AN AUTOMATICALLY REFEREED SCHOLARLY ELECTRONIC JOURNAL

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ABSTRACT

Internet growth seems to amplify the critiques to peer review mechanism: many researchers maintain that Internet would allow a more fast, elastic, interactive, and effective model of publishing. I propose a new kind of electronic scholarly journal, with the aim of changing the submission-review-publication process. The new electronic scholarly journal is described in both intuitive and formal ways.

1 INTRODUCTION

The communication mechanism that modern science still adopts nowadays arose in the 17th Century, with the publication of the first scientific journals reporting, in paper form, the ideas, discoveries, inventions, of researchers. Nowadays, since about 1930, the dissemination of scholarly information is based on peer review: the researcher that wants to disseminate her work writes a paper and submits it to a scholarly journal; the paper is not immediately published, but it is judged by some referees; if they judge it adequate, the paper is published.

The peer review mechanism is usually retained an adequate solution, even if not the ideal one: sometimes, the reviewing process takes too long, even one or two years, so that the published paper describes something old; sometimes the reviewers do not do a good job, accepting a bad paper or not accepting a good one, that after two years cannot be resubmitted because too obsolete; and so on.

Internet has changed, and is changing, this situation [1, 2, 7, 10]. A peer reviewed journal can be distributed by electronic means. The refereeing process too can take place completely electronically, drastically reducing time and money: see, *e.g.*, JHEP (http://jhep.sissa.it) or Earth Interactions [5] (http://EarthInteractions.org). Multi-mediality can lead to a more effective communication [5]. Of course, there are also some drawbacks of electronic journals (copyright problems, legal validity, accessibility, and so on), and they seem to have not a large impact by now [4], but the general feeling is that these are just temporary problems.

Internet growth seems to amplify the critiques to peer review mechanism: many researchers maintain that Internet would allow a more fast, elastic, interactive, and effective model of publishing. For instance, Nadasdy [9] suggests substituting the peer review with democracy: each submitted paper is immediately published and readers will judge it. Of course, the problem with this approach is that the readers may not be capable of correctly judging the paper: whereas the referees are chosen among the experts of the field, everybody can read and judge a paper published on Internet. Harnad [3] says that "peer commentary is a superb supplement to peer review, but it is certainly no substitute for it".

I propose a new kind of electronic scholarly journal, with the aim of changing the submission-review-publication process. I try to make a step further on the road suggested by the not refereed journals just mentioned, and to present a mechanism that avoids some of the above described problems. A longer description of these ideas is available in [8].

This paper is organized as follows: in Section 2 the idea is presented in an intuitive way; in Section 3 some mathematical formulae describe more formally the proposal; and Section 4 discusses some open problems and future developments.

2 GENERAL DESCRIPTION

The basic idea is the following. Each paper is immediately published after its submission, without a refereeing process. Each paper has a score, measuring its quality. This score is initially assigned on the basis of the goodness of paper author(s), and later dynamically updated on the basis of the readers' judgments. A subscriber of the journal is an author or a reader (or both). Each subscriber has a score too, initially assigned on the basis of the editorial politics of the journal (*e.g.*, the average of all subscribers, a predefined constant score, and so on), and later updated on the basis of the activity of the subscriber. Therefore, subscribers scores are dynamic too, and change accordingly to subscribers behavior: if an author with a low score publishes a very good paper (*i.e.*, a paper judged very positively by the readers), her score increases; if a reader expresses an inadequate judgment on a paper, her score decreases accordingly, and so on.

While time goes on, readers read the papers, judgments are expressed, and the corresponding scores vary consequently. The score of a paper can be used for deciding to read or not to read that paper; the score of authors and readers are a measure of their research productivity, then they will try to do

their best for keeping their score at a high level, hopefully leading to a virtuous circle (publishing good papers and giving correct judgments to the read papers).

For understanding the details of the automatically refereed journal proposed here, let's follow the events happening while a paper is written, submitted, published, and read. The paper has an initial score, inherited from the score of its author. The paper is later read and judged by readers. When a paper is read and judged, five steps are executed:

Step 1. The paper score is updated: if the judgment is lower (higher) than the actual paper score, the paper score decreases (increases). The score of the reader determines the weight of the judgment: higher rated readers' judgments will be more important (will lead to higher changes) than lower rated ones.

Step 2. The author's score is updated: when the score of a paper written by an author decreases (increases), the score of the author decreases (increases). Thus, authors' scores are linked to the scores of their papers.

