Open Science Network

The Future of Scientific Research

“Might scientific problems now regarded as out of reach become accessible with more effective ways of structuring scientific attention?” Michael Nielsen

Introduction

As with many systems that have developed through adaptation over time, the way humanity currently manages scientific research has become outdated. Information is kept in silos where other researchers cannot use it, funding is competitive and filled with bias: as the problems get harder and more complex this system ceases to be effective. With science at the core of civilization’s progress, the value of an accelerated rate of discovery cannot be overemphasized.

The Open Science Network (OSN) will be a distributed research network using blockchain technology for an efficient, open and transparent transmission of information and value and a significant re-aligning of incentives. By applying this distributed technology and paradigm to science, we look to increase the quality and level of interactions between all actors in the scientific network and an evolution of the scientific research, funding and publishing cycle.

Aspects of the OSN solution will include:

- p2p interactions without any need for trust, centralized entities or information silos. Value flows in the network natively and consensus is built into the system.
- The freedom to develop any type of complex interaction that we can think of between different independent agents, instant, and worldwide.
- The development of tools and implementations that allow the creation and governance of network agents, which can be adapted for the specific needs of each of the elements on the scientific ecosystem.

This shared open protocol, where researchers, universities, companies with R&D budgets and government institutions can all interact effectively, will lower barriers to entry and reduce friction in each step of the process. Research overheads will be drastically reduced, greatly increasing the efficiency of the global funds being distributed. Above all, in creating a more collaborative ecosystem, science research will become infinitely more accessible, allowing anyone to take part.

1. The Current Scientific Ecosystem

The scientific knowledge of humankind can be seen as a web-like structure made up of interconnected discrete blocks of knowledge. Each block is a scientific paper that tries to elucidate a particular characteristic of the universe, and each link is a citation that a paper makes to previously established research.

If a block is later found to contain information that was erroneous or deceiving in nature, it must be retracted. The credibility of any research that built on top of that retracted block is then put into question and the web is potentially compromised.

Ideally we want to add blocks as quickly as possible while ensuring that they are accurate, but current incentive structures simply do not align with these ideals. Although the creation of scientific knowledge is dependent on the work of the scientists who actually produce and verify the research, the institutions on which they are dependent form a system that is inefficient and often counterproductive. This is a situation that is entirely solvable.

2. Funding:

No research is possible without funding, which is usually delivered in the form of grants. Governments are the largest funders of scientific research, followed by private companies, nonprofits and philanthropists. The global domestic spending on science and R&D is 1.14 trillion dollars[7].

Problem:

The scientific community invests an extraordinary amount of time, energy, and effort into the writing and reviewing of research proposals, most of which end up not getting funded at all. To receive a grant, researchers must write an application, which can involve weeks to months of work. Depending on the field, the success rates to get accepted can vary between 9%-30%.

It's not unusual for a researcher to spend more than half their time writing grant applications to acquire the funds to do actual research. [1] These proposals are then reviewed by other scientists in order to pick the winners. This means that, in total, millions of potential research hours are spent just allocating research funds every year. This time would be better invested in conducting the research in the first place.[3]

Solution:

Private and public institutions can use blockchain tech and the OSN to greatly streamline the grant allocation process, reducing overheads and keeping a constant record of the process; from proposal submission to fund allocation, peer review, reputation updates, etc. Although this a significant development in itself, the true impact will be the freedom blocktech provides to easily implement any type of funding scheme at all, no matter how complex, and know that the system will work just as we expect it to.

Opening up the funding system is the first crucial step towards true innovation and OSN will provide an ecosystem where anyone can create new funding methods or types of funding institutions and release them into the network. Private and public funds, global and local funds, grants, investments, etc will interact seamlessly in myriad different ways that we've never seen before.

Any new funding method can follow whatever fund distribution, prerequisites and other rules that the creator sees fit. By having a permanent record of all interactions past and present within the blockchain, (combined with the ID system explained in section 4.1), distribution of funds can be instant, global and granular, depending on the choices made by the funding entity.

