DEIP: DECENTRALIZED RESEARCH PLATFORM

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INTRODUCTION

The scientific community encounters a wide range of problems that significantly hinder its development.

The problem of financing science. Scientific research projects generally involve significant expenditure and directly depend on external financing for purchasing equipment, paying research staff, renting laboratories and other accompanying expenses[1].

The majority of funds allocated to research activities come either from public grants or from the budgets of corporate bodies that conduct research for their own commercial interests[1].

Despite considerable subsidies, demand for research funding is much higher than the available supply. This is attributable not only to the insufficient amount of allocated funds, but also to the capacity and scalability of the organizations distributing them[2].

As a result, a large number of potentially valuable research projects don't receive necessary funding and are therefore unrealized.

The problem of access to results of existing scientific research. Presently, only scientists from prestigious and well-funded universities have full access to a full range of published papers. The current system hinders professional communication, constrains the possibility for data analysis and as a result slows scientific progress. Qualitative growth is possible only when scientific papers are available to all levels of stakeholders, both young scientists and experienced professionals.

At the same time the major prestigious publishing companies achieve high profit margins. They often choose to publish only the papers they subjectively consider valuable. Consequently, research that is potentially important for scientific development might be put aside and is never published.

The problem of evaluating the quality of research. Peer review should ensure that only the highest quality papers are published. However, it is not clear that this process is effective[3]. One of the main reasons is that reviewers may conduct shallow analysis, skip falsifications and miss out on an array of errors. This may happen because the referees are not usually paid for their work and don't receive any compensation for the time they have spent on it[4]. As a result, incomprehensible and low-quality articles make it to publication. Thus, scientists who wish to cite previous research studies have to verify their credibility.

In addition to that, there is a problem of peer review bias. Very often, the identity of an author is known to editors and reviewers, but not vice versa. Although such anonymity offers freedom to reviewers, it also reduces accountability, making the process vulnerable to unprofessional and obstructive commentaries[5].

This is not a complete list of the core problems science faces. Nevertheless, it clearly shows that the system of scientific knowledge has serious weaknesses.

One of the possible solutions for these problems is a decentralized scientific community, where the relations between its members are regulated by the consensus algorithm. It can be built using a system of electronic transactions without relying on trust[6].

I. PLATFORM OVERVIEW

DEIP is a decentralized research platform governed by the scientific community. It provides its members with tools for publishing their research works, open access to all published material, a decentralized review system and progressive funding mechanisms. Its infrastructure is entirely decentralized. The participants can use the platform without any commissions or intermediaries.

An important part of the platform is its token system (I A). This is designed to simplify the interaction between platform members and to create reputation and financial incentives for them to contribute to science. Some

[1] 2018 Global R&D Funding Forecast. [http://digital.rdmag.com/researchanddevelopment/2018_global_r_d_funding_forecast].
[2] National Science Foundation. NSF 07-45, Impact of Proposal and Award Management Mechanisms (IPAMM) Final Report. (2007) [https://www.nsf.gov/pubs/2007/nsf0745/index.jsp]
[3] Steen RG, Casadevall A, Fang FC. Why Has the Number of Scientific Retractions Increased?. PLOS ONE 8(7) (2013) [https://doi.org/10.1371/journal.pone.0068397]
[4] Kulkarni S. What causes peer review scams and how can they be prevented?. Learned Publishing (2016) [https://doi.org/10.1002/leap.1031]
[5] Smith R. Peer review: a flawed process at the heart of science and journals. J R Soc Med. 2006 Apr; 99(4): 178–182. [https://doi.org/10.1258/jrsm.99.4.178]
[6] Nakamoto S. 31 Oct 2008. Bitcoin: A Peer-to-Peer Electronic Cash System [https://bitcoin.org/bitcoin.pdf].

types of tokens are emitted and distributed between the participants as a reward for their contribution of expertise to the platform. The bigger the contribution, the more influence the scientist has on the platform's internal processes.

Platform members can use its infrastructure to conduct their research projects. The DEIP Storage Sidechain enables uploading large volumes of research data, making this available to all the participants (I B). Reviewers can access such data to verify the results of the research project. A smart contract system makes it possible to establish new models of relationship between platform members and to customize existing ones (I D). With the help of smart contracts research groups can automate some aspects of their operations.

DEIP opens up an opportunity to launch scientific journals with brand new monetization mechanisms (I C). This will help to make published research papers open and accessible to everyone.

After launch, the platform will belong to its members. They will govern it with the help of the consensus algorithm (III B).

A. Token System

The DEIP platform provides an internal system of tokens that helps its participants to interact with the protocol. Tokens are responsible for the platform's main functionalities including research group management, decentralized assessment of research papers, attracting funds and rewarding contributors to science on the platform.

DEIP Token. The DEIP Token is the liquid currency of the platform. It is used to reward scientists for their contribution of expertise and to finance projects published on the platform. It is also distributed as a reward for maintenance of the platform infrastructure.

The DEIP Token is emitted in accordance with the model established in the protocol. Following this model, the quantity of DEIP Tokens should change in correspondence to the level of contribution of expertise to science. Thus, the main purpose of this asset is to tokenize scientific contribution by means of the DEIP protocol. Tokenization is intended to reflect the demand for new scientific knowledge by members of the platform.

Expertise Token. The Expertise Token is a fundamental basis of the DEIP protocol. This token is the basis for participation in platform governance, reviewing research papers and in influencing the distribution of rewards and grants.

Each scientific discipline represented on the platform is recognised with its own type of Expertise Token. These Tokens are used to reflect the contribution of expertise by DEIP members to a particular discipline.

Expertise Tokens cannot be bought or transferred. They can only be earned by making a contribution to science on the platform, for example by publishing a paper that receives positive assessment from other Expertise Token holders within the relevant discipline, or by reviewing other papers within a certain discipline. Expertise Tokens can also be received at the point of registration with the platform, provided that a newly registered member has a proven qualification in a particular domain of science (I E). Researchers may hold Expertise Tokens in various disciplines.

Research Token. This token defines the ownership rights for a research project on the DEIP platform. Every research project is allocated a number of unique tokens, all of which initially belong to the research group. The research group may sell some of these tokens to stakeholders to raise funds for its project.

A research project conducted on the platform can be rewarded by the emission of DEIP Tokens. These are then distributed among the Research Token holders (IV B).

Journal Token. Journals on the DEIP platform are able to emit their own tokens that could be sold to attract additional funds. This mechanism opens up new opportunities for monetization of scientific journals without charges for publishing, access or review.

