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# Blockchain-based reputation system for peer reviewing

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Master's Thesis

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Máster en ingeniería informática

Masters degree in software engineering

Facultad de Informática

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# Blockchain-based reputation system for peer reviewing

*Memoria que presenta para optar al master en ingeniería informática*

**Viktor Jacynycz García**

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*A mi madre, porque sí*

*A mi hermano, porque también*

*A jenny, poque tl*

*A mi padre, porque yokse*





# Agradecimientos

*I find your lack of faith disturbing*  
Darth Vader, Star Wars: A New Hope.

I thank you.



# Resumen

...  
...

... Resumen chulo



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# Capítulo 1

## Introduction

*Who Watches the Watchmen?*

Watchmen - Alan Moore

Scientific research nowadays is based on publications in journals with a high impact factor[1], the most well-known is the Journal Citation Reports (*JCR*). This factor was originally determined by the Science Citation Index, born in 1955[2] but nowadays it is managed by a private company dedicated to benefit from the work of researchers[3]. This poses two important problems when it comes to entering the world of academic research:

The first is that scientific journals that want to maintain their impact factor, have to make sure that the articles that come out in their issues have a large number of citations, so they are always going to look for novel and high-impact articles. Therefore, the editors of these journals will have a network of reviewers on which they can trust to review the article. But sometimes these reviews are not entirely objective, there are many cases of unfavorable reviews due to gender causes, especially in scientific fields [4].

Besides, it is necessary to consider that the time of revision for an article is excessively long, causing the process of academic investigation being quite slow [5].

The second problem is that the benefits of the scientific distribution are centralized in publication systems, nor the authors, the reviewers or the readers get money from it. Today, with electronic paper distribution, universities purchase site licenses for online access to journal contents. This system implies an additional cost for the universities who want to advance in their research fields and does not have enough money for it. However, site licenses are not always disadvantageous. Some journals issued by private companies and universities adjust their prices to maximize subscriptions [6]. But generally, people who earn money from this paper-based system only act as an intermediary between the authors, the reviewers and the readers.

The internet offers the possibility to meet people all around the world, and when it comes to trust total strangers, you should have a system in which you can rely to deposit your trust in them. Reputation systems are the solution to this problems, since they offer you a first good impression of an unknown person [7].

Editors who want to assign the review of a paper to a series of reviewers have to rely on them beforehand. Thus limiting the spectrum of fields that can be revised to the fields in which those reviewers are experts. If you want to broaden the scope of reviewers with more fields of expertise, you need to contact new reviewers. But there is no easy way to predict reviewer quality from reviewers training andviktor@jacynycz.es experience factors [8], so a rating system of reviewers should be useful for journals to select the best reviewers. The solution is a reviewer reputation network, in which reviewers get rated based on their reviews and build up their reputation based on good practices, and helpful reviews. In this network, publishers who have to find new reviewers for their papers, do not have to know them beforehand, since trust is placed in the reputation network instead of the person itself.

Science publication and peer review are based in a paper-based paradigm, with few changes in the last centuries [9]. Critics to current science publication and peer review systems include concerns about its fairness [4], quality [10], performance [5], cost [6], and accuracy of its evaluation processes [1], among others.

The development of the Internet enabled the proposal of alternatives for science dissemination [11] and evaluation [12]. The reduction of distribution costs enabled wider access to scientific knowledge, and questioned the role of traditional publishers [13]. It is acknowledged that the Open Access and Open Science movements have successfully reduced the economic cost of readers to access knowledge [14]. However it has not successfully challenged traditional publishers business models [15] that are now combining charging readers and charging authors [16].

Peer review has suffered multiple criticism, and yet only marginal alternatives have gathered success [17]. The literature provides multiple proposals around open peer review [18], and proposals of reputation networks for reviewers [19]. In fact, a start-up, Publons<sup>1</sup>, provides a platform to acknowledge reviews and open them up.