2.1 Basic Income for Research

By utilizing tokens and having a pseudo anonymous ID representation for members of the network, we can subsidize research work utilizing a monthly emission of research tokens. The specific rules for this have to be analyzed in detail to manage inflation control. Cutting dependence on grants and the time and overheads spent on research applications and their analysis represents a potentially huge increase in efficiency per dollar spent.

2.2 Science Syndicates

Companies like Angel List, in which amateur investors can delegate their investment decision to knowledgeable partners, have a proven track record of successfully allocating capital for increased returns. With OSN allowing anyone to gain reputation based on their track record of funding in science, this model could enable a new wave of participants to invest based on a much wider and more refined structure of criteria.

2.3 Drug Discovery and Patents as Financial Instruments

Roger Stein [4] has demonstrated how the development and testing of new drugs can be looked at as a financial instrument where pension funds, investment firms, and insurance companies can expect a yearly return comparable to that of more traditional investment possibilities. This makes tokenization (securitization) of biomedical research an area to explore to add liquidity and more cross-border options to the market.

In order to achieve this, there needs to be clearer regulation from countries and regulation authorities but it is our objective to work together with partners, regulators, and other organizations to open a path where this can be achieved. In the near future, we'll develop a basic prototype of how this could work.

2.4 Satoshi Prize

With yearly awards similar to the Nobel Prizes, we can reward the biggest contributors to the scientific network. Besides any specific prize element earned, with everything tied in on the blockchain, researchers can easily prove their particular achievement.

3. Publishing:

The central metric to advance a researcher's career is to publish papers. They want their work published in well-known journals and to get as many citations from their peers as possible because it gets them promotions within academia, easier access to funds, etc.

Problem:

Under the current ecosystem, journals are the keymasters of humanity's scientific knowledge. All research gets published through them, so they control what gets approved as 'valid' research and are in control of who can see it and when.

Besides holding the power to direct the course of scientific discourse, their monopoly also provides a business model that is hard to beat:

1. Government and industry fund the research that is carried out by scientists.
2. Scientists deliver this research to journals either for free or even after paying for the opportunity to get published. In addition, they also often have to relinquish their copyrights to the publisher.
3. Journals then review the papers using work provided voluntarily by other scientists at no cost.
4. At the end of this cycle, journals then charge exorbitant fees for the right to access any published content to the same universities and laboratories where the scientists who produced the material actually work.

In this process they effectively monetize the same content multiple times while providing little of real value themselves. The amounts they charge institutions can be staggering. In 2012 Harvard University was paying $3,750,000 USD per year to get access to published scientific research and eventually had to cut back on the number of journals provided for students.[2] If Harvard can't afford access to scientific knowledge, the picture is clearly bleak for less privileged universities and independent researchers.

Solution:

The basic purpose of journals is simply to validate and distribute knowledge, which they have been doing for more than 100 years. Technology has, of course, moved on. Developing a blocktech solution allows us to greatly increase efficiency while enabling content to be open and public at all times. All this is possible at a fraction of the cost (and price!) and allows for the distribution of any earnings to the contributors that actually provide the value in the first place.

With blockchain technology at the heart of a new ecosystem, everything will be publishable without a pre-approval process beyond basic validation to prevent network spam.

All research that scientists consider ready for the world will exist in a continuum state instead of the binary unpublished/published state of the current ecosystem. Peer review will be conducted in the open, allowing anyone to review a particular paper. The owners of a paper can create new versions of that paper following a versioning system like the git system used in the programming world.

3.1. Negative Results Don’t Get Published

Journals want to publish interesting papers that move the field forward and are not so keen to publish dead ends or failed hypotheses. Even when negative findings are published it is less likely that the paper will receive as many citations, so the work necessary to release an experiment with negative results is often not worth the researcher’s time.

This is a big problem for the scientific community because it means that valuable information is kept unavailable from other researchers. It promotes wasteful work duplication by the many scientists that will keep on testing the same hypotheses, unaware that it has already failed.