A scientific journal combines a particular number of research papers published on the platform. After a paper is rewarded, the journal is entitled to a part of its reward, that is then distributed among the Journal Token holders (I C).

Research Group Token. Each research group is assigned its own Research Group Tokens which are distributed

among its members and can be used to manage the group and its research activity (II A). These tokens influence the distribution of Expertise Tokens received after a research paper has been published, for instance in respect of contribution to the outcome (III D).

Research Group Tokens identify the affiliation to a particular research group and can be transferred only within it. New members receive these tokens from other members. Their quantity is determined by a group vote.

Research Group Tokens are used to vote for decisions concerning the entire research group. The number of tokens defines a researcher's voting power.

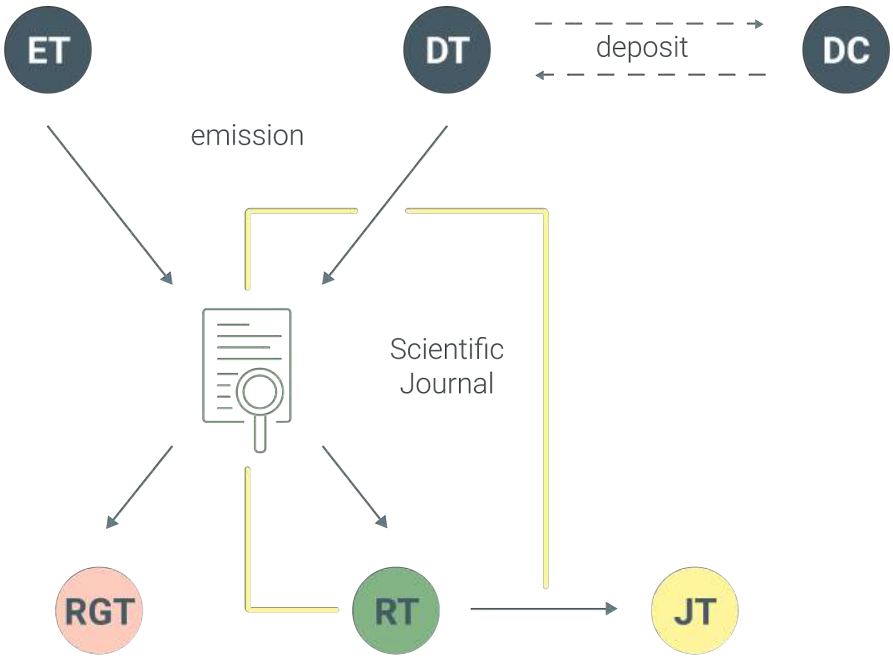

FIG. 1. Token System.

DEIP Common. The DEIP Common token is used to distribute network throughput among DEIP participants. This token is allocated to new platform members and allows them to use its functionality for free. The amount of DEIP Common tokens influences the storage capacity assigned to researchers (I B) and defines the maximum frequency of their operations.

DEIP Common tokens cannot be transferred, but can be converted to and from the liquid DEIP Token. The conversion from DEIP Token to DEIP Common happens immediately, but the reverse conversion takes a certain period of time. The amount of DEIP Common on a member's account cannot be lower than that initially received.

The combined token system is a tool that helps participants to interact within the protocol and which provides financial and reputation incentives. These incentives are aimed at maintaining the network's sustainability. In particular, they are the basis of the rewards system for publishing new research results and encourage high quality assessment of research papers and thus high quality science overall.

B. Decentralized Storage

The DEIP Storage Sidechain is a protocol for a public decentralized database integrated with the DEIP platform. It offers reliable public storage of the data produced as a result of research activities.

DEIP Sidechain Storage capacity is allocated in several ways. Some of it is allocated among research projects

proportionally to their Expertise Contribution Index (1). Thus, the higher a project is assessed by the community, the more storage space it will be provided with.

Additional storage space for any other data can be acquired by depositing Common Tokens (I A).

If a research project has no storage capacity due to a low Expertise Contribution Index or an insufficient amount of Common Tokens, research group members can donate up to 50% of their personal storage capacity to the project. Once the project has been allocated with its own storage capacity, members can opt to withdraw the capacities they donated.

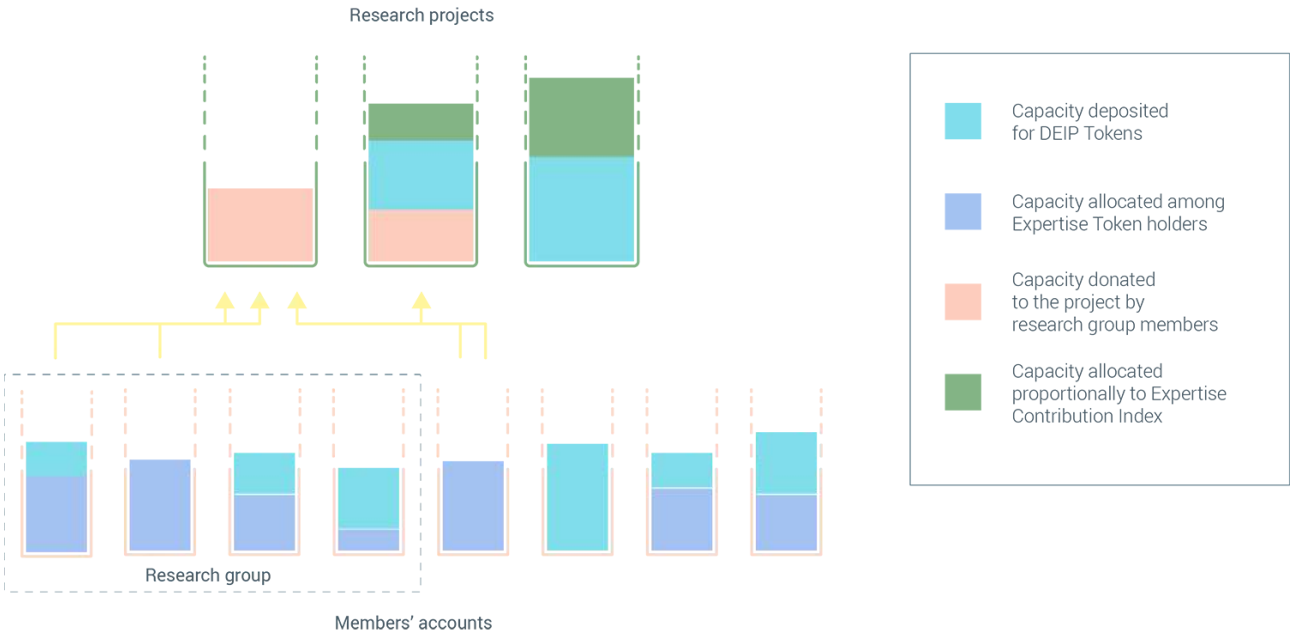

FIG. 2. Decentralized Storage.

