

A decentralized paper dissemination system employing blockchain technology, peer review and expert badges – First report

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Motivation

Access to high-quality research is a critical matter when it comes to developing new methods and techniques for problem solving, or to proposing innovations in various fields of study. Researchers showcase their ideas by writing articles and presenting them at conferences or publishing them in journals. Regardless of the publication method, the article validation involves a peer review process, which implies that members of academia and experts in their fields evaluate the article and offer notes on how to improve its quality.

The peer review process [1], which is currently accepted as the status quo, is not without flaws. The associated control flow that ends with a paper being published consists of editors who aggregate the feedback from reviewers and then decide if the paper is relevant enough to be published. An important aspect that can taint this flow is the integrity of authorship and, specifically, unethical peer review [2]. This can lead to paper retractions, a decrease in trust of the involved journal or conference, and of the overall peer review process.

Currently, there is no adequate method of checking if a reviewer read the whole article or just skimmed through the introduction and offered a superficial review. Such superficial reviews offer no assistance to the author on how to improve the paper and no insight to the editor, who has to decide if the paper gets published.

Another issue is the reviewer's level of knowledge regarding the paper's topic. Usually, manuscript management systems allow reviewers to input their degree of confidence regarding their expertise on the topic. This, however, is no real indicator respective to their level. A finer approach is impartially validating the reviewer's knowledge and ensuring that the paper is handled by experts.

The purpose of this paper is to provide the means for constructing a solution which improves the current peer review system and facilitates access to the published papers. This is achieved by integrating new technologies, such as blockchain, into the traditional process of article reviewing, which currently creates concerns regarding integrity and accuracy. Most platforms used for peer review are centralized, which implies the existence of a third party control, instead of a community driven alternative.

The internet represents a vast network of interconnected devices that facilitates global information dissemination. It is underpinned by a complex set of protocols and standards, which determine data transmission and reception. This rigorous approach offers a remarkable degree of resilience and adaptability. The revolution sparked by the internet has been regarded as one of the most significant and transformative shifts in human history. Due to its compact and portable nature, digital information offers a higher degree of efficiency compared to other forms of information [3].

Despite its numerous benefits, the internet still has its shortcomings. One such issue is the challenge of ensuring the security and privacy of the transmitted data. The internet's intrinsic structure also leaves it vulnerable to single points of failure, which can be harmful to the network. Another significant challenge is the questionable integrity of various parties, including individuals, organizations, and governments.

Blockchain has emerged as a potential solution to the above mentioned issues, offering a decentralized and transparent approach to data storage and transaction processing. By utilizing a distributed ledger that records transactions in a secure and immutable manner, blockchain promises

to enhance security, transparency and efficiency [4] of all online transactions, while also enabling a greater degree of trust in digital interactions.

Related work

Editorial peer reviewing has been around since the 20th century and the institutionalization of the process served the purpose of meeting demands regarding objectivity in an increasingly specialized world [5]. Nevertheless, the means of evaluation are no longer fit for today's increase in the number of paper submissions, which has led to rushed and perhaps superficial reviews [6].

Internet based peer review systems constitute over 80% of publisher employed systems, according to ALPSP [7]. The Open Access and Open Science movements have come very far regarding cutting costs for information access. These movements have managed to set aside previous cultural borders and create the means for global scientific exchange and equal chances.

However, one of the most emphasized adversities of the system is the lack of quality control. It appears that this unreliability comes from the fact that approximately six reviewers would be needed for quality assurance, whereas, in practice, editors typically use two or three [8]. One study [9] discovered that the odds of two reviewers agreeing when it comes to a particular paper were only slightly better than chance.

There are several well-known peer review systems for conferences and journals like PaperCept [10], EasyChair [11] or MDPI [12]. These solutions use the same paper submission process, containing the deficiencies which were previously discussed in this paper. MDPI has the advantage of also publishing papers in an open-access manner, i.e., once published, anyone can access those articles without paying any fee. This is due to the fact that the author pays a fairly large amount of money to get the paper published.