Even when the failed experiment is published, some scientists try to turn it into a positive by reframing or coming up with a new hypothesis that can explain the data they found. Instead of a prediction the hypothesis becomes a ‘postdiction’ and this can lead to erroneous conclusions and, in turn, to weak foundations for future contributions.

The solution is a practice called “Experiment Pre-Registration”. Following this method, a researcher publicly commits and specifies in detail a particular hypothesis and experiment design before gathering any data. Because the research criteria are public, other scientists can check that the researcher complied with the previously disclosed structure and didn’t change it in order to get more interesting results.

This practice is good for the ecosystem but, as we have seen, researchers pursuing career advancement are not properly incentivized to follow it. This is one of the many things that will change under OSN’s streamlined and restructured funding, publishing and workflow protocols.

4. Research:

With new systems in place for funding and publishing, costs go down, processes are simplified and barriers disappear. With this, the actual creation and verification of research should accelerate dramatically with additional tools to operate in this new ecosystem.

4.1. Upgrading Scientific Identity

In order to take full advantage and control of their work within the OSN system, a scientist must be able to identify their contributions within the indelible record, providing a link between the academic and their professional activities and ensuring that their work is recognized. [2]

Projects like ResearchID and ORCID provide a persistent digital identifier that can be integrated within key research workflows such as manuscript and grant submission to distinguish specific researcher contributions.
Although this is a long-overdue advance, the information relating to the individual's credentials is currently located in the private databases of Universities, research labs, and other institutions where access is complicated and involves intermediaries.

A blockchain based identity system not only allows for this information to be connected and available but also allows researchers to own this data and decide how others within the network can access it. Connecting the information from past publications, university credentials, previous work in the field, and reputation obtained in the OSN network, will allow for a more granular representation of the value provided by each member.

4.2. Open Collaboration

Some parts of the scientific community have realized that cooperating in large multidisciplinary groups could produce better overall results. There have been some attempts at this, with varying degrees of success. One of the most prominent success cases is The Polymath Project, started by Tim Gowers, a field medalist mathematician. The first problem they postulated was solved within 3 months, with contributions from more than 40 different mathematical minds, ranging from high school math teachers to the top mathematicians of the world.

They continued to tackle other math problems, following a set of guidelines to ensure that everyone contributes information that might be useful to others, no matter how small[5]. Despite the initial promise displayed, the Project remains only a partial success. With no advanced tools to enable the collaboration, they have to rely on a simple wiki and comments on blog posts so contributing requires considerable time and effort. In addition, all papers published from the discussions in any of the Polymath Project problems must be published under a pseudonym, so there is little real incentive besides goodwill and a mental challenge.

With the blockchain used as a ledger to keep perfect track of everyone's contributions, it would now be far simpler to distribute academic credit or revenue from possible patents and applications after a piece of research is complete. Scientists from around the world will be free to cooperate in solving problems in a way that has never before been possible.

A grant, or any other kind of contract given through our platform can be cryptographically tied in the blockchain to a particular set of files with the only the contributions made to these files counting when credit is distributed. This way any researcher can contribute and be assured that she will be able to prove that she made a particular contribution to solving a scientific problem, whether applying for a job or looking for more funds.
If necessary, credit can be distributed once a research item is ready for publication using a prediction market composed by third party peer reviewers or a subset of the people that participated in active research. Researchers can be granted a title in the publication that comes from that research, or they can receive an amount of tokens that represent the share of value provided.

5. Verification:

Reproducing another's work to check the validity of a piece of research is at the core of the scientific method. It is the central tool to ensure that the foundations for future contributions to the scientific body of knowledge are solid and that future work isn't wasted pursuing erroneous paths.

Problem:

Reproducing a paper is bound to get fewer citations than doing original research so, in practice, it is not pursued. This is a well-known problem within the scientific community called the *Reproducibility Crisis*.