The storage capacity allocated to a particular research project S_{R_i} is calculated by

$$S_{R_i} = S_d + (R_{e,i} + R_{d,i}) * R * S_t,$$

where $R_{e,i}$ is the amount of storage capacity automatically allocated to research project i based on the expertise assessment; $R_{d,i}$ is the total amount of storage capacity allocated to the research project i based on the amount of Common Tokens deposited by the research group; S_d corresponds to the amount of storage donated by the research group members. R is a percentage of storage allocated to all research projects, S_t — total size of DEIP Storage Sidechain.

DEIP participants can provide storage capacity to other members and research projects from their own allocation, earning DEIP Tokens in return. (IV B).

Storing data on DEIP Storage Sidechain protects the platform from overload. As it is decentralized, the stability of the infrastructure directly depends on the amount of memory donated by the platform members. This, above all, is determined by the effectiveness of the incentives for memory donation.

C. Scientific Journals on DEIP

Scientific journals contribute to science in two main ways — by distributing knowledge and by regulating the quality of research papers.

Journals have to monetize their activity to cover operational expenses, for example by introducing subscription fees. This has a negative impact on the accessibility and openness of scientific knowledge.

The DEIP platform offers an opportunity to create scientific journals with completely new monetization mechanisms which allow them to avoid conflicts of interest with the scientific community.

Journals on DEIP curate selections from the papers uploaded to the platform. All papers remain open to access and authors are able to retain their copyrights.

After a paper is published in the journal, it may get a part of its Research Tokens and therefore a part of

its reward. This is the basis of the default monetization model of journals on the platform and is meant to stimulate them to publish only papers of the highest quality.

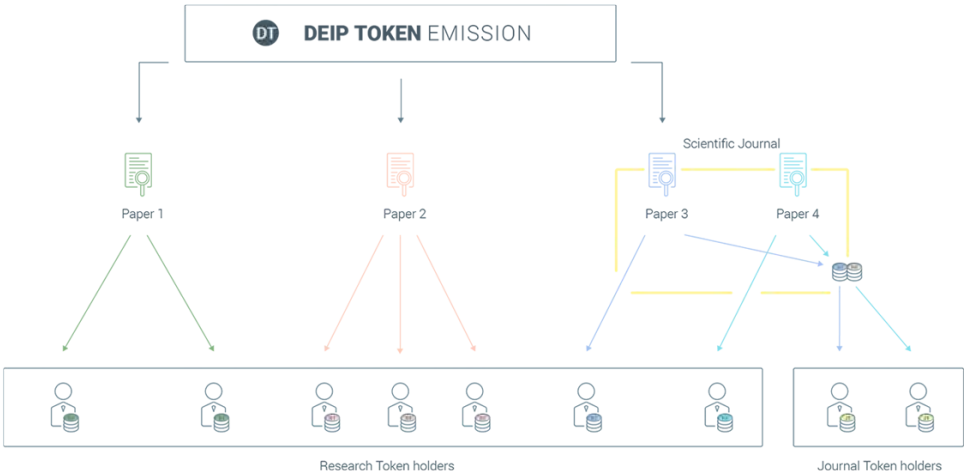

FIG. 3. Monetization of Scientific Journals.

Scientific journals are able to raise additional funds by selling a part of their Journal Tokens, similarly to Research Token sale (I A). Journal Token holders are automatically entitled to a share of the income that a journal gets from publishing research papers.

A journal can additionally receive income when its editorial board reviews scientific papers on the platform. In such cases a journal can receive a reward in liquid DEIP Tokens in a proportion set by the journal itself.

The platform provides journals with decentralized storage (I B) and a smart contract system (I D). This allows them to automate operational activity and create custom monetization models. Journals may also use the results of decentralized assessments to choose research papers for publication (II D).

The proposed model can be a solution to the problem of openness of scientific knowledge, currently obstructed by paywall or "pay-for review" revenue models.

D. Smart Contract System

The main processes on DEIP: publishing of scientific papers, research group management, reviewing scientific projects and funding research projects follow particular rules. Platform members are able to customize these by means of smart contracts.

Further, platform participants can build decentralized applications with brand new relationship models on the basis of general-purpose smart contract tools.

Grant Distribution. Through the DEIP platform, grant givers are able to automate the process of grant distribution (IV B). They can also customize grant allocation and its distribution among research groups.

Data inputs to smart contracts can be any information stored on the DEIP blockchain. For example, it could be data related to previously distributed grants or from researchers' personal profiles, the results of decentralized review or assessment results.

Smart contracts make it possible to set the amount of grant support during a specific period. They can also be used to motivate the scientific community to conduct specific research or achieve particular goals. For example, in order to accelerate transfer of expertise within a discipline, an algorithm could select only projects of research groups with junior scientists.

Research Group Management. Within the standard platform model of research group management, members vote with their Research Group Tokens on every decision within the group (II A). The Expertise Tokens reward that a research project receives is distributed among research group members in accordance with their share of Research Group Tokens.

If desired, participants are able to adapt the default model: to change the algorithm of reward distribution

or the mechanism of making decisions on behalf of the research group (II). For example, a group member can be allocated rewards in accordance with the proportion of their research papers, published within the research project, which receive positive reviews.

Review Process. A research group can apply its own incentive model to reward reviewers (II D). This might be in order to attract reviewers with particular expertise, increase the number and the quality of reviews, and consequently increase the quality of the research papers.

This type of smart contract can distribute additional rewards to reviewers following any criteria. For example, the research group could create a smart contract, in which the reward is distributed among reviewers according to the number of their papers within a previous year that they were involved with.

Scientific Journals. According to the default monetization model on DEIP, a journal can receive a part of the income of the research papers published through it (I C). By means of smart contracts, journals are able to create their own monetization models and automate their operations. For example, a journal may set up criteria for research papers to be automatically selected for publication.

General-purpose Smart Contracts. General purpose smart contracts allow members to create their own decentralized protocols and applications, using the infrastructure and data stored on the DEIP blockchain.

An example here is the decentralized system of management of gene production in Syntau[7]. The project uses the DEIP infrastructure, and the decisions on adding some genes to a ban list are taken by voting with Expertise Tokens.

Thus, the DEIP protocol allows the customization of platform functionality and create new relationship models between its members.

A model created by a platform member, could perhaps become more widely used than the one proposed by default, and potentially replace it. This flexibility will allow the scientific community to continue improving the protocol after its launch.