Step 3. The reader's score is updated: if one reader's judgment about a document is "wrong" (too far from the average), the reader's score has to decrease. Then, the reader's score is updated depending on the goodness of her judgment (how much adequate her judgment is, or how much it agrees with the new score of the paper).

Step 4. The score of the readers that previously read the same paper are updated: if a judgment causes a change in a paper score, the goodness of the previously expressed judgments on that paper has to be re-estimated. Then, a judgment on a certain paper leads to an updating of the scores of all the previous readers of that paper.

Step 5. The steadiness values of the scores are updated: every object with a score (author, reader, paper) has a steadiness value too. This indicates how much steady the score is: old papers will have a high steadiness; new readers (authors) will have a low steadiness. Steadiness affects the score update: a low (high) steadiness allows quicker (more slow) changes of the corresponding score. A steadiness value increases as the corresponding score changes.

The goodness of a reader's judgment as calculated in steps 3 and 4 is an approximation of the ideal goodness calculated as the difference between the reader's judgment and the score of the paper at time $= +\infty$. Since this score is obviously not available, it has to be guessed (step 3), but this guess can be revised and refined as time goes on (step 4).

3 FORMAL DESCRIPTION

The behavior of the whole system can be specified in a formal way by means of some formulae that define how to compute, at each judgment expression, the new values of the scores and steadiness of reader, paper, author, and previous readers. There are many possible choices for the formulae, and the best solutions have to be chosen after some experimental activity, but even the simple and naive ones presented in this section will demonstrate the feasibility of the journal.

3.1 Notation

I will indicate with:

- $s_r(t), s_p(t), s_a(t)$ the score of a reader, a paper, and an author, respectively, at time t. I will sometimes omit the time indication when this does not rise ambiguity.
- $\sigma_r(t), \sigma_p(t), \sigma_a(t)$ the steadiness of a reader, a paper, and an author, respectively, at time t.
- $j_{r,p}(t)$ the judgment expressed at time t by reader r on paper p.

All the score values are in the range $[0, 1]$ (0 is the minimum and 1 the maximum); all the steadiness values are in the range $[0, \Sigma]$, with $\Sigma \leq 1$.

The scores updatings take place in similar ways, though with different parameters, for all the above values. The general approach is that if j is the new judgment and s the previous score of an author, a reader, or a paper, the new score $s(t+1)$ is obtained as the weighted mean of j and $s(t)$:

$$s(t+1) \quad = \quad \beta \cdot j + (1-\beta) \cdot s(t). \tag{1}$$

β is in the range $[0, 1]$ and indicates the importance of the new judgment with respect to the old score: if $\beta = 0$ the new judgment is not taken into account; if $\beta = 1$ the old score is not taken into account; if $\beta = 0.5$ the new judgment and the old score have the same importance and the new score is equally distant from old score and new judgment; and so on. The value of β depends on other parameters, that are different depending on the kind of score that is being updated, as we will see in the following subsections.

Rewriting (1) as

$$s(t+1) \quad = \quad s(t) + \beta \cdot (j - s(t))$$

it is emphasized how the new score $s(t+1)$ is obtained adding to (or subtracting from) the old score $s(t)$ a quantity depending on how much the judgment j is different from the old score $s(t)$.

3.2 Step 1: paper score updating

When, at time t, a reader r reads a paper p and expresses a judgment $j_{r,p}(t)$, the new paper score $s_p(t+1)$ is updated (step 1). Following the template (1), $s_p(t+1)$ is calculated as the weighted mean of the judgment $j_{r,p}(t)$ expressed by r and of the old paper score $s_p(t)$:

$$s_p(t+1) = \pi(t)^{H_P} \cdot j_{r,p}(t) + (1 - \pi(t)^{H_P}) \cdot s_p(t), \tag{2}$$

where the constant H_P (a positive integer) is used for having a score changing more slowly (the higher H_P is, the

		σ_p	
		0	1
s_r	0	$> 0, < 1$	0
	1	1	$> 0, < 1$

Table 1: Constraints on π.

more $s_p(t+1)$ is similar to $s_p(t)$, since $\pi(t) \in [0,1]$ and $\pi(t)^{H_P} < \pi(t)$ if $H_P > 1$). For choosing the best function and constants, some experimental activity should be needed; the value $H_P = 4$ seems reasonable.

$\pi(t)$, that has the same role as β in (1), depends on:

- The reliability of the judge, measured with the reader's score s_r. A "good" reader's judgment should have more effect than a "bad" reader's one.
- The steadiness of the paper $\sigma_p(t)$. Typically, if a paper has a very high steadiness, the paper has been read by many readers, and its score should be quite stable. In this way, a new different score by another reader (even if a very good, *i.e.*, with a high score, one) will not heavily change the paper score.