## 1.1. Objective

We aim to challenge middlemen in science publication such as traditional publishers. Particularly, we propose a decentralized publication system for open science, allowing 1) paper submissions, 2) assignment of reviewers, 3) peer review, and, as a novelty, 4) the rating of peer reviews. With this distributed system, we aim to improve the quality and efficiency of reviews and knowledge distribution, helping editors, authors, and reviewers:

- Editors and journals will be able to find the best peer reviewers in their fields of interest, and those that respond quickly. Thus reducing time-to-publish and publishing costs.
- Authors will be able to submit papers to time-responsive, free, open access journals, and forget about slow, unfair and unaccountable anonymous reviews.
- Reviewers will finally have their work recognized.

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<sup>1</sup><https://publons.com/>

We are interested in exploring the following challenges, that could be dealt with our technology:

- Reduce time-to-review by rewarding on-time reviewers.
- Measure and prevent sexism, nepotism and other abuses in peer review.
- Develop fully autonomous decentralized journals.
- Explore fully free publication systems for Open Access science, while enabling innovative business models.
- Explore alternative and open metrics for papers, journals and reviewers.

## 1.2. In this work

In this work there will be the following sections:

- **State of the art:** This chapter is about what methods, systems and technologies try to change the actual publication systems and how good or bad they are.
- **Methodology and Technology:** This chapter is about the methodology I followed during the realization of this work, and the technologies I have used to face the challenges and why I decided to use them.
- **Platform description:** This is the main chapter of this work. It contains the platform description, its implementation, how it works, why is better than the actual publication systems, the challenges I have faced during the realization and the internal structure of the final system.
- **Results and discussion:** This chapter is about the results obtained after the realization of the work proposed in this project, how it will affect the scientific community and how I measured the potential impact if it becomes a wide-used publication system.
- **Conclusion and future work:** This chapter is about the implications of this work in the scientific community and settles the next steps to follow to create an ecosystem of autonomous publication systems without the need of middlemen such as journals or editors, proposing a future PhD about this subject.



## Capítulo 2

# State of the art

*The needs of the many outweigh the needs of the  
few*

Spock - The Wrath of Khan

Decentralized alternatives, despite their promises [20], are still in their infancy. A few proposals, none of them functional to date, have appeared recently: a peer review proposal using cryptocurrencies [21], a blockchain-enabled app with voting and storage of publications, again using cryptocurrencies [22], or a peer review quality control through blockchain-based cohort trainings [23]. Additionally, Ledger<sup>1</sup> journal records the publication timestamps in the Bitcoin blockchain.

This paper proposes the development of a decentralized publication system for open science. It aims to challenge the technical infrastructure that supports the middlemen role of traditional publishers. Due to the successes of the Open Access movement, some of the scientific knowledge is today freely provided by the publishers. However, the content is still mostly served from their infrastructure (i.e. servers, web platforms). This ownership of the infrastructure gives them a power position over the scientific community which produces the contents [24]. Such central and oligopolistic position in science dissemination allows them to impose policies (e.g. copyright ownership, Open Access prices) and concentrate profits.

The proposed system aims to move the infrastructure control from the publishers to the scientific community. It entails the decentralization of three essential functions of science dissemination: 1) the peer review process, 2) the selection and recognition of peer reviewers, and 3) the distribution of scientific knowledge. The following section provides an overview of the system features, while the final section discusses its challenges.

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<sup>1</sup><https://ledgerjournal.org>





## Capítulo 3

# Methodology & Technology

*The needs of the many outweigh the needs of the  
few*

Spock - The Wrath of Khan

### 3.1. Methodology

The idea of this project came up in a Hackathon in September 2017. We were a group of 4 developers with one month to create an idea and a small prototype to implement using blockchain technologies.

To give birth to the idea of a decentralized publication system for open science we used agile methodologies.

#### 3.1.1. Brainstorming

Brainstorming was born as a method to increase creativity in groups and organizations. There are only few rules on this method: do not criticize any of the given ideas, quantity is desired over quality, try to combine suggested ideas and give all the ideas that come to mind, no matter if they are possible or not [25].

This method is used nowadays in companies and work groups as part of the process of the creation of a product, although there are some critics about brainstorming and sometimes instead of encouraging creativity, inhibits it [26; 27]

Leaving apart these problems, we decided to make a brainstorming session to define what we were going to do. Many ideas emerged and were captured into a white board without discrimination, no matter how hard or easy to implement they were.