E. Decentralized Identity Verification Mechanism

In order to use all the functions related to research activity on the platform, members are required to verify their identity. This can be done at any point after registration. The identity check is performed by the Verification Committee.

Verification Committee. Each DEIP participant can become a member of the Verification Committee. For this, it is required to provide a security deposit in DEIP Tokens, that is frozen on the verifier's account. It is also used to stimulate verifiers' efficiency. The total of these deposits also determines the number of participants that can be verified during a certain period.

Identity Verification Procedure. Each member of the platform is able to initiate their own identity verification procedure. For this they choose a verifier to send an application form to with their personal information.

Verifiers receive a reward from DEIP Token emissions when they confirm a new member's identity (IV B). The amount of this reward is determined by Verifier Score, defined by the number of successful verifications, the time spent on applications and the level of research activity of members whose identity has been confirmed.

$$V = \sum_{k=1}^{n} \left(1 + \sum_{i=1}^{p_k} S_i^k + \sum_{j=1}^{r_k} RI_j^k\right),$$

where n is the number of participants, whose identity was confirmed by a verifier during a certain period of time, p_k is the number of papers of k^{th} verified member, S_i^k is the Expertise Contribution Index (1) of i^{th} paper, r_k is the number of reviews of k^{th} participant, RI_j^k is the Review Index (6).

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[7]Syntau. Gene Synthesis Blockchain Platform. [http://syntau.com]

Verifiers can ask for any amount of information they consider necessary to confirm an identity, as well as set their own rules for receiving and processing applications.

To confirm a member's identity, their application should be approved by one or several verifiers, whose total Verifier Score is higher than the required minimum. If the application is denied, the platform member can begin a new one.

Tokens Received in Case of Verification. New members who are experts in a particular field of science can receive a certain amount of Expertise Tokens (I A) immediately their identity has been verified. For this, experts in a corresponding discipline on the platform should confirm the expertise of the new member.

Researchers, who are not verified but whose papers are cited on the platform, can receive a reward in DEIP Tokens (I A), accumulated for the citation (II C) after their identity is confirmed.

Disputes. If a decision made by a verifier raises doubts, it can be appealed by other members. In this case, a member with falsely confirmed identity can be deprived of their Expertise Tokens, and a verifier who made this mistake — of their security deposit.

II. CONDUCTING RESEARCH ON DEIP

A research project on the DEIP platform starts with the publication of an announcement where a research group can describe their project and give some prospective research results. A project can include any number of papers, each of which is open to review by experts in corresponding disciplines. Fair reviewing is incentivised by the DEIP protocol.

The platform opens up several ways for research projects to bring in funds: accessing finance by selling Research Tokens of a research project (I A), getting a grant, being rewarded from emission (IV B), if the work has been positively assessed by the scientific community.

A. Research Group

Researchers on the DEIP platform conduct and manage research on behalf of a research group. Decisions within a group are taken by means of voting. The right to vote is given by ownership of Research Group Tokens (I A), the number of these tokens a member possesses determines the power of their vote.

When a particular issue is put to vote, the system creates a proposition. For a proposition to be accepted, a proposition needs to receive the votes based upon a certain quantity of Research Tokens once a Quorum has been assembled. This quantity is defined when creating a research group and can be changed for each type of issue. If the quorum is not assembled, the proposition is automatically declined.

Issues that can be put up to vote within a research group are:

1. Adding a new member to the research group;
2. Removing a member from the research group;
3. Publishing research results;
4. Transfering Research Group Tokens from one member to another;
5. Transfer of Research Tokens from the research group account;
6. Transfer of DEIP Tokens from the research group account;
7. Research Token sale announcement;
8. Changing the size of the quorum, if needed, for an issue that may be put to a vote.

When a new member is added to a research group, Research Group Tokens are automatically transferred to their account from other members in proportion to the amount of tokens they own.

Each member of a research group is able to leave the group without any additional conditions. In this case, all their Research Group Tokens will be distributed among the remaining members.

The platform presents the opportunity to create custom research group governance models that can differ from the default one. These models are implemented using a smart contract system that regulates the relations between research group members (I D).

B. Research Structure

Research projects on the DEIP platform are created within a specific scientific discipline. Each research project must be assigned either to one or several disciplines.

Results are published in several categories, each corresponding to a particular stage of the research:

1. Announcement — published when creating a project;

2. Milestone papers — introduce interim results; every project can have any number of these. Though interim, each milestone paper should be self-consistent.

3. Final result or summary, after which the project is considered complete.

Once published, papers are available for peer review to experts in corresponding disciplines. Then, after a certain time a Reward Period opens up, during which rewards are distributed. The amount of reward distributed depends on the results of the reviewing experts' assessments. Multidisciplinary research projects receive rewards from several Discipline Pools (IV B).

While the project is running, the reward period of each paper starts two weeks after publication and lasts for a week. Experts' reviews during this period influence the amount of tokens the paper will receive during its reward period.

FIG. 4. Research Structure.

As soon as the project is completed, two reward periods open up:

1. The first one opens up in a month and lasts for another month;

2. The second one opens up in six months and lasts for two weeks.

The structure suggested above allows the research group to have their papers reviewed throughout the entire duration of the research project.

C. Citation System

A paper cited within another paper has the opportunity to receive a part of its reward. Thus, the project can bring income to the holders of its Research Tokens (I A) even after the end of the reward period.

Since the majority of completed research projects have been already published in journals outside the platform, there is a continuity between the platform's citation system and the outside environment. DEIP gives an opportunity to refer not only to papers within the platform, but also to the ones from external sources. Papers published outside the platform will accumulate rewards according to their citations. The authors of such works will be able to receive these rewards as soon as they join the platform (I E).

D. Research Assessment

Every paper on the platform can be assessed by experts of the corresponding discipline. On the one hand, the authors have additional incentives to attract as many reviewers as possible, because their assessment influences the amount of reward the research will get. In their turn, the reviewers have their own financial and reputation incentives for reviewing. One of them is determined by research groups, that can share up to a half of their reward with reviewers. This mechanism helps scientists to attract more experts to review their papers.

When reviewing, scientists specify whether they assess the paper positively or negatively. The more Expertise Tokens a reviewer possesses, the more influence on reward distribution the review has. The review in its turn can also be assessed by the expert community, or, in other words, the curators. Their assessment is also taken into account when distributing the reward.

Each paper in the system has a score — Expertise Contribution Index.