The problem has two parts: Firstly researchers are not actively incentivized to contribute enough information for others to reproduce their work. Including the additional information, data and processes so that the work can be easily reproduced takes time. As it is not strictly required within current practices, there are no systems in place to accelerate the process and make it an integral part of the research workflow.

The second part is that researchers are poorly incentivized to do the work necessary to actually reproduce other people's research. Compared with creating original work, it does little to advance your career.

In short, the *Reproducibility Crisis* creates a free-rider problem: it is in everyone's interest that research is reproduced but no one is individually incentivized to do it. Without coordination or external incentives it just doesn't get done, greatly increasing the likelihood that other research is then built on top of dubious conclusions.

Solution:

Part of our network's revenue (from patents, applied technology and donations) will be used to create a reproducibility fund. The objective will be to subsidize reproductions of important papers with fund allocations voted on by the network through our governance token. (more details in section 4.) With the experiment pre-registration step in the OSN workflow layers, any research reproduction is already easier and now has solid financial and career-enhancing incentives attached.

6. Notes On Developing The OSN:

6.1. Network Infrastructure

Protocols that support scalability and enhanced features are in development by the blockchain community and will be important in the future growth of OSN. Our smart contracts and libraries will be written using current best practices for adaptability to future developments and we'll continue working closely with different community projects to increase the level of scalability for the whole ecosystem.

As a base, we will be using the Ethereum blockchain but we will also be compatible with the RSK chain. The Aragon platform will be used as our governance solution. Distributed storage will initially be managed utilizing the IPFS network in order to create the prototypes but will transfer into Filecoin once the project is available in a beta. For identity we will be using either Civic, uPort or just a pure smart contract library solution, depending on how the project develops over time.

6.2. Why is a token needed?

OSN is a protocol layer, which means that the base rules and incentives for the network will be created as a set of smart contracts on the Ethereum or Rootstock network. This set of contracts and libraries allows us, and any other entity in the science ecosystem, to build applications (Dapps) that expand as top layers, using the OSN infrastructure.

Governance within the network will be defined by its own community and members and tokens allow for a granular attribution of value within a network or system, without being tied to the price fluctuations of the base currency. The Science token will serve a dual purpose as a medium of exchange for value and governance allowing changes and development in the protocol.

The Science token follows the standard ERC20 token development framework. This allows it to be accepted and interact with the entire Ethereum ecosystem, wallet providers, decentralized exchanges, etc.
More information about the token mechanics are described in our Tokenomics paper.

6.4 Minimum Viable Network

Early, experimental iterations of the Network will need to exceed minimum standards of viability:

R

Researcher

CPR - Create a pre-registration

CR - Contribute to a piece of research

VP - Vote to publish a piece of research

RW - Reproduce an existing work

P

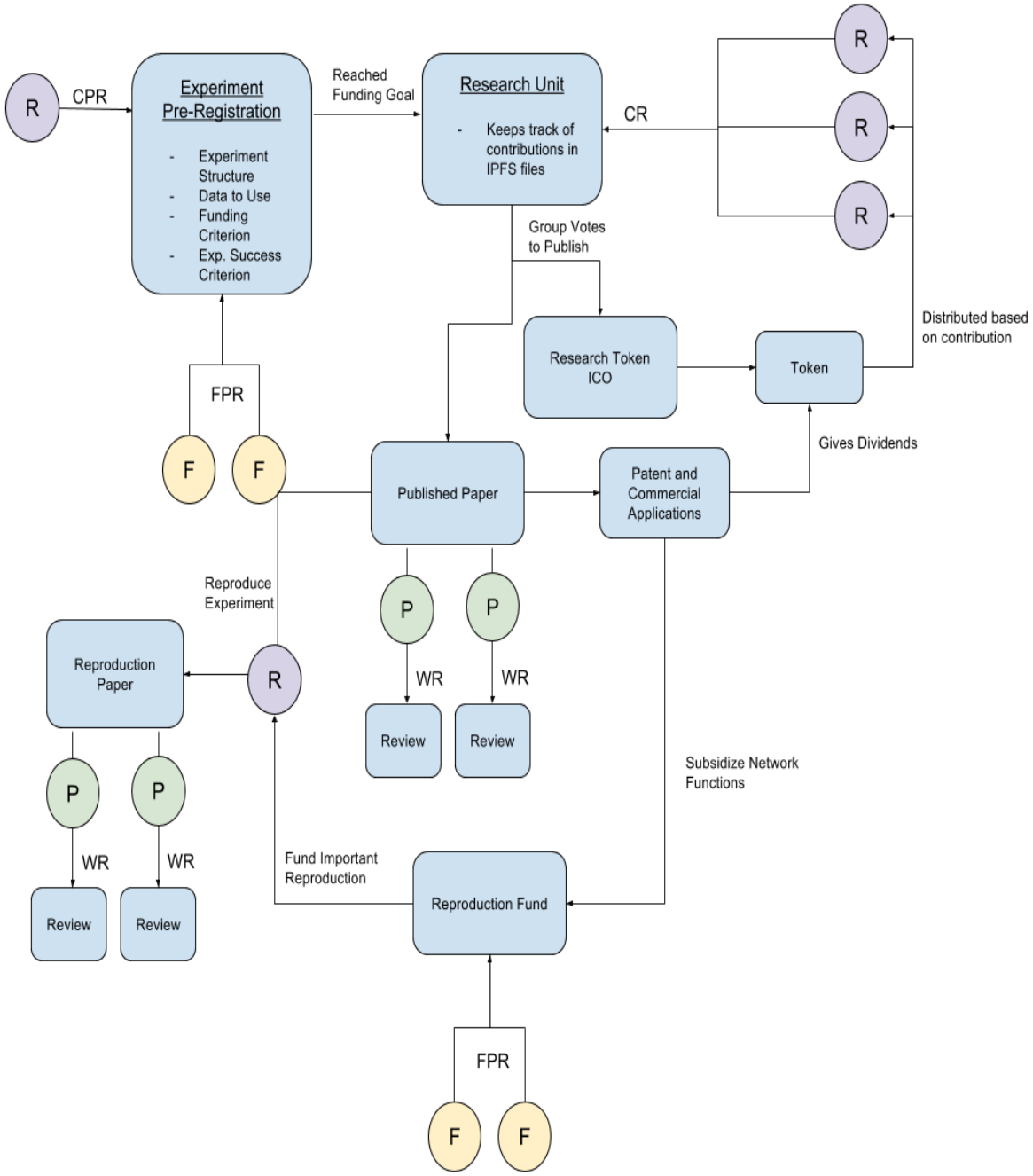
Peer Reviewer

WR - Write a review

F

Funder

FPR - Fund a pre-registration
FF - Fund Network Fund



6.5. Network Seeding

Tokens allow for a wide variety of strategy options to incentivize use while focusing on those who will create the most impact on value creation at an early stage.

Our earliest adopters will be members of the blockchain research community who have knowledge of both science and blockchain technology, enabling them to better understand the project, test it and put it into practice.
We also intend to jumpstart the user base by leveraging the relationships of existing networks. For example, we will be assigning early access tokens to research scientists that already have an ORCID or ResearchID number. University students, faculty professors, and writers involved in the open science and blockchain movement will also be invited as early adopters.

A percentage of the tokens will also be used to incentivize working partnerships in order to develop industry and academia specific tools. Long-term contracts with universities to facilitate access and feedback from their students will also be desirable. Campus Hackathons will be set up to further incentivize the use of the network and encourage students to build new solutions and projects for their own particular fields of study.

7. References

[1] https://report.nih.gov/success_rates/Success_ByIC.cfm
[2]http://gantercourses.net/wp-content/uploads/2013/11/Faculty-Advisory-Council-Memorandum-on-Journal-Pricing-%C2%A7-THE-HARVARD-LIBRARY.pdf
[3] http://embor.embopress.org/content/15/2/131
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