After saying enough ideas to fill the board we filtered the ones that were impossible to achieve. Then, each one voted the best three, making a ranking of the 3-4 best projects to start working on. Some of the ideas were creating a distributed wikipedia with governance models, an application to contact people from minority groups in countries where they are persecuted collectives, a distributed and community driven NGO, and a crowdfunding



offered that help the customer get a job done, 2) *Pain relievers*: how the customer pains are going to be alleviated, 3) *Gain creators*: how the products and services create customer gains

We decided to use this methodology for the definition of the final platform, since it established the general development framework of the application.

### 3.1.3. Agile methodologies

#### REPASAR

El gran crecimiento de internet y la economía digital ha alterado el concepto de ingeniería del software. Las metodologías de desarrollo de software (*MDS*) tradicionales están siendo eclipsadas por nuevas *MDS* ligeras o *MDS* ágiles. Estas metodologías (en adelante *MDSAs*) están caracterizadas por la integración continua, desarrollo iterativo y la capacidad de asumir cambios en los requerimientos de negocio.[31; 32]

La *MDSAs* más popular es conocida como programación extrema o *Extreme Programming (XP)*[33] basada en una serie de conceptos básicos a la hora de realizar el desarrollo de un programa: simplicidad del código y prototipado rápido, comunicación continua del cliente con el equipo de desarrollo, responsabilidad del código de todos los integrantes del grupo, reuniones cortas y rápidas, refactorización e integración continua.[34; 32]

Otros métodos dentro de las *MDSAs* son scrum[35], métodos cristalinos[36] y desarrollo basado en funcionalidades (en inglés *FDD*)[37]. El uso de estas *MDSAs* permite a los desarrolladores crear software de mejor calidad en periodos de tiempo más cortos. Estas metodologías han sido desarrolladas para mejorar el proceso de desarrollo, quitando las barreras a la aceptación de cambios en los requerimientos del cliente, un hecho que se da con bastante frecuencia[33].

## 3.2. Technology

To face the challenges proposed by this project, there are many possibilities to distribute both the data and the information about the reputation network. To build a robust and decentralized system i

### 3.2.1. IPFS

IPFS stands for Interplanetary File System. It is a peer-to-peer file-sharing protocol that uses a cryptographic hashes to store files in a distributed network. IPFS works very similar to HTTP protocol but in a BitTorrent way. It can be seen as a giant git repository where everyone can store, share and exchange files[38].

IPFS merges three main ideas: Distributed Hash Tables, BitTorrent, Git and Self-Certified Systems.

### 3.2.1.1. Distributed Hash Tables

A distributed hash table (*DHT*) is a decentralized structure that works very similar to a hash table. Hash tables are used to identify items in a database. The table performs simple mathematical operations generating a random string called hash. The hash acts as a pointer that directs to the data, this allows the user to find data directly instead of looking through the entire database[39].

In a distributed hash table, any node can use a hash as a key to retrieve data. This system includes a data structure called “keyspace” that is a set of all possible keys, which is split up across the nodes in the system. The mapping of the keys is made by another function that describes the distance from one key to another. All the nodes have an identifier and a set of identifiers pointing to all its neighbors nodes. If a node is removed from the network, only a small portion of the data must be recovered by other nodes[39].

This system makes *DHTs* scalable, fast and robust. It is used by frameworks such as Tapestry [40], Chord [41], Kelips [42], Kademlia [43] and IPFS [38]. These platforms are similar in cost and performance if they are tested in a large enough network. They behave very fast when it comes to searching for a key through massive networks of nodes[44], that’s why it is used by IPFS to create its distributed file system.

### 3.2.1.2. BitTorrent - File sharing

BitTorrent [45] is a P2P file sharing system used worldwide. In this system, files are divided into very small chunks of data, and are shared in a peer-to-peer network. Each peer aims to maximize its download rate by connecting to low latency peers. In BitTorrent’s network, peers with high upload rate will get higher download rate, so the key is balancing the network bandwidth between downloading and uploading files[46].