Definition 1. *Expertise Contribution Index* of a paper is defined as :

$$S_{dp} = \sum_{r=1}^{k} m_r C_r E_r, \tag{1}$$

where k — the number of reviews per this paper. $m_r \in \{-1, 1\}$, if r^{th} review is positive, then $m_r = 1$, if negative — $m_r = -1$. E_r — the amount of Expertise Tokens a r^{th} reviewer has. C_r — is the weight of r^{th} review.

C_r is calculated with the following formula

$$C_r = C_{ea}\frac{E_r}{\overline{E_r}} + C_{va}(1 - \frac{1}{n})\frac{V_r}{\sum_{i=1}^{k} V_i},$$

where C_{ea} — coefficient, that regulates the influence of reviewer's expertise contribution, and C_{va} — coefficient, that regulates the influence of curators expertise votes for a review. They are defined by means of simulations and cross-validation of the system. $\overline{E_r}$ — is the average number of Expertise Tokens each reviewer has. n — the number of reviewers, and V_i — total number of curators' votes for i^{th} review. The first component in this formula reflects the expertise contribution of a reviewer in relation to other reviewers in the final assessment. The second one indicates how the Expertise Contribution Index is influenced by curators' votes for a corresponding review.

The final result of the research project is automatically attributed to the score of all the previous papers published within it. Thus the Expertise Contribution Index value of the research is equal to

$$S_{dfr} = V_{dp} + S_{dp},$$

where S_{dp} — value (1) for a final result. Then,

$$V_{dp} = \sum_{k=1}^{p} (\max_{m>0} E_k - \min_{m<0} E_k),$$

where p — the number of experts who reviewed the milestone papers but didn't review the final result. $\max\limits_{m>0} E_k$ — maximum amount of Expertise Tokens a reviewer gets if a milestone paper got a positive review, and correspondingly $\min\limits_{m<0} E_k$ — the maximum amount of reviewer's Expertise Tokens if a milestone paper got a negative review. In case a reviewer provided neither positive nor negative reviews, a corresponding value will equal zero. Therefore, the Expertise Contribution Index of a research project is based on reviews and influences the reward distribution between research projects.

E. Research Token Sale

When a research group starts a project they are allocated Research Tokens. While the research is being conducted, the group can sell any number of them to other platform members to attract funds. For this purpose the process of token sale, or in other words — public sale of Research Tokens, can be carried out. Participants who acquire Research Tokens are entitled to a share of the income in DEIP Tokens that are distributed to a project after each of its milestone papers have been published.

After completion of a research project the remainder of the Research Tokens are distributed between research group members in proportion to Research Group Tokens they own.

The default token sale model uses the following parameters: the percentage of Research Tokens sold, hard cap, soft cap, the starting and the finishing point of the token sale. Through the system of smart contracts on DEIP the research group can customize the token sale model using a different set of parameters (I D).

III. PLATFORM GOVERNANCE

The decentralized DEIP platform is governed by the scientific community who are members to represent their interests.The main instrument of platform governance is the Expertise Token.

A. Expertise Token

Expertise Tokens are used to reflect the contribution of expertise by platform members to a particular discipline. They cannot be bought or transferred, but can only be earned by contributing to science on the platform. Expertise Tokens are emitted and distributed between participants in accordance with their expertise contributions.

Expertise Tokens are a fundamental basis of the DEIP protocol and allow participation in the governance of the platform. On the basis of Expertise Token holdings, the scientific community on DEIP elect block producers — the delegates who make decisions on behalf of the whole community.

Expertise Tokens in the various scientific disciplines are also the basis upon which members review published papers, influencing the reward their authors will receive.

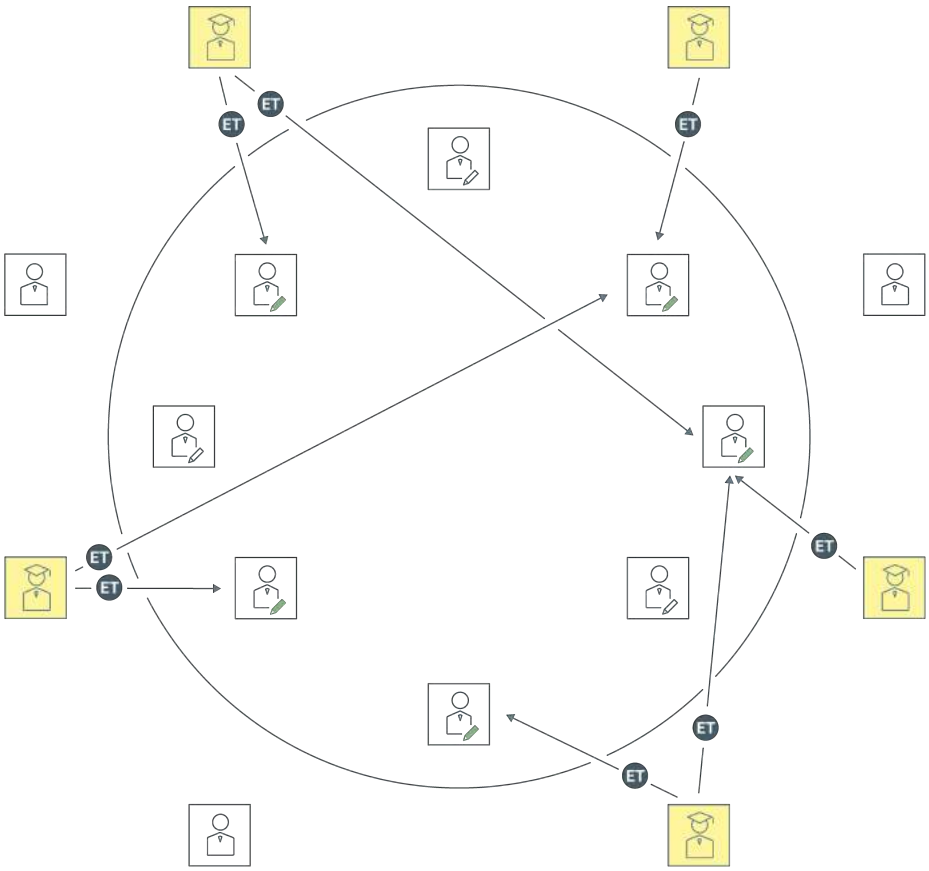

FIG. 5. Delegates Election.

Further, the quantity of Expertise Tokens each member possesses directly influences the capacity of DEIP Storage Sidechain (I B), the computing power and throughput capacity of the network that they can use.

Consequently, the more expertise contribution on the platform a member provides, the more significant their role in platform governance will be.

