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DESIGN OF A DECENTRALIZED PEER-TO-PEER REVIEWING AND PUBLISHING MARKET

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Research paper

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Abstract

This normative paper conceptualizes an alternative for the current scientific peer reviewing and publication system. Based on design science research methodology, we propose a distributed peer-to-peer network and transactional data base system (APOLLO) and a cryptocurrency (APL). We conceptualize a market for peer-to-peer reviewing and publishing of research contributions and associated assets that is based on economic market mechanisms and does not require centralized authorities or intermediaries. We discuss how the resulting decentralized and pseudonymous market for research assets could help to mitigate unresolved conflicts of interests and biases prevalent in the current system.

Keywords: Peer Review, Review Markets, Blockchain, APOLLO, APL.

1 Introduction

Journal and conference publications are an important asset for scholars working in academia (Mahoney, 1977; Straub, 2009). To ensure a sufficient quality of research contributions and to increase credibility, many scientific venues employ a practice known as peer reviewing (Campanario, 1998a, 1998b; Lee, Sugimoto, Zhang and Cronin, 2013). As such, peer reviews directly influence grant allocation processes and ultimately determine who gets promoted in academia (Smith, 2006). Interestingly, there is no consensus among academics whether peer reviews are beneficial to the scientific progress as a whole (Zmud, 1998; Jefferson et al., 2002; Bornmann and Mungra, 2011; Lee et al., 2013). Despite recent advances such as mega journals, open access and post-publication reviews (Björk and Catani, 2016; Björk and Hedlund, 2015; Kingsley and Kennan, 2015; Laakso et al., 2011; Solomon, 2014; Silva and Dobránszki, 2015), numerous conflicts of interests and biases still persist.

Within this paper, we synthesize different drawbacks of the current peer reviewing and publishing system. Specifically, we show how conflicts of interests of peer reviewing practices are related to wrongly aligned incentive structures and how the non-pseudonymous nature of research leads to multiple biases. Based on this, we formulate the overall research question of this paper as follows: *Can decentralized peer-to-peer reviewing and publishing systems based on economic market mechanisms mitigate conflicts of interests and biases in scholarly peer reviewing?*

We design two constructs as the *causa materialis*, i.e. entities of interest in the design theory (Gregor and Jones, 2007), which together represent our designed artifact: first, a distributed peer-to-peer network and blockchain-based transactional data base system (called APOLLO) and second, an entangled cryptocurrency (called APL). Thus, we provide a first high-level conceptualization of a purely decentralized pseudonymous peer-to-peer reviewing and publishing market without the need for any centralized authorities or intermediaries. We broadly define decentralization closely related to Merriam-Webster (2017) as the dispersion of power away from central authorities. In addition, market mechanism refer to "a process of interaction between the market forces of demand and supply to determine the equilibrium price" (Dwivedi, 1980). We contribute to the research stream of peer reviews by designing an artifact that potentially mitigates issues arising from wrongly aligned incentive structures as well as the non-pseudonymous nature of today's peer reviewing and publication practices. Furthermore, by integrating a means of payment and payment infrastructure within the peer review and publication system, we provide a first answer to the prevailing question (Gray et al., 2006) of how a research market can be operationalized.

The remaining portion of this paper is structured as follows: Section two provides an overview on the current peer reviewing and publication system, synthesizes associated drawbacks of previous related work and introduces necessary technological concepts to understand the proposed artifact. Furthermore, we provide information on the design science research methodology applied within this study. Section three specifies the artifact by explicitly stating meta requirements, our solution design strategy, constructs, principles of form and function, considerations of the artifacts' mutability as well as principles of implementation. Section four provides an expository instantiation of the artifact by describing its building blocks and visualizing the key components and dependencies in an exemplary fashion. Section five provides an assessment of the proposed artifact. Section six concludes the study.

2 Background and Research Methodology

2.1 Traditional peer reviewing and recent advances

Peer reviewing describes the process in which domain experts "appraise the professional performance, creativity, or quality of scientific work produced by others in their field or area of competence" (Lee et al., 2013). Peer reviewing involves multiple stakeholders, such as editors, reviewers and authors. The exact definition and number of these roles as well as their associated tasks vary between scientific venues such as journals and conferences. Nevertheless, generally speaking, the process involves authors creating scientific contributions, which are then evaluated by reviewers, while the overall process is supervised and managed by editors. Based on the individual reviews and their own assessment, editors either accept or reject the manuscript or initiate another revision cycle. In addition to this decision making component, peer reviewing ideally is a co-constructive developmental process, which improves the overall quality of a contribution through the interaction of the different stakeholders (Davis, 2014; Davison, 2015; Ragins, 2015). Depending on which stakeholder is aware of the identities of other involved parties, peer reviewing is either fully transparent, single-blind or double-blind (Lee et al., 2013).