IPFS uses three main features from BitTorrent’s protocol[38]:

- BitTorrent’s data exchange protocol rewards nodes who contribute to the network, and punishes the ones who don’t.
- BitTorrent tracks the availability of file chunks, sending the rarest first rather than sending the most common ones.
- IPFS uses PropShare[47] bandwidth allocation strategy to improve BitTorrent’s behavior facing exploitable scenarios.

### 3.2.1.3. Git - Version control system

Git is a distributed version control system (*DVCS*)[48]. Git was born in 2005 when the development process of the Linux kernel lost its version control system. The Linux kernel is one of the biggest free software projects nowadays, it has a great team of developers behind and the code usually changes very frequently. In 2002 the team used BitKeeper as VCS since they had a free license. But in 2005 when this license was over, Linus Torvalds decided to develop his own VCS[49].

Git was designed to be scalable and distributed, and the most important factors that IPFS inherits from Git are: [38]:

- Git implements a Merkle Directed Acyclic Graph [50], an object that reflects changes in a file system in a distributed way.
- Objects are identified by the cryptographic hash of their contents.
- Version changes only update preferences and add objects. To broadcast version changes, git only needs to transfer the new objects and update the remote references.

#### **3.2.1.4. Self-Certified File Systems**



## Capítulo 4

# Platform Description

*The needs of the many outweigh the needs of the  
few*

Spock - The Wrath of Khan

We propose a blockchain-enabled decentralized publication system for open science. It consists of three main components that decentralize and try to improve three different aspects related to scientific publication:

1) Peer review governance communication is traditionally centralized and controlled by editors and publishers. Our proposal opens and decentralizes these communications making the process more transparent.

2) Peer reviewer quality and reliability information is difficult to predict [8], and it is usually held private by publishers and journals. The system proposes to open this information through a decentralized reputation network of peer reviewers over a blockchain.

3) Scientific papers are traditionally obtained or bought from a centralized publisher. We propose a decentralized network to distribute academic works and promote free access to science.

These ideas are further discussed in the following sections.

### 4.0.1. Transparent Peer Review Governance

The system provides a platform for the peer review process communication, from paper submission to paper acceptance or rejection. It registers all the interactions into a blockchain based distributed ledger.

The interaction diagram of the system (Figure 4.1) describes the interactions of the supported peer review governance. Following, these interactions and their implementation are described.

A paper submission is registered by submitting the IPFS address of the paper to an Ethereum contract. Then, the Ethereum sender address is recorded as the corresponding author, and the submission is timestamped in the blockchain.



Figura 4.1: Sequence diagram of platform interaction

A journal editor may invite a peer reviewer to review a specific paper. The transaction will record the Ethereum address of the reviewer and optionally, a deadline to submit the review.

An invited reviewer may accept or reject the review of a paper. The response will be recorded into the blockchain.

A reviewer should make a transaction to deliver the review. The transaction will record the acceptance/rejection and the IPFS address of the detailed review.

A novelty of the system further discussed in Section 4.0.2 is the rating system for reviews.



The transaction will record the sender address and the rating as well as the rated review and reviewer addresses.

#### 4.0.2. The Peer Review Reputation network

The system proposes the use of a peer review reputation network where the quality of peer reviews is rated by the authors, editors and reviewers of the system. The work extends traditional peer review governance with the possibility of rating the reviews, building a reputation system for reviewers [7]. Reviewers get rewarded for worthy, fair, and timely reviews, or penalized otherwise.

This network of peer reviewers would enable a better reviewer selection, a fair recognition of reviewers' work and a protection against unfair reviews for authors. However, it could also rise privacy concerns for both reviewers and raters [51; 52]. We consider these privacy issues in section 4.1.

#### 4.0.3. Distributed Open Access infrastructure

Open Access focuses on the free access to scientific knowledge. While publishers provide free of charge their Open Access content, their control of the science dissemination infrastructure allows them to impose certain rules, such as charging authors unreasonable fees to offer their work as Open Access [53] (Gold Open Access) or the temporal embargo and restrictions on the dissemination of the final version (Green Open access) [54], among others.