We have the constraints on π summarized in Table 1. A simple function that satisfy these constraints is:

$$\pi(t) \quad = \quad K_P \cdot s_r(t) + (1 - K_P) \cdot (1 - \sigma_p(t))$$

for $0 \leq K_P \leq 1$. The constant K_P represents the relative importance of reader's score s_r with respect to paper steadiness σ_p: if $K_P = 0$ then reader's score is not taken into account at all, if $K_P = 0.5$ then the reader's score and the paper steadiness have the same importance, and if $K_P = 1$ then the paper steadiness is not taken into account at all. For deciding a good value for K_P some experimental activity is needed; it seems anyway reasonable that the score of a very steady paper (*e.g.*, $\sigma_p = 0.8$) has not to change a lot, even if a very good reader (*e.g.*, $s_r = 0.8$) expresses a judgment quite different from the actual score. Therefore, K_P should be chosen such that σ_p is more important than s_r; $K_P = 0.2$ seems a good choice.

3.3 Step 2: author's score updating

A paper judgment causes also an updating of the score of the author of the paper (step 2). The new author's score $s_a(t+1)$ is, following again the template (1), the weighted mean between the previous author's score $s_a(t)$ and the (new) paper score $s_p(t+1)$:

$$s_a(t+1) = \alpha(t)^{H_A} \cdot s_p(t+1) + (1 - \alpha(t)^{H_A}) \cdot s_a(t),$$

where $H_A = 4$ and $\alpha(t)$ depends on author's steadiness $\sigma_a(t)$ only: when $\sigma_a(t)$ is low (high), $\alpha(t)$ must be high (low), since author's score has to change a lot only if it is not steady. We can choose

$$\alpha(t) \quad = \quad (1 - \sigma_a(t))$$

3.4 Step 3: reader's score updating

Also the reader's score s_r has to change when r expresses a judgment $j_{r,p}(t)$ (step 3): following the template (1), the new score $s_r(t+1)$ is the weighted mean between the goodness of the expressed judgment $j_{r,p}(t)$ evaluated at time $t+1$ (denoted as $g_{j_{r,p}(t)}(t+1)$) and the previous score $s_r(t)$:

$$\begin{aligned} s_r(t+1) \quad = \quad & \rho(t)^{H_R} \cdot g_{j_{r,p}(t)}(t+1)^{H_G} + \\ & (1 - \rho(t)^{H_R}) \cdot s_r(t). \end{aligned} \tag{3}$$

H_G indicates how much the goodness increases. Goodness also has to belong to $[0,1]$, and can be measured using the distance (*i.e.*, the difference in absolute value) between the reader's judgment $j_{r,p}(t)$ and the (new) paper score $s_p(t+1)$. In general, the goodness of a judgment $j_{r,p}(t)$, evaluated at time t' is:

$$g_{j_{r,p}(t)}(t') \quad = \quad 1 - |j_{r,p}(t) - s_p(t')|. \tag{4}$$

With this definition, $g_{j_{r,p}(t)}(t+1) = 1$ (the best judgment) if and only if $j_{r,p}(t) = s_p(t+1)$, *i.e.*, the expressed judgment is equal to the new (and old) score of the paper.

$\rho(t)$ depends on:

- The steadiness of the reader $\sigma_r(t)$: the more the steadiness of a reader, the less her score will change, and thus s_r is important. Intuitively speaking, if $\sigma_r(t) = 1$, then the score of the reader does not change, and thus $\rho(t) = 0$.
- The steadiness of the paper $\sigma_p(t)$: the more a paper score is steady, the more the goodness of the judgment is important (or: the more a judgment distant from $s_p(t+1)$ is "bad"). If $\sigma_p(t) = 1$ then $\rho(t) = 1$.

We can then define $\rho(t)$, as the weighted mean between $\sigma_p(t)$ and $1 - \sigma_r(t)$, using a constant K_R indicating the relative importance of $\sigma_p(t)$ and $\sigma_r(t)$, as previously done for $\pi(t)$ with K_P. More generally, we can have:

$$\rho(t) \quad = \quad K_R \cdot \sigma_p(t) + (1 - K_R) \cdot (1 - \sigma_r(t)). \tag{5}$$

Possible values for the constants might be: $H_G = 10$, $K_R = 0.1$ (it has to be low for giving higher importance to σ_r), and $H_R = 1$.