Recently, traditional scientific venues such as journals and conferences are complemented by new venues such as mega journals (e.g. PLoS One and PeerJ), new publication models such as "open access" as well as "post-publication reviews" (Björk and Catani, 2016; Björk and Hedlund, 2015; Kingsley and Kennan, 2015; Laakso et al., 2011; Solomon, 2014; Silva and Dobránszki, 2015).

2.2 Selected issues of peer reviewing

Previous research indicates some defects and flaws within today's peer reviewing and publishing practices (Wilkes and Kravitz, 1995; Jefferson T et al., 2002; Smith, 2006; Straub, 2009) but stresses that it is likely to remain a central component of science because there is no known alternative to it (Campanario, 1998b; Smith, 2006). At the International Conference on Information Systems 2004, Richard T. Watson conducted a survey regarding the drawbacks of the traditional publication system. Key findings are that 49% of the respondents find that the current reviewing system is somewhat or very unfair. Furthermore, 66% find that reviewer selection processes should entail some form of accreditation. Most importantly, a majority of 71% thinks that the current publication system needs a change. Furthermore, 64% of the respondents think that a market for research articles is either worth considering or an improvement over the current system.

As shown in the following, there are a number of unresolved issues despite improvements made in recent advances of scientific peer reviewing and publication practices. These issues can be largely attributed to conflicts of interests and a wide array of biases as exemplified in the following.

Potential conflicts of interests arise in situations in which the "professional judgment concerning a primary interest (such as patients' welfare or the validity of research) may be influenced by a secondary interest (such as financial gain)" (ICMJIE, 2016).

From a reviewer's point of view, writing high-quality and developmental reviews takes time. While there are a multitude of altruistic rewards such as personal satisfaction, early access to research papers and competence signaling (Straub, 2009) there are few tangible incentives to write high-quality reviews and to write them in a timely manner. One obvious reason for this is that as reviews themselves are seldom made publicly available, there are little direct or indirect tangible benefits to investing a lot of resources. The time is better spent on writing own papers, which are visible and directly influence careers and grant allocation processes. Even worse, there are incentives for reviewers to deliberately delay publications to publish own studies first. From an editor's point of view, this behavior is hard to spot because of information asymmetries. This leads to the classical principal-agent problem known from economics, describing potentially adverse situations when decision making processes are delegated from the principal to the agent (García, Rodriguez-Sánchez and Fdez-Valdivia, 2015) which we rely on to build justificatory knowledge. Although this issue is partially mitigated by recent advances such as "post-publication reviews", there is still little tangible incentive for reviewers to write high-quality and timely reviews. And in case of post-publication reviews, it is questionable if people will write reviews at all as one of the key merits in writing high-quality reviews - the early access to unpublished work - is missing. As a result, the scientific progress is slowed down substantially and important scientific advances diffuse very late into practice.

Another potential conflict of interest arising from the traditional peer reviewing system is that it neither incentivizes nor enforces reproducible research by providing access to research assets such as datasets (Baker, 2016). For example, while some journals and conferences require authors to publish data sets from empirical studies, many don't. This leads to a conflict of interest as a free flow of datasets is beneficial to academia as a whole but not necessarily for an individual author. This is because authors that publish their datasets limit their own potential to write additional studies based on the same data set.

We argue that these conflicts of interest are related to wrongly aligned incentive mechanisms, which favor the publication of papers over the provision of other equally important research assets such as high-quality reviews or datasets. Recently, senior scholars addressed this implicitly by proposing the provision of "systematic feedback to reviewers" and to "reward great reviewers" as possibilities to improve the quality of peer reviews (Iivari, 2016).

Peer review is subject to a variety of biases (Smith, 2006), which in this context "is understood as the violation of impartiality in the evaluation of a submission" (Lee et al., 2013). These biases include but are not limited to the "nationality and prestige of institutional affiliation; reviewer nationality, gender, and discipline; author affiliation with reviewers; reviewer agreement with submission hypotheses (confirmation bias); and submission demonstration of positive outcomes (publication bias)" (Lee et al., 2013). Confirmation bias refers to the observation that individuals lean towards "discrediting, ignoring and ultimately rejecting results not supported by one's own believe of views" (Mahoney, 1977). This leads to a situation in which incremental steps in research are favored as truly revolutionary papers are rejected when "the ideas are too radical and lie too far beyond the reviewers'/evaluators' experience" (Straub, 2009). Publication bias refers to the "tendency for journals to publish research demonstrating positive rather than negative outcomes" (Lee et al., 2013).