Alternatives that challenge traditional publication processes have been around for some time. Preprints are full draft research papers that are shared publicly without peer reviewing, which enables writers to gain more visibility [13]. Such initiatives tackle the concern regarding reviewer unfairness by removing the peer review process completely from the publishing scheme. However, some argue against this [14], in the sense that even slightly biased reviews can sometimes prove more beneficial than the complete absence of peer reviews.

The BMIF Journal [15] suggests a peer review process that is double-blind, for both reviewers and authors, which should prevent all entities from forming bias.

The Hyperjournal project has a distinctive approach, because it stores the accepted, as well as the rejected articles in its repository. This is a method of acknowledging that the notion of quality is strictly correlated with other extrinsic factors [16].

All of the above mentioned system share one identical characteristic: centralization. Centralization means bureaucratic leadership, which often implies that some entities have disproportionate power. In this context, third parties have more control than the scientific community and editors have more authority that it is necessary. The data record may also be manipulated, e.g., by malicious conference organizers or editors who plan to plagiarize from submitted work [17]. Decentralized systems eliminate such issues by employing traceability. Furthermore, if there is no more need to pay the editor, there is more money for the reviewers, in order to ensure the quality of their work.

The current motivations for people to participate in peer reviewing are prestige and the desire to determine quality in a research area [18]. Nevertheless, a financial motivation could benefit everyone from the scheme.

One decentralized approach is a currency system for academic peer review [19]. In the proposed exchange system, the users are paid with a cryptocurrency called r-coin, which can be further used for the cost of publishing in a journal. Another decentralized approach, which involves a tokenized peer review system [20] as well, suggests penalties for members that do not uphold the agreed standard.

Nevertheless, creating a currency for peer review systems cannot provide the means to solve the problem of having too few people that offer reviews. A cryptocurrency that can be used solely to publish in a journal will probably not attract many new people into the ecosystem. The infrastructure for exchanging cryptocurrency is still in its infancy. Therefore, exchanging r-coin for another more widely used coin could actually mean losing money, due to fees. Until the infrastructure evolves further, coins with a broader use remain a preferred choice. The proposed Paper Dissemination System (PDS) offers payment in a more popular coin, Ether, that people can use for other transactions as well, without having them limited to a token that only has value inside the academic peer reviewing system.

Name of the system	Decentralized	User Remuneration	Double-blind reviews
Preprints	✗	✗	✗
BMIF Journal	✗	✗	✓
Hyperjournal	✗	✗	✓
R-coin	✓	✓	✗
PDS	✓	✓	✓

Figure 1: Comparison of the proposed system (PDS) with other similar solutions

Hardware/software resources

The successful implementation of any software system requires careful consideration of the resources that will be required. In the context of the proposed solution, a diverse set of programming languages have been selected for the development of various system components, each tailored to specific requirements.

User interface

The user interface is built using HTML, CSS and Javascript. The decision results from a preference for these technologies over modern frameworks, such as Angular or React, due to the short-lived nature of the latter. Such frameworks have a greater likelihood of becoming obsolete and falling out of favor in the development community. In contrast to that, the fundamental components of HTML, CSS, and Javascript endure over extended periods, providing greater stability and longevity to the developed system. The interface is built using Visual Studio Code, which is a free to install IDE, and a lightweight programming tool.

Web services

The Java-based API code is developed in the Spring Boot Framework, which simplifies the development process, by providing numerous pre-configured features, which accelerate development time. The decision to opt for Spring Boot was influenced by the scalability and robustness

that it offers. In the context of this Paper Dissemination System, employing Spring Boot means that any future improvements to the system can be readily implemented. For this part, IntelliJ IDEA was deemed the preferred option, since it includes a fully functional integration with Maven and Gradle build systems.

Database

A relational database is used for storing the data from the system. MySQL offers many advantages, as it is ideal for storing structured data and most data in the current context is structured. Additionally, MySQL provides flexibility and scalability, the latter being essential, as article reviewing systems generally need to handle a large number of articles and reviews. The database is hosted by XAMPP, a software package that includes Apache web server, MySQL database and PHP scripting language. XAMPP simplifies the organisation of data, providing a graphical interface for SQL (phpMyAdmin).