The system proposes a decentralized infrastructure for science publication. Academic documents - from first drafts to final versions, including peer reviews - are shared in IPFS, an open P2P network [55]. Thus, the system inherently grants Open Access by the design of its distributed infrastructure and circumvents the publishers' dominant role.

### 4.1. Privacy Settings of Open Peer Review and Rating

Anonymity of reviewers and authors in peer reviews is traditionally used to improve the fairness of the process. Thanks to single blind reviews, anonymous reviewers can honestly critic a paper without fearing the reactions of the authors. Double blind reviews also allow to reduce the impact of personal biases. Finally, open review models propose that both authors and reviewers know each other. These different privacy settings are shown in the left part of Figure 4.2.

Note, however, that the anonymity of the reviewers can be also abused. Unfair and low quality reviews are not discouraged by the system due to the lack of consequences. In order to alleviate this problem, our system proposes the construction of a reputation network of peer reviewers so that reviewers are awarded or criticized according to their work. This reputation network can also adopt different privacy settings, allowing both anonymous and signed ratings of either signed or anonymous reviews as depicted on the right side of Figure 4.2.

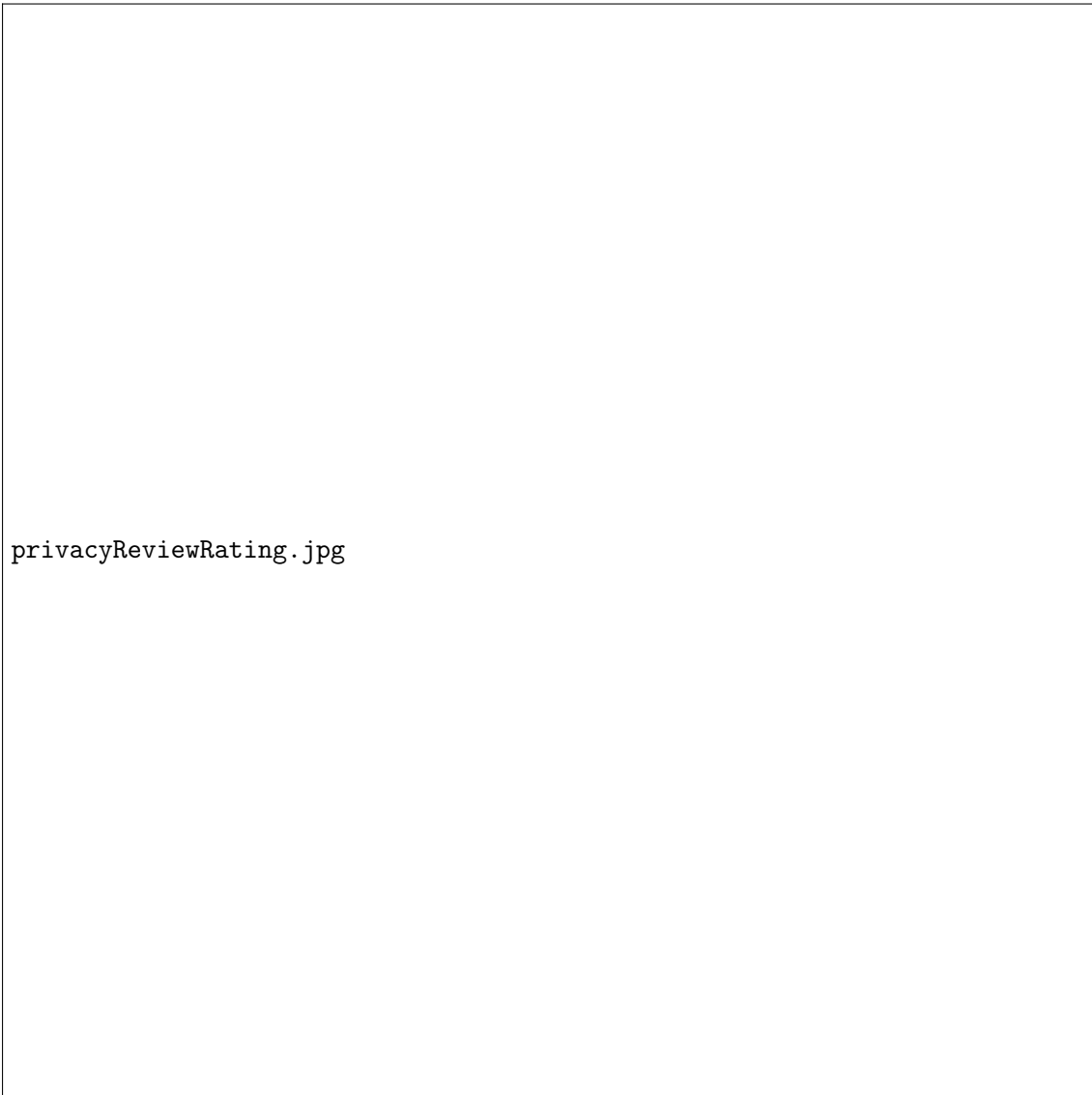


Figura 4.2: Review and Rating privacy models

The implementation of these different privacy settings in a blockchain requires different approaches. The question of whether we can keep the benefits of blind review while providing accountability and recognition to reviewers deserves special consideration. Next, we discuss the different privacy models for review and privacy settings.

### **Blind peer review**

Blind review is the protection of the identity of reviewers in the peer review process. In a blockchain, this protection could be easily achieved by using single-use addresses

previously agreed with the editor.

### Double blinded peer review

A double blinded review is a blind review that additionally protects the authors identity to prevent social bias [56] [57]. Authors could protect their identities prior to publication by providing a single-use public address on submission. Later they can reveal their real identity since they are the only ones with access to that address.

### Open peer review

Open evaluation proposes the de-anonymization of all the parties involved in the peer review process [18]. While studies found effect on the percentage of reviewers declining to review [51] other implications remain open to debate [58].

### Open Rating

Similarly to open reviews, open ratings are easy to implement by maintaining a public identity for the raters.