We argue that with the exception of the confirmation and publication biases, all biases summarized by Lee et al. (2013) are due to the non-pseudonymous nature of the current peer review system: apparently, biases regarding the nationality, gender, institutional affiliation and discipline as well as the authors affiliation with reviewers are all directly linked to the knowledge of the authors identity. This is also known to journal editors: A study among 221 senior editors, of which 98% claimed that their journals are peer reviewed, revealed that 46% were in favor of masking the authors names and affiliations entirely (Wilkes and Kravitz, 1995).

Based on the synthesized issues related to conflicts of interests and biases, we state the research question of our study as follows: *Can decentralized peer-to-peer reviewing and publishing systems based on economic market mechanisms mitigate conflicts of interests and biases in scholarly peer reviewing?*

2.3 Cryptocurrencies, blockchains and smart contracts

With the proposition of Bitcoin in 2008, decentralized and pseudonymous peer-to-peer transactions without the need for any financial intermediary became a reality (Nakamoto, 2008). Bitcoin itself is both a digital asset and payment network. In a simplified notion, Bitcoin is the digital version of cash as transactions are conducted pseudonymously, meaning that it is impossible to reveal the true identities of the sender and/or receiver of a transaction. Bitcoins underlying technology - the blockchain - does not require any centralized trust-building intermediaries such as banks to create a secure way to send and receive digital cash and to keep track of account balances (Nakamoto, 2008). In fact, the transaction ledger itself stores the entire ordered transaction history redundant and publicly visible at each full node in a pseudonymous nature. Each block in the blockchain contains a set of cryptographically signed transactions broadcasted into the network by network participants and is linked, i.e. chained, to previously validated blocks. In order to prevent the so-called double spending problem, one must ensure that no-one can spend Bitcoin tokens more than once (Nakamoto, 2008).

Each node in the network keeps track of the entire transaction history. In order to reach a consensus about the current state of the blockchain, each block (consisting of unverified transactions) must be verified by the so-called proof-of-work (PoW) algorithm before being added to the blockchain (Nakamoto, 2008). PoW requires each node in the network to solve a computationally intensive puzzle. The first one to solve the puzzle broadcasts his solution to the network and receives newly created Bitcoin and transaction fees as a reward for providing computing power to the network. The puzzle itself requires miners (i.e. network nodes participating in solving of the puzzle) to find a number (the nonce), which added to the unverified block, results in subsequently calculated hash value whose binary representation matches some pre-specified property (e.g. a specific number of leading zeros). The complexity of the problem is automatically adjusted to the overall hashing power of the network to ensure that new blocks are verified in 10 minutes on average (Nakamoto, 2008).

Latency limitations and the probabilistic nature of the PoW algorithm can lead to situations in which more than one node finds the same nonce at roughly the same time. This results in a (temporary) split of the blockchain into two competing chains - a situation which is known as a fork (Decker and Wattenhofer, 2013). Nevertheless, as each node tries to work on the longest chain, probability theory enforces that one of the competing chains will outrace the other, which is subsequently abandoned. This works as miners within the network have an incentive to work on the longest chain to keep their rewards. It follows that Bitcoin transactions never reach absolute finality but only approach it asymptotically as the possibility of forks decreases and finality increases with each new block added to the blockchain (Decker and Wattenhofer, 2013). The example of Bitcoin demonstrates the practical feasibility to operate such a probabilistic cryptocurrency based on the PoW algorithm.

The blockchain-concept can be applied to other digital assets such as research contributions as demonstrated by so-called colored coins (Glaser and Bezzenberger, 2015). Colored coins utilize the Bitcoin scripting language (especially the *op_return* opcode) to store data on the blockchain. A representative of a colored coin is Astroblocks, which allows for the tamper-proof recording of the discovery of asteroids and comets (Torpey, 2015). Other related projects are Journalcoin, Researchcoin and Genomecoin, briefly described by Swan (2015). However, as of October 2016, no information on the progress of these projects is available. Smart contracts are a very related concept to the scripting capabilities of Bitcoin and "allow mutually distrustful parties to transact safely without trusted third parties" and provide means for the automatic execution of contractual terms (Kosba, Miller, Shi, Wen and Papamanthou, 2015). While Bitcoin's scripting language provides many of the required functionalities to write and deploy decentralized smart contracts, numerous projects such as Ethereum work on smart contracting and decentralized application system (Ethereum, 2016) to allow "running arbitrary user-defined programs on the blockchain" (Kosba et al., 2015).