B. Consensus Algorithm

Activity of a platform member recorded on the blockchain represents a transaction. This transaction is considered approved after it has been included into a block of transactions. This occurs when certain participants come to a joint decision, in other words, a consensus. These participants, the "block producers", are the delegates chosen by the DEIP scientific community. The mechanism that regulates the election of delegates and their activity is called the consensus algorithm.

The DEIP consensus algorithm has been created specifically for the scientific community and is referred to as Delegated Proof of Expertise Contribution. It is based on the expertise contribution of each member to science on the platform. The higher their contribution is assessed by other participants, the stronger is the member's influence for choice of block producers. The quantitative value of expertise contributions is reflected in Expertise Tokens. Members can vote for block producers using the total of their Expertise Tokens across all disciplines. Thus, Expertise Tokens are the main tool that allows the scientific community to govern the platform in line with their interests.

Block production is conducted in rounds and measured in blocks. Each round lasts for 21 blocks. Consequently, 21 block producers can participate in each round. Each of them is randomly assigned a 3-second time slot, during which they should produce, sign and send a new transaction block to the network.

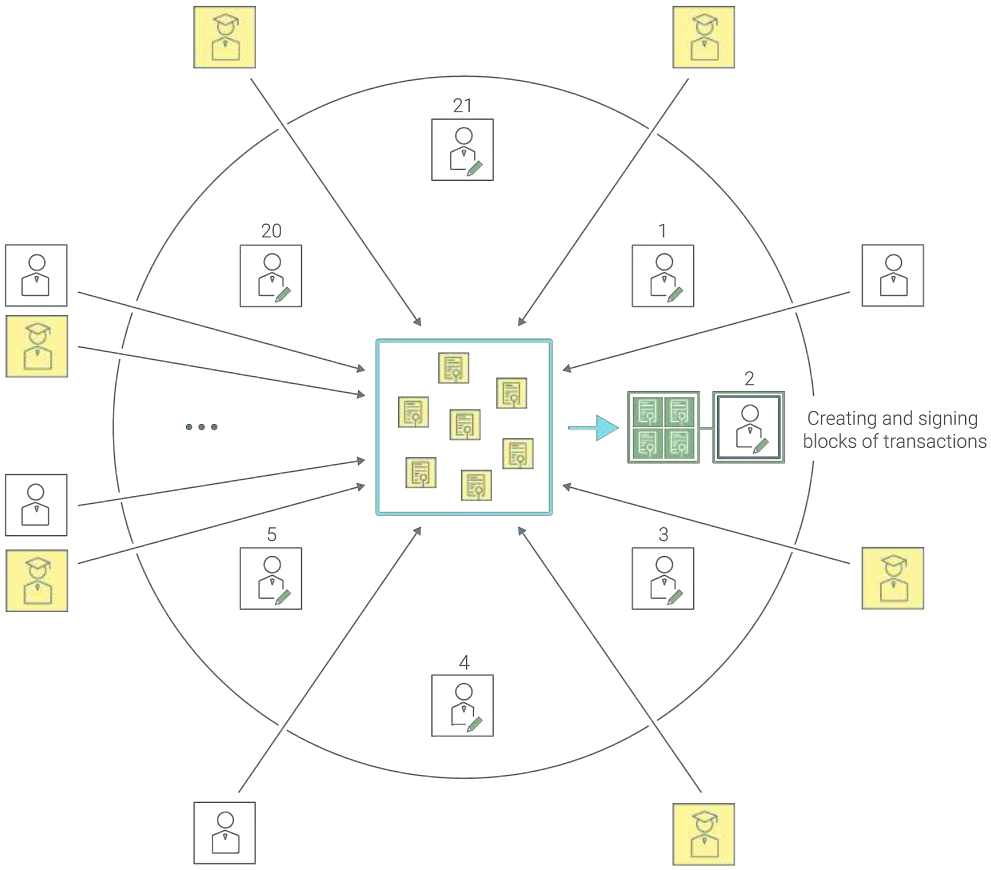

FIG. 6. Block Production.

The first 20 block producers represent the candidates that the scientific community has given most votes to.

The 21st candidate is elected by a special algorithm according to which, the probability of being selected is proportionate to the number of received votes. This helps candidates who have fewer votes have a chance to participate in block production. The order in which producers will sign the blocks is defined by a schedule. This is made at the end of every round and takes into account changes in vote distribution between candidates.

The delegates have significant power, because they ensure the stability of the system and are empowered to accept changes to the protocol. In the case that their activity does not correspond to the interests of the scientific community, members can withdraw their votes at any moment. A delegate will also be suspended from block signing if no blocks have been produced in a 24-hour period. The delegate will be automatically restored to the list of candidates provided that the digital signature for block production is updated.

C. Expertise Token Emission

Expertise Token emission helps to make the platform governance stable and adaptive. The base of the emission model is the idea that the amount of emitted tokens reflects the level of expertise contribution of the platform members.

Suppose that $t_0, t_1, \ldots, t_n, \ldots$ — are the points on time axis, that corresponds to the time of signing a transactions block.

If $X(t)$ defines the amount of Expertise Tokens at the time period t, the change of the amount of tokens between time periods $t_0 = 0$ and $t_n > 0$ can be defined as

$$X(t_n) - X(t_0) = \sum_{k=1}^{n} [X(t_k) - X(t_{k-1})],$$

where n — the number of expert contribution intervals on the platform between the time periods t_0 and t_n, and $X(t_k) - X(t_{k-1})$, that defines expertise contribution during a k^th interval, $k = 1, 2, \ldots, n$.

Assumption 1. *Change of expertise contribution on the platform is directly proportional to the amount of Expertise Tokens owned by reviewers who assess on-going research papers.*

$$X(t_n) = X(t_{n-1}) + C(t_n)\frac{E_a(t_n)}{E(t_n) + E_0}X(t_n), \tag{2}$$

where E_a is the amount of Expertise Tokens that are used to assess papers in their reward period. E is the amount of Expertise Tokens, that is used to review all the papers on the platform. E_0 is the initial value of expertise contribution t_0. C is the weight of expertise contribution.

When calculating the expertise contribution E_a at a certain point in time t_k, only papers in their reward period are taken into account.

C — the correction of token emission. In this case, the correction is used to prevent possible emission abuse:

$$C(t) = 1 - \frac{p_a^n}{p_a},$$

Where p_a^n is the number of negatively reviewed papers in a reward period, p_a is the total number of papers in a reward period.

One of the goals of token emission modeling is to define the initial metrics of equation (2), more specifically $X(t_0)$ and E_0. They can be assigned with the help of heuristic algorithms and computer emission simulation.

The model described above can be elaborated with respect to assumptions and factors that influence the creation of new knowledge on the DEIP platform.