#### 4.1.1. Anonymous Rating

Protecting the identity of raters is interesting in several reputation systems. We can support this anonymity feature using *blinded tokens* [52] that grant permission to rate without revealing the identity of the rater. People authorized to rate a review, such as authors, editors and other reviewers involved in the process, may each get one of these tokens.

### Rating anonymous reviews

In a system that support voluntary signing of reviews, unsigned reviews would not affect the reviewers reputation unless they acknowledge their authorship. Thus, reviewers may only reveal their identities for well rated reviews, reducing the desired accountability for poor quality, unfair or late reviews.

A system allowing anonymous, yet accountable, reputation system for peer reviewing is therefore of great interest. Following, we discuss the feasibility of adopting different anonymity approaches to realize this system.

*Collateral models* are widely used in blockchain technology to ensure that an actor assumes negative consequences of an interaction in order to avoid the greater consequence of loosing the collateral. A similar strategy can be used for the anonymous reputation network. If a reputation collateral is requested from the reviewers, they would be encouraged to claim even negative ratings. This model can be combined with anonymity measures to ensure accountable yet anonymous, peer reviews.

*Coin mixing* protocols are designed to obfuscate the relation between senders and receivers of Bitcoin payments by mixing in a single transaction many senders and receivers [59]. We can not directly apply this approach to rate reviews since the receiver identity is known. However it can be used in collaboration with other techniques discussed below.

*Reusable payment codes* enable the possibility of using a large amount of addresses to receive a payment [60; 61]. Reviewers may share one of this addresses with each of the actors with permission to rate and then collect the reputation probably using an anonymity layer such as coin mixing. Using a collateral model would encourage the acceptance of bad ratings.

*ZK-Snarks* are a cryptographic tool enabling to prove a statement without revealing anything else than the statement is in fact true (Zero-Knowledge Proof of Knowledge) [62; 63]. They also provide this property in a succinct and non-interactive fashion (i.e. using a relatively small proof and not requiring further communication between prover and verifier). Zcash uses this technology to build an anonymous cryptocurrency [64]. A similar approach could be used to manage anonymous ratings. A reviewer could also receive the rating of a review she did without revealing from which review or which rating the reputation comes. As before, a collateral model can be used to encourage the acceptance of low ratings.