Smart contracts

Solidity is an object-oriented, high-level programming language for implementing smart contracts. Given that the contracts in this system operate on the Ethereum Virtual Machine, and Solidity is the predominant programming language used in the Ethereum blockchain, the smart contracts have been developed using this language. Remix IDE is an online tool, used for the entire journey of smart contract development. One of the most significant advantages of Remix is that it eliminates the need to set up and maintain a local Ethereum node, which can be a resource intensive process. As a result, the development process is significantly accelerated.

In terms of hardware resources, no special requirements have to be met, in order for the system to be used.

Selected algorithms or methods

Blockchain

Blockchain is an immutable ledger that is continuously updated and shared among a network of peers. There are many blockchain-based applications and systems [21], because it is ideal for delivering and tracking information by maintaining a secure and decentralized record of transactions. Blockchain is free from censorship, it is not controlled by any single party, instead, it relies on the trustworthy network of nodes and on consensus protocols for validation. In addition to this, blockchain is also immutable and transparent, since data cannot be tampered with, due to the fact that any change will reflect in all the other nodes. In order to maliciously alter the state of a blockchain, 51% of all the computing power from the network would be required. Removing all third-party interventions creates an efficient system and reduces the cost for the business.

In the context of this paper, the security employed by blockchain means that the data record can no longer be manipulated by other entities looking to profit from the work of others. An unaltered history of paper submissions and provided reviews is permanently available. Furthermore, third party removal accelerates the peer review process and reduces costs.

Ethereum Blockchain and Smart Contracts

Whereas the Bitcoin blockchain was primarily designed to enable a completely distributed digital currency and the exchange and storage of value, the Ethereum blockchain is programmable and establishes a peer-to-peer network with various applications in fields like finance, web browsing, gaming, etc. The Ehtereum network securely verifies and executes application code, called

smart contracts. A smart contract is a snippet of code, executed within the network, inside the Ethereum Virtual Machine (EVM), which cannot be altered after its deployment. It runs as it is programmed to, establishing independence from its creators and automatic enforcement.

In this Paper Dissemination System, smart contract are employed for different flows: when users are awarded a skill badge, upon successful completion of a test, when the author uploads an article, to store they payment and at the end of the review stage, when users are remunerated.

Non-fungible tokens

Non-fungible tokens, also referred to as NFTs, are cryptographic assets, that rely on block-chain technology and are designed to prohibit interchangeability with other assets. Originally, virtual objects were thought to be indistinguishable from one another, but digitally distributed ledger systems brought innovations that created grounds for non-fungible items [22].

Through the use of NFTs, one can prove the ownership of a digital asset, in the form of an image, song, video, character from a game or ticket to an event. Although still in its infancy, this technology has been adopted in different sectors, such as: digital collectibles, characters in games [23], securing ownership of domain names [24], music [25], or even sneakers in the fashion industry [26]. Furthermore, features like traceability, deep liquidity and convenient interoperability suggest that this technology is a "promising intellectual property (IP) - protection solution" [27].

To review a paper in the proposed system, users are required to take and pass one or more tests. Upon passing a test, the user is awarded a badge, which attests a certain skill and level. All badges act as NFTs, so that participants are granted complete ownership.

Expected results

The proposed Paper Dissemination System represents a decentralized solution, meant to persuade more experts to connect with the scientific community, by offering peer reviews, and receiving payment for their contribution. The system is also devoted to building a trust-worthy network of peer reviewers, all of which have been rigorously assessed, prior to grading a paper.

By employing smart contracts, non-fungible tokens and blockchain technology, the system establishes autonomy, traceability and becomes tamper-proof. Double-blind reviews eliminate bias, while the involvement of the previously mentioned technologies creates a culture of accountability. All these features build the infrastructure for a community-driven alternative to the current peer review process and by doing so, solve the existing issues regarding unreliability and challenge the traditional involvement of third parties.

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