D. Expertise Token Emission Distribution

After allocation, Expertise Tokens are first distributed among scientific disciplines, and then between their contributors.

Scientific Disciplines. Every scientific discipline is assigned with a score

$$S_d = \Big(\sum_{rs_d=1}^{q} \sum_{rv_d=1}^{p} E_{rv}^{rs} \Big)^a, \tag{3}$$

where $a \in (0, 1]$ is used to stimulate the development of less popular disciplines on the platform. E_{rv}^{rs} — the amount of a reviewer's Expertise Tokens rv, used for research assessment rs.

In this case, if $X(t_k) - X(t_{k-1})$ — is the amount of emitted tokens in the block k, as a result, the amount of Expertise Tokens, allocated to a discipline d is equal to

$$DP_d = (X(t_k) - X(t_{k-1})) \frac{S_d}{\sum\limits_{f \in \mathbb{D}} S_f}, \tag{4}$$

where $\mathbb{D}$ — is a set of all disciplines on the platform, $d \in \mathbb{D}$.

Research and Reviews. Within a scientific discipline Expertise Tokens are distributed between two pools — a Research Pool to reward papers and a Review Pool to reward reviewers.

For discipline d a Review Pool will make

$$AP_d = DP_d \left(R_{min} + \left(1 - \frac{\max(\min(\overline{n_r}, n_r^b), n_r^u) - n_r^b}{n_r^u - n_r^b} \right)^a (R_{max} - R_{min}) \right). \tag{5}$$

Here $0 < R_{min} < R_{max} < 1$, consequently, the minimum and maximum amount of Expertise Tokens, that can be allocated to a Review Pool. n_r^b — admissible number of reviews per research, n_r^u — efficient number of reviews per one research. $\overline{n_r}$ — average number of reviews per active research in a particular discipline. $a \in (0, 1]$.

The remaining part of the discipline pool goes to its Research Pool.

Researchers. Expertise Tokens of the Research Pool are distributed among papers. Their reward period is opened in accordance with the Expertise Contribution Index (1). After the reward period is closed, tokens are distributed among the authors of the research papers according to the amount of Research Group Tokens they have.

Reviewers. The reviewers get a reward according to a Review Index

$$RI_r = 1 - C_{ri} \frac{V_r}{\sum_{i=1}^{n} V_i}, \tag{6}$$

where C_{ri} — is a coefficient, that defines the significance of the curator's voice during a research paper assessment. n — the number of reviews per a particular paper, and V_i — is a sum of votes for i^{th} paper r^{th} review.

The emission distribution model contains some unknowns, that should be defined before the platform is launched. It can be done with cross-validation of parameters of the system's computer simulation. This approach also helps to verify the stability of the model for various behaviour patterns of its members. Besides, it allows to predict and assess the work of the platform during a certain period of time.

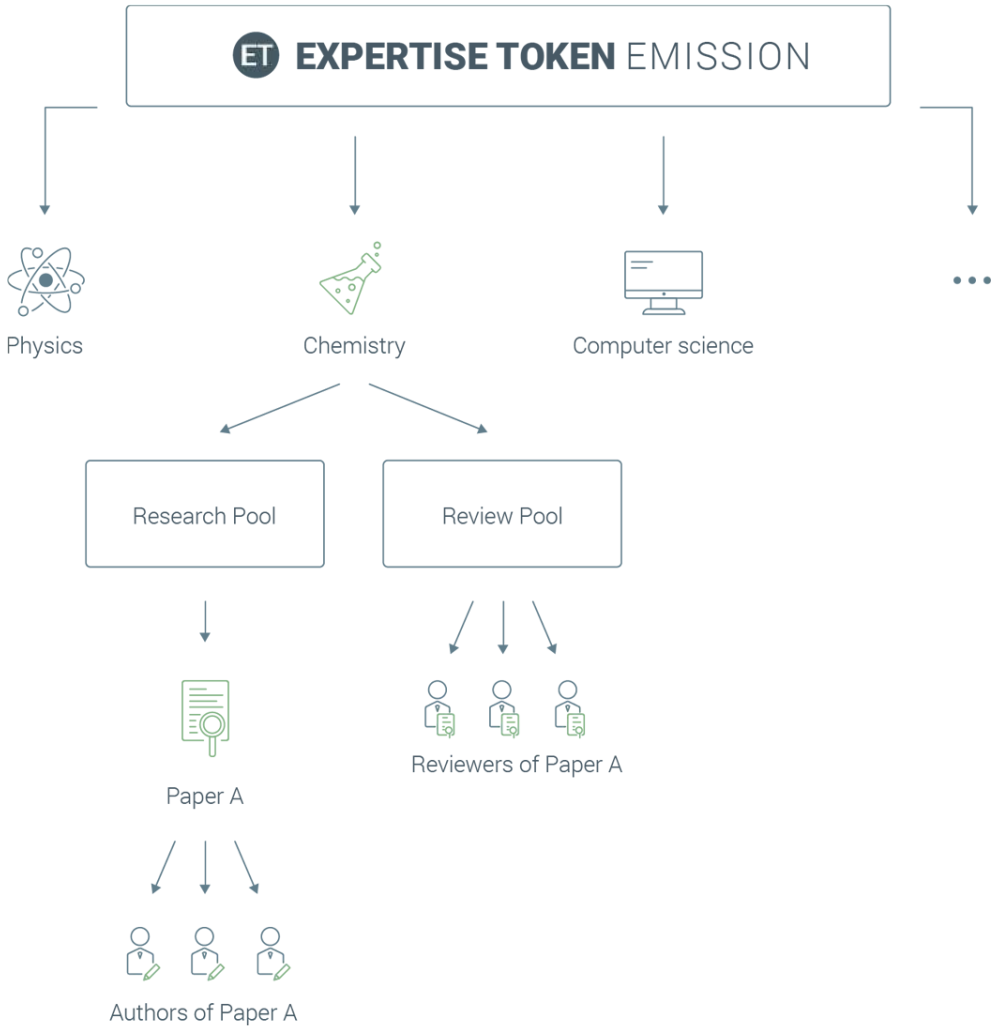

FIG. 7. Expertise Token Emission Distribution.

IV. DIGITAL ECONOMY FOR SCIENCE

Any research conducted on the DEIP platform can generate reward in liquid DEIP Tokens (I A). This reward depends on the evaluation of the published paper by experts and is possible due to the emission of internal currency. This currency is then distributed among community members based on their contribution to the creation of new scientific knowledge on the platform.

A. DEIP Token Emission

The amount of DEIP Tokens emitted should precisely reflect the expertise contribution to the scientific knowledge creation on the platform.