3.5 Step 4: previous readers's score updating

After the paper score has changed, it is possible to revise the goodness of the old readers's judgments, and to update the old readers's score consequently (step 4): for instance, if an old reader r expressed a judgment $j_{r,p}(t_i)$ that was "bad" (distant from the paper score) at that time t_i, but after that the paper score changes and becomes more similar to $j_{r,p}(t_i)$, then s_r has to increase.

Let us take into account a simple concrete example (Figure 1):

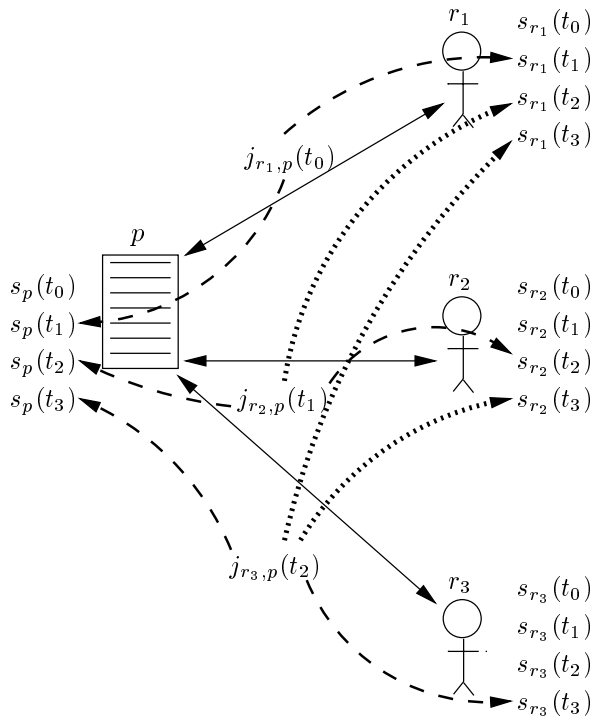

Figure 1: The updating of previous readers' scores.

- At time t_0, we have a paper p with score $s_p(t_0)$, three readers r_1, r_2, and r_3 with their scores $s_{r_1}(t_0)$, $s_{r_2}(t_0)$, and $s_{r_3}(t_0)$.
- At time t_0, reader r_1 reads paper p expressing judgment $j_{r_1,p}(t_0)$ (continuous double arrow line in figure). This causes the updating of the scores of p and r_1 (dashed lines in figure), with the previously seen Formulae (2) and (3): we obtain $s_p(t_1)$ and $s_{r_1}(t_1)$, where $t_1 = t_0+1$.
- At time t_1, reader r_2 reads p expressing $j_{r_2,p}(t_1)$. The scores of p and r_2 are updated consequently, leading to $s_p(t_2)$ and $s_{r_2}(t_2)$, where $t_2 = t_1+1$. But also the score of r_1 has to be updated (dotted line in figure), since the goodness estimated at time t_0 for $j_{r_1,p}(t_0)$ with respect to $s_p(t_1)$ has to be re-estimated now that the score of p is $s_p(t_2)$.
- At time t_2, r_3 reads p expressing $j_{r_3,p}(t_2)$. This changes the score of p ($s_p(t_3)$), the score of r_3 ($s_{r_3}(t_3)$), and the scores of the previous two readers ($s_{r_2}(t_3)$ and $s_{r_1}(t_3)$), where $t_3 = t_2 + 1$.

We have seen in the previous subsections how to change the scores of the paper and of the reader that is expressing the judgment; I still have to define how to modify the scores of the previous readers. Let us take into account $j_{r_2,p}(t_1)$, that modifies p's score from $s_p(t_1)$ to $s_p(t_2)$. $s_{r_1}(t_1)$ was obtained, at time t_0, with (3)

$$s_{r_1}(t_1) \quad = \quad \rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_1)^{H_G} + \qquad (6)$$

$$(1 - \rho(t_0)^{H_R}) \cdot s_{r_1}(t_0),$$

where the goodness of $j_{r_1,p}(t_0)$ was calculated at time t_1 with (4), on the basis of $s_p(t_1)$

$$g_{j_{r_1,p}(t_0)}(t_1) \quad = \quad 1 - |j_{r_1,p}(t_0) - s_p(t_1)|\,. \qquad (7)$$

But s_p now has changed (from $s_p(t_1)$ to $s_p(t_2)$), and therefore the goodness too: its new, more correct, value is

$$g_{j_{r_1,p}(t_0)}(t_2) \quad = \quad 1 - |j_{r_1,p}(t_0) - s_p(t_2)| \qquad (8)$$

(*i.e.*, the goodness evaluated at time t_2). Therefore, the score of r_1 was not updated in a correct way, and it has to be recalculated. We can