2.4 Design science research methodology

Behavioral science and design science are the two predominant research paradigms in IS research (Hevner, March, Park and Ram, 2004). In our study, we utilize design theory as one of five different classes of theory in IS described by Gregor (2006). Origins of design science research (DSR) trace back to Simon's (1996) work on the sciences of the artificial. "The design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts" (Hevner et al., 2004).

Simon (1996) defines an artifact as "a human product that prescribes something based on a certain rationale to attain goals and to function by relating an artifact design to artifact requirements". Gregor and Jones (2007) seminal work on the nature of theory in DSR yields six core components: purpose and scope (*causa finalis*), constructs (*causa materialis*), principles of form and function (*causa formalis*), artifact mutability, testable propositions, justificatory knowledge and two optional components: principles of implementation (*causa efficiens*) and expository instantiation. In our work, we draw on these eight components of DSR as well as its proposed idealized structure of Gregor and Jones (2008) as a conceptual guidance. Please note that we discuss the DSR component justificatory knowledge within section two as proposed by Gregor and Jones (2008) and leave out an explicit discussion of testable propositions due to the highly conceptual nature of our work.

3 Specification of the Artifact

3.1 Meta-requirements of the solution

Based on our previous discussion on problems of the current scientific peer-reviewing and publishing system, we define meta-requirements that our artifact must fulfill. Meta requirements are "the purpose and scope (the *causa finalis*)" of a design theory which "specifies the type of artifact to which the theory applies and in conjunction also defines the scope, or boundaries, of the theory" (Gregor and Jones, 2007).

To state the meta-requirements of the artifact, we make the following explicit assumptions: first, peer reviews improve the quality of papers and act as a gate keeper of the body of knowledge. Second, economic market mechanisms are more efficient in allocating resources in the context of academic research and the publication of findings than the current altruistic approach. Third, research relevance is non-stationary over time, meaning that the importance of specific findings changes over time in both directions.

The final artifact aims to create an adaptive, fair and self-organizing market for research output that removes the necessity for any central authority that might distort the research market quality, i.e. create a decentralized and distributed market place for research to gradually replace journals and conference proceedings. The quality of research output should not be measured by its association with a specific venue but solely by its specific contribution. Therefore, and considering the synthesized drawbacks of the current peer review system outlined in the background section of this paper, we propose the following meta-requirements: the artifact ...

- ... should change incentive structures in a way that research articles, reviews and the provision of other intangible research assets such as data is treated alike. Its value should be determined via market mechanisms, i.e. demand and supply (requirement 1).
- ... must enforce reproducible research results, e.g. by enforcing the publication of datasets with a specifiable time-delay (requirement 2).
- ... should allow for changing the currently static nature of research articles to lively documents that are constantly updated and refined (requirement 3)
- ... should allow for browsing the revision history of digital assets as well as associated reviews (requirement 4).
- ... must allow for a ranking and voting system to quickly determine the quality of all contributions (research articles, reviews, data, etc.) (requirement 5).
- ... must match demand for and supply of reviewing resources automatically and in an unpredictable fashion (requirement 6).
- ... must persist ownership of research contributions and its exact date and time in an incorruptible way while keeping the contribution pseudonymously (requirement 7).

3.2 Solution design strategy

In the following, we explicitly state our solution design strategy to arrive at our solution. Two types of DSR strategies can be distinguished (Iivari, 2015): while researchers following the first strategy aim to build meta-artifacts to solve a class of problems, researchers following the second strategy attempt to create a generalized solution to a class of problems in a second step and based on an artifact that is concerned with a specific problem. In our work, we follow the second route by addressing the specific issue of today's reviewing and publication practices in academia. Thus, we see the current system as an inspiration for the emergent IT artifact. As proposed by Simon (1996) and Gregor and Jones (2007), we employ an "iterative design with intermediate test stages" in our search for an optimal artifact. That is, we aim to discuss the proposed artifact at conferences and other meetings of the scientific community to incorporate as many views as possible.

