointed by the system:** With the rule determined at this stage that the cited authors and authors from the same institutions and the region cannot be an editor or a reviewer for an article, the biased evaluation process is decreased. In addition, the most cited authors with domain knowledge are automatically assigned as editors and reviewers in our proposed system.
- **Fast evaluation process:** If the article is not accepted for the current journal, but the article is suitable for a different journal, the previous editor's and reviewer's evaluation are taken into account for the evaluation process in the new journal (the paper that is not good enough for the high-quality journal can be appropriate for less prestigious journals). In this way, the process of submitting separately for each journal is eliminated in terms of the author, and the expected time for evaluation is saved. When the evaluation process is over and accepted, the article is published in the journal.
- **There are two versions of the published article:** with this feature, the ability of other authors to contribute to the first version ensures that quality articles are presented in the literature.
- **Most cited articles' authors get paid in 6-month intervals:** The authors of the most cited papers get rewarded with a system token every six months. This feature encourages authors to work hard and publish high-quality scientific studies.
- **Reviewers with successful evaluation scores can also be awarded more tokens:** This allows the reviewers to keep the evaluation period short and to make more careful, detailed, and high-quality evaluations. In addition, this feature contributes to both sides by increasing the review quality and, thus, the publication quality.

The proposed SJP and other proposed blockchain-based publication platforms [15,20] are new systems that we need to evaluate over a period to collect enough data for comparing and obtaining sufficient statistical findings. This is a process that will be resolved with a healthy analysis in future works. However, we aim to solve the limitations, as mentioned in Section 2, of the proposed blockchain-based platforms: not being implemented or tested [20], missing information to clarify the components of the system [21–23], the ambiguity of the system presentation [25], lacking implementation of the idea [26], and ignoring the part handling diverse journal connections and trustworthiness [15].

5. Limitation of the Proposed Method

A system has been developed that aims to prevent monopolization in the scientific publishing system, accelerate the process of publishing articles, and can make an unbiased evaluation. In addition to the important contributions made, our system has some limitations. These limitations can be listed as follows:

- Data are limited and data loss may occur;
- Many people still have not mastered the use of blockchain;
- MetaMask wallet is used in the system, and there may not be many users with this wallet;
- The reviewer assignment system can also be improved by adding machine learning techniques;
- There may not be enough editors or reviewers to be appointed in the system;
- The developed system has been tried and tested but should be tested with real publishers;
- The system can be made more consistent by adding more rules to the system;
- Our system is not currently used in real time, so we do not have enough data. However, when real-time is used, the data we have will increase, and our claims can be calculated statistically;
- The proposed publication system requires reward sharing among stakeholders, such as reviewers, editors, and the current publication system holders. However, current publication system holders may refuse to use this system by following the policy of not

sharing the reward. For this reason, we need a new publication consortium containing the stakeholders who agree to use this system as an alternative to the current systems. Surely, this is a process that will take time;
- In addition, it is aimed to make the editor system autonomous by applying machine learning techniques on the system developed in our future studies.

It is planned to develop the proposed system further by adding the abovementioned shortcomings, and limitations for future studies. In summary, for future work, we aim to expand our application and test the proposed system with publishers in real time. In addition, it is planned to decrease the publication time of the article while increasing its quality by adding different algorithms and features to the system.

6. Conclusions

Computer-based systems and related technologies are continuously improved to meet business and scientific requirements. The scientific publication industry still has not change its publishing model to increase productivity. The current scientific publishing industry is dominated only by a few publishers that use centralized systems and faces several problems related to the publication process. These deficiencies are mainly a long evaluation process, high publication cost, lack of rewards for evaluators, and highly biased process. These insufficiencies decrease the quality of scientific studies while delaying the publication process.

Blockchain technologies provide decentralized environments to many scientific fields to improve the efficiency of the current models. Blockchain and smart contracts allow decision making more efficiently and provide proof of work for many industrial applications. In this paper, we operated the blockchain and Ethereum smart contracts to build a decentralized, efficient scientific publishing platform. We implemented our model based on Ethereum Virtual Machine (EVM). The system consists of three main components: front-end, middleware, and back-end. First, the author(s) submit a scientific paper to our new publication system. The system automatically determines the most relevant journals and assigns more than one editor to the article. After editors make their first decision, the selected reviewers receive the paper. Editors and reviewers (reviewer list given by the editors and appropriate reviewers chosen by the system) are automatically selected by the system for given scores based on each field. At the end of the evaluation process, each contributor (such as editors, reviewers, and authors of cited papers) receives a reward as a token-based cryptocurrency.

The proposed system is fast, efficient, and makes the publication process easier. The system lowers the publication cost, making the publication process fully traceable and making the scientific papers globally available to anyone with a small fee. Our system also allows copyright ownership for authors, provides journals with decentralized models, and integrates scientific papers with related data or datasets. The suggested system also improves the quality of scientific studies by adding new features to the publication process. These features are summarized in the following:

- Authors referenced in the article should not be editors or reviewers for the related article;
- To increase the scientific paper quality, the process is progressed according to the evidence that the authors, editors, and reviewers are not related to one another;
- Authors should be paid tokens based upon the number of references they receive at 6 month intervals after the article is published;
- The author(s) enters the article information, and the system returns the most suitable journals according to the best criteria (money, acceptance rate, journal quality, acceptance period, etc.);
- New metrics are considered to choose the most appropriate editors and reviewers;
- More tokens are given as awards to the reviewers with good evaluation scores;
- If the peer-review process is over for the paper that is not accepted for the current journal, the reviewers and editors comment on the paper in which the journal can be published. If the paper is appropriate for a different journal, the same editors and

reviewers can evaluate the papers (if no need to evaluate again), and the paper can be published in a different journal directly;
- There are two versions of published papers, such as that for the first version other authors can improve the paper quality by obtaining rewards;
- In future work, we aim to extend our implementation and try our system with real publishers. In this process, we will test our system with some journals from different platforms and evaluate the feasibility of the proposed model in a real-world environment. Further, more rules will be added to the proposed model to improve the quality of scientific studies while decreasing the biased evaluation process.

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