The emission model of DEIP Tokens, similarly to the emission of Expertise Tokens, is based on **Assumption 1** (III C). Consequently, the amount of emitted tokens follows the formula (2), where in this case C — is a coefficient correcting the emission in accordance with the number of active researchers and newly created research on the platform.

$$C(t) = \frac{n(t)p_a(t)}{p(t)n_a(t)},$$

where $n(t)$ is the number of scientists on the platform, $n_a(t)$ is the number of researchers on the platform,

including both those who take part in active research and those who have reviewed them. $p(t)$ is the number of researches on the platform and $p_a(t)$, is consequently the number of active research projects on the platform.

If the number of projects per active researcher is less than the average number over the lifetime of the platform, the number of emitted tokens will decrease.

The model described can be expanded in regards to the hypotheses and factors that influence new knowledge creation on the DEIP platform.

B. DEIP Token Emission Distribution

As soon as a certain amount of tokens has been emitted, they will be distributed among the participants of the platform. A part of these tokens goes to maintaining the system infrastructure, while the other part is distributed between scientific disciplines, similarly to Expertise Tokens distribution (4).

Within a scientific discipline, DEIP Tokens as well as Expertise Tokens are distributed between two pools: the Research Pool and the Review Pool (5). From the Review Pool, DEIP Tokens are distributed among reviewers in accordance with the Review Index (6).

From the Research Pool, DEIP Tokens are distributed between the researchers in compliance with the Expertise Contribution Index (1). This happens during the reward period.

As soon as the reward period is closed, a fixed amount of reward is allocated to the Research Token holders of other papers that have been cited in it. In the case that a research group decides to share the reward with reviewers, a corresponding percentage of DEIP Tokens will be distributed between reviewers, depending on the Review Index (6). The rest of the tokens are distributed among the Research Token holders of the particular research.

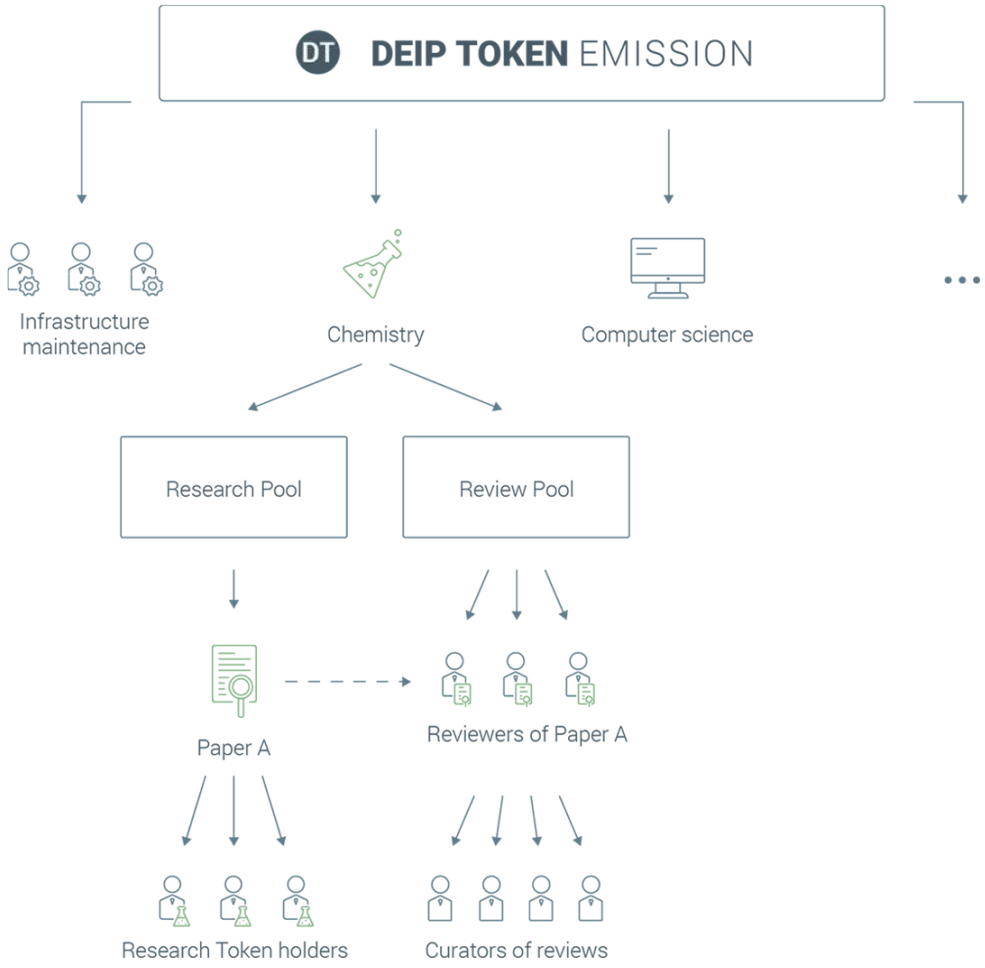

FIG. 8. DEIP Token Emission Distribution.

A fixed part of the reviewers' reward is distributed between review curators in proportion to their votes.

Granting System

DEIP Token holders are able to allocate a grant to a research group or to a particular research. In this case the grant is directly transferred to the research group account.

DEIP Token holders can also allocate grants to a particular discipline. In this case funds are distributed among research groups working in this domain in accordance with their Expertise Contribution Index (1).

Grant givers can set a time frame for when the funds are distributed among research papers that are in a reward period. Also, with the help of a smart contract system, they can set specific conditions for allocation of a grant. For example, it can be used only for particular purposes, or allocated only after certain intermediary results have been achieved. It is further possible to create custom systems for grant allocation and distribution (I D).

SUMMARY

In this paper we present a new model for research. It is made possible through a decentralized platform which is governed by the scientific community. The platform presented, provides its members with open access to all published materials and a decentralized system of peer review, both of which are tightly integrated into transparent and innovative funding mechanisms. On DEIP, relations are built on top of reputation and financial incentives, aimed at rewarding those who make contributions to science. All these contribute to building up the basis for an efficient digital economy for science.

We believe that science should be open to everyone who wants to have the opportunity to use its results. New science will be accessible to scientists from all over the world and will give them the opportunity to make their personal contribution to its development. Peer review of scientific papers will be transparent and rewarded, and its quality will be controlled by scientists. These factors will improve the communication between the researchers and the level of scientific papers produced.

All of this will take time and will be evolving step by step, like the scientific process itself. The results that the humanity has achieved with the help of current scientific methods, would be impossible to imagine several hundred years ago. Improving these methods can drive science to even more remarkable results.