3.3 Constructs and principles of form and function

Based on our previous discussion of meta-requirements to solve shortcomings of today's reviewing and publication system, we now present the constructs as well as the principles of form and function of our artifact. Constructs as the *causa materialis* are a "representation of the entities of interest in the theory" (Gregor and Jones, 2007), whereas principles of form and function as the *causa formalis* in DSR provide "an 'abstract' blueprint or architecture that describes an IS artifact" (Gregor and Jones, 2007). Our proposed artifact consists of two primary constructs: first, the distributed peer-to-peer network and blockchain-based transactional data base system (called APOLLO) and second, the networks own cryptocurrency (called APL), which are described in the following.

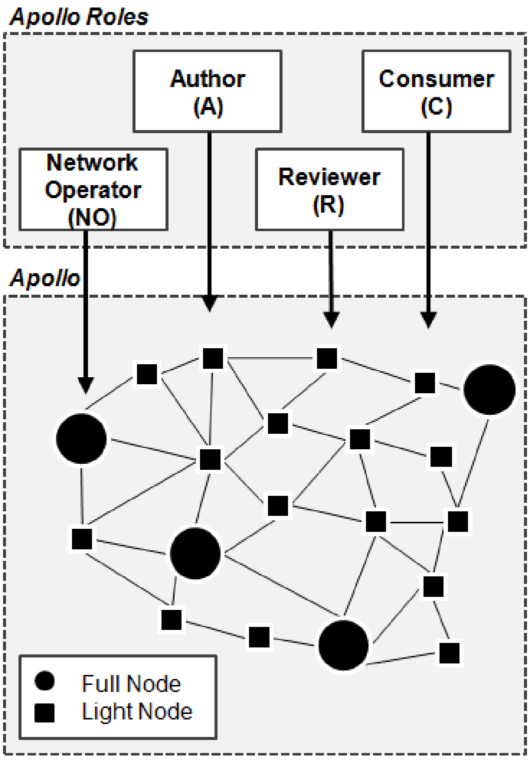

Figure 1. Stylized Network Structure and Roles of APOLLO

Figure 1 provides a high-level overview of a possible network structure and roles within APOLLO. While squares represent light nodes, circles represent full nodes of the network (i.e. light nodes plus additional large-scale storage facilities for data other than plain text). A peer-to-peer network and a distributed data base system - the blockchain - builds the technological basis for APOLLO. A consensus of the current state of the blockchain, is reached via the PoW algorithm.

Each transaction within APOLLO represents an incremental change to the body of knowledge stored and is therefore comparable to a version control system (VCS) such as Git. These incremental changes contain textual data in a uniformly document markup language such as LateX. However, it is not necessary that every node stores the entire data nor that the data is stored in the decentralized network itself. In addition, smart contracting capabilities allow for the time-delayed publication of datasets used in research articles.

APOLLO supports different roles for market participants: authors (contributing research, reviews and other digital research assets such as data), reviewers (checking the quality of research output, data sets and other digital assets supplied), consumers (downloading and/or using contributed content), and network operators (providing additional computational power and data storage facilities to the network). Figure 1 stylizes potential usage patterns of APOLLO roles and the operation of light and full nodes. That is, each user can decide whether they want to operate a full or light node. The usage of randomly assigned pseudonyms mitigates potentially negative consequences of the association of an individual with a specific research project.

APOLLO orchestrates the reviewing and publication processes and allows its stakeholders to vote on the quality of research articles, reviews, data and any other digital asset contributed to the network. To match the supply and demand (e.g. for reviews) autonomously, APOLLO might utilize methods such as Latent Dirichlet Allocation (LDA) to extract latent topics from research contributions or other Natural Language Processing (NLP) techniques for feature extraction. These features could be used in an autonomous Machine Learning (ML) matching engine.

The second construct of the artifact is the networks own cryptocurrency APL, which are digital coins gained for contributing research to APOLLO that is consumed and/or used by others (e.g. downloads, cites, etc.), writing reviews, providing data or other digital assets, operating network nodes and storage facilities and also for voting on contributed content from others. APL are spent for faster reviews, downloading research, citing others and using data provided by others. In summary, this aspect of the proposed artifact allows for the efficient allocation of scarce resources in academia via market mechanisms (supply and demand).

Table 1 provides a structured overview of the primary roles and functions of selected APOLLO stakeholders as well as the most important sources and uses of APL by role and activity.