## Capítulo 5

# Results and discussion

*The needs of the many outweigh the needs of the  
few*

Spock - The Wrath of Khan

### 5.1. Cool Section

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## Capítulo 6

# Conclusions and future work

*The needs of the many outweigh the needs of the  
few*

Spock - The Wrath of Khan

Decentralizing and opening academic publishing and peer review infrastructure enable many possibilities to foster the Open Access and Open Evaluation vision of a free and fair science publication. The paper has introduced the decentralization of three essential functions of science dissemination: 1) the peer review process, 2) the selection and recognition of peer reviewers, and 3) the distribution of scientific knowledge.

The transparency provided by opening the peer review allows the construction of a reputation system of reviewers, but also rise concerns about privacy and fairness. The paper studies the different privacy settings in the peer review process and the reputation network.

Blockchain technology enables the introduction of a new review model that support the accountability of peer reviewing proposed by open peer review models while keeping the anonymity of blind and double blind reviews to improve fairness.

This challenging proposal raise many issues. The implications of such accountable, open and anonymous review models are still to be revealed. Moreover, a deeper study of the strategies to grant anonymity to different actors is also to be done. Nevertheless, we believe the proposal opens a debate worth having.

This paper proposes the opening and decentralization of three of the peer review and publication functions: 1) the peer review process communication, 2) the reputation of reviewers, and 3) the distribution of papers and peer reviews. Arguably, this decentralization of the infrastructure could help to challenge the central role of middlemen such as traditional publishers.

Distributed technologies such as Blockchain and IPFS may finally realize the promise of Open Access, while enabling new not-for-profit models of science dissemination. Opening and decentralizing the infrastructure enhances the transparency and accountability of the system, and fosters innovation.

Note the proposed system does not rely on the use of cryptocurrencies, since it is focused on a not-for-profit approach, far from the startup-driven commercial approaches common in the blockchain space.

This challenging proposal raises multiple issues. The opening of the peer review process may reduce the privacy of current closed system. Blind review relies in such privacy, and a lack of this protection can cause a great rejection by the community. Recent technical cryptographic innovations may be used to circumvent this issue [62] and allow transparency while still allowing double blind reviews.

The introduction of a new public metric (reviewers' reputation) may also affect researcher careers, adding pressure to the already straining processes for academic survival [65].

Additionally, the proposed system's infrastructure relies in new technologies with their own challenges. Blockchain technologies face scalability, transaction costs, inclusiveness and usability problems that remain open and under discussion. On the other hand, distributed file systems such as IPFS may be more resilient, but they still need somebody in charge of preserving and providing the data, since without that responsible actor, it may result in unpredictable loss of content.

Other open issues that may be explored in future work are the exploration of different copyright regimes, the challenging of traditional journal-centered metrics to rate publication quality, different reputation algorithms, different levels of openness, and the exploration of decentralized autonomous journals.

Despite the existing challenges, we are confident that decentralizing the processes that Science relies on, would open up a whole new playing field, with implications we cannot possibly foresee now. Will its benefits outweigh its risks? We believe it is a conversation worth having.

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*Y así, del mucho sleer y del poco dormir, se le  
secó el cerebro de manera que vino a perder el  
juicio.*

Miguel de Cervantes Saavedra

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*–¿Qué te parece desto, Sancho? – Dijo Don Quijote –  
Bien podrán los encantadores quitarme la ventura,  
pero el esfuerzo y el ánimo, será imposible.*

*Segunda parte del Ingenioso Caballero  
Don Quijote de la Mancha  
Miguel de Cervantes*

*–Buena está – dijo Sancho –; fírmela vuestra merced.  
–No es menester firmarla – dijo Don Quijote–,  
sino solamente poner mi rúbrica.*

*Primera parte del Ingenioso Caballero  
Don Quijote de la Mancha  
Miguel de Cervantes*