Role	Primary Function / Contribution to APOLLO	APL Gained for	APL Spent for
Authors (A)	Contribute research articles, data sets and other useful digital content/assets	Downloads, citations and positive votes of own contributed content as well as operating network nodes	Requesting reviews, citing other works
Reviewers (R)	Contribute reviews	Writing reviews, positive votes of own reviews and operating network nodes	Requesting reviews, citing other works in the role of an author
Consumers (C)	Consume research and make research visible to practice	Operating network nodes	Downloading research
Network Operators (NO)	Operation of APOLLO network nodes and storage Facilities	Operating network nodes and storage facilities	Transferred to authors and consumers

Table 1. APOLLO Stakeholders: Roles, Functions and Sources and Uses of APL. Note: Each market participant could buy and sell APL for fiat money (e.g. U.S. Dollar) or other cryptocurrencies (e.g. BTC) on exchanges.

3.4 Consideration of artifact mutability and principles of implementation

Because of the highly conceptual nature of the proposed artifact, we will discuss its mutability and principles of implementation only briefly.

Artifact mutability refers to "changes in state of the artifact anticipated in the theory, that is, what degree of artifact change is encompassed by the theory" (Gregor and Jones, 2007). Our proposed artifacts will evolve over time. During the inception phase, our proposed solution will most likely exhibit a high level of decentralization. Looking at the example of Bitcoin and similar PoW based cryptocurrencies, there seems to be a tendency for such systems to strive towards centralization over time. We conjecture this is due to the decreasing probability for payouts to individuals due to an increasing number of participants in the network. This must be anticipated when implementing our proposed artifacts. Another potential issue arising in the future are hard forks of the APOLLO blockchain, which happened in the past to Ethereum due to a large scale disagreement within the user community on how to deal with the DAO issue (Del Castillo, 2016).

Principles of implementation must outline "a description of processes for implementing the theory (either product or method) in specific contexts" (Gregor and Jones, 2007). While our work is highly conceptual, future work towards an implementation must carefully address regional and disciplinary differences to foster the adoption of scholars. From a user interface perspective, it is important to hide as much of its underlying complexity as possible when implementing our proposed artifacts. Minimalism should therefore be the design philosophy of the client software and UI specialists must work closely together with programmers and researchers to assist in the development.

4 Expository Instantiation of APOLLO

Within this section, we provide an expository instantiation as one of the optional components of DSR research discussed by Gregor and Jones (2007). Because of the complexity of the proposed artifact and the purpose of an expository instantiation to communicate key ideas in an easy to comprehend way, we provide a case study of an individual extending the current body of knowledge stored within APOLLO in the following. Figure 2 exemplifies this process.

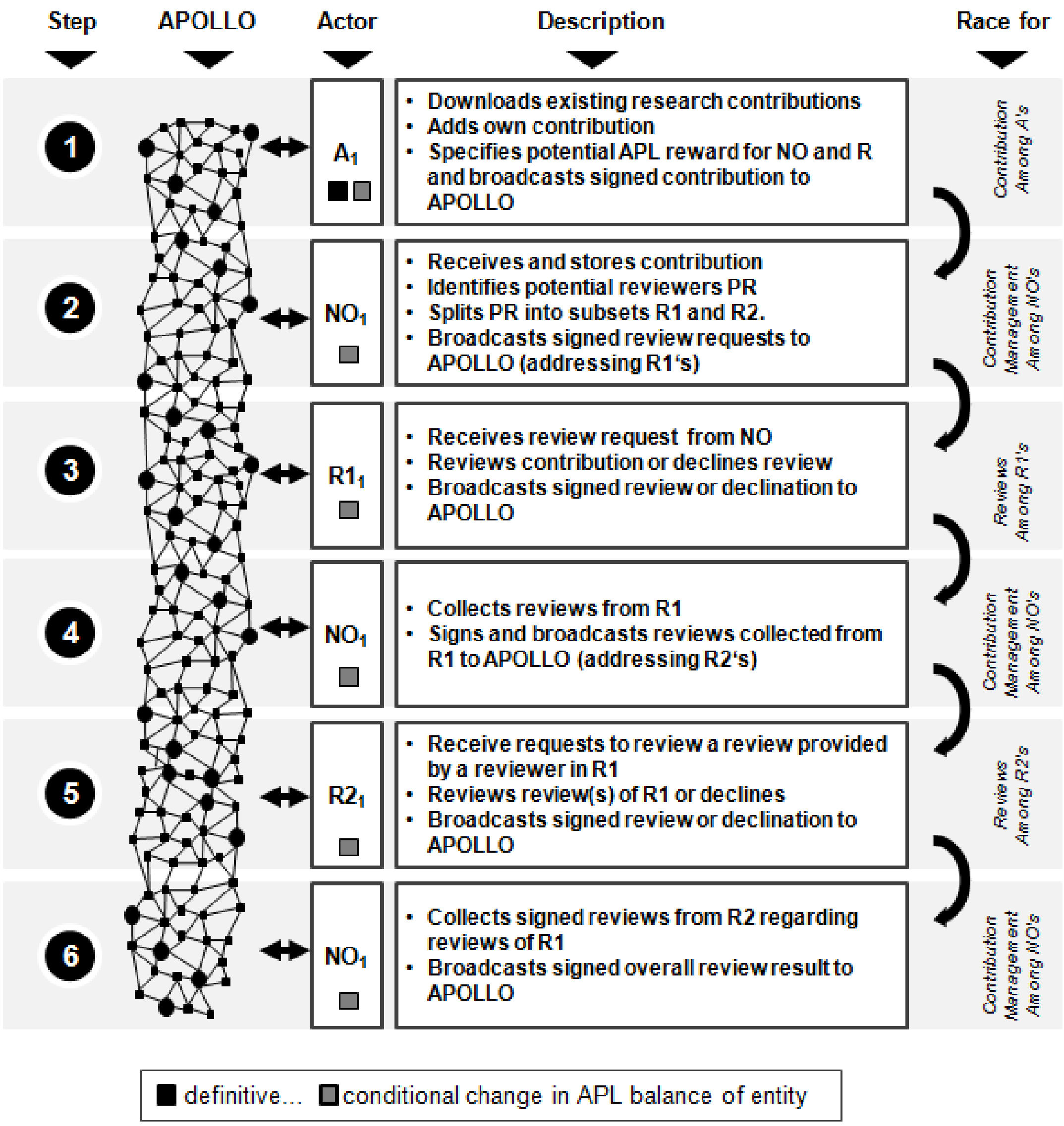

Figure 2. Expository Instantiation: Contributing research to APOLLO

With the exception of consumers (C), the case study entails actors representing all APOLLO roles described previously in this work: authors (A), reviewers (R) and network operators (NO). For simplicity, we assume that each of these three actors only covers one role. Please note that within Figure 2, upper case numbers represent subsets of individuals while numerical indices represent specific individuals.

First, let's assume that author A_1 wins the race among A's to contribute a specific finding to a research stream. She then broadcasts the cryptographically signed contribution to APOLLO and specifies the amount of APL she is willing to pay to NO for the selection of reviewers and to R for the reviews itself. The specified amount of APL is locked until either transferred to R and NO or until a pre-specified time is passed.

Second, let's assume that NO_1 is the only NO that perceives the transaction fees that A_1 is willing to spend as sufficiently high. He then starts to search for appropriate reviewers for the contribution of A_1 among previous contributors to APOLLO, e.g. by means of NLP/ML methods such as LDA. Subsequently, he splits the resulting set of potential reviewers PR into subsets R1 and R2 and broadcasts signed review requests and a reference to the contribution of A_1 to each PR within set R1.

Third, assuming that R1 consists of only one reviewer $R1_1$ and he accepts the offer to review the contribution of A_1 - a decision that is based on both altruistic motives as well as tangible economic incentives, i.e. the amount of APL the author is willing to pay for the review. Subsequently, he signs and broadcasts his review of the contribution of A_1 to APOLLO. Note that non-responding potential reviewers could be punished by automatic down votes from APOLLO.

Fourth, NO_1 collects the signed responses from reviewers R1 (in this case only $R1_1$) and broadcasts them to PR within the hold-out set R2.

Fifth, and assuming that R2 consists of only one reviewer called $R2_1$ which accepts the request to review the reviews within R1, he signs and broadcasts his review of the review of $R1_1$ to APOLLO.

Sixth, NO_1 collects the signed reviews from reviewers within R2 and subsequently broadcast the overall review results to APOLLO.

As indicated by the grey and black boxes, most APL streams are conditional on decisions of network participants. However, to prevent from spam, authors submitting research contributions to APOLLO should be required to spend a small amount in either case.

5 Evaluation

In the evaluation of an DSR-based artifact, authors are required to demonstrate its "utility, quality and efficacy via well established methods" (Hevner et al., 2004). To evaluate our proposed design we combine the descriptive approach of informed argument described by Hevner et al. (2004). Specifically, we evaluate our proposed artifact along the identified conflicts of interests due to wrongly aligned incentive structures and biases due to the non-anonymous nature of current scientific peer review and publication practices, which we synthesized in the background section.

Our first meta requirement calls for a paradigm shift to treat different kinds of digital and research related assets alike and to let market forces (demand and supply) decide on their value. The designed artifact incorporates this requirement by integrating a cryptocurrency and payment system into the artifact itself. APL are gained or spent for research assets and related tasks. Thus, APOLLO addresses this requirement. The rationale behind this is that once a market makes the value of high-quality reviews explicit, the public perception of the true value of different research assets will be revealed and perhaps, the value of research assets other than papers becomes more prominent. Please note that it is not the intention to commercialize research but to create a system which allocates scarce resources more efficiently with the overall goal to strengthen academia. Our proposed solution to the first meta requirement combined with smart contracting capabilities that allow for the time delayed decryption of research assets broadcasted to APOLLO such as datasets, allow to meet our second meta requirement of enhancing the reproducibility of research.

Our third meta-requirement aims to change the currently highly static nature of research articles towards lively documents which are constantly refined and updated. Thus, it is closely related to the fourth meta-requirement, which requires the possibility to browse the entire revision history of research assets. As APOLLO works on an incremental basis in a way that is comparable to VCS's such as Git, these requirements are both met by the design. Every full node within the network can see every change made to every research stream stored in APOLLO.

The fifth meta-requirement identified is the necessity to allow for rankings of research contributions and implicitly of pseudonymous authors within APOLLO to allow for a quick determination of the quality of contributions. Within the design of APOLLO, we incorporated this requirement by adding the possibility to vote on every research asset. However, it remains debatable how to balance voting powers among different stakeholders of the artifact to prevent from fraudulent actions, e.g. pump and dump strategies. One possible solution could be to bind voting power to a quota system or directly to APL.

Our sixth meta-requirement identified is an automatic matching of reviewing demand and supply in an unpredictable fashion. This is especially important to prevent research from being published or rejected because of biases related to the knowledge of the identity of authors. Within the design of APOLLO we addressed this requirement by describing potential ways to match research contributions with reviewers in an automatic fashion using NLP and methods from machine learning. The last meta-requirement identified requires the designed artifact to keep track of the ownership, submission dates and times in an incorruptible way. This requirement is met by building the artifact upon blockchain technologies.

6 Conclusion

Today, journal and conference publications are an important asset for individuals working in academia with direct effects on promotions and grant allocation processes. Recently, numerous advances such as the emergence of open access journals and post publication review practices aim to improve on several defects of current peer review practices found in related studies. However, we show that several conflicts of interests and biases still persist. Specifically, we argue that wrongly aligned incentive mechanisms, which favor the authorship of papers over the contribution of reviews and other research assets such as data, lead to severe conflicts of interest. Furthermore, we identify the non-pseudonymous nature of the current academic peer reviewing and publication practices as one of the root causes for multiple biases, for example discriminations related to the nationality and institutional affiliation of authors, the nationality of reviewers, gender, discipline, and others.

Therefore and in light of recent technological advances such as the blockchain, within this paper, we tackle the overall research question: *Can decentralized peer-to-peer reviewing and publishing systems based on economic market mechanisms mitigate conflicts of interests and biases in scholarly peer reviewing?* Drawing on DSR as our methodological foundation, we identified seven meta-requirements of the proposed artifact and design two entities of interests as the *causa materialis*, which together represent our designed artifact: first, a distributed peer-to-peer network and blockchain-based transactional data base system (called APOLLO) and second, a dedicated and network inherent cryptocurrency (called APL). Thus, we provide a first high-level conceptualization of a purely decentralized pseudonymous peer-to-peer reviewing and publishing market without the need for any centralized authorities or intermediaries.

Academics and practitioners alike can benefit from our research. With the design of an adaptive, fair and self-organizing market for research output that is not controlled by central authorities, we mitigate multiple drawbacks of the current peer reviewing and publishing system. Our proposed solutions can be applied to many other areas and is not limited to scientific research. For example, variations of the proposed principles can be used to create decentralized and self-organizing markets for user-generated content and digital assets. For example, a marketplace for verified user-generated news or other user-generated content such as blogs.

We are aware of the complexity of the proposed artifact and thus encourage the IS research community to support us to answer many open questions. Future research could investigate questions regarding the market microstructure of the supply and demand matching, the distribution of APL for providing computational resources to the network, and the mitigation of potential issues arising from the clustering of APL around senior researchers as APOLLO matures. Another avenue for future research is the evaluation of different strategies to increase the adoption of APOLLO by established scholars and traditional scientific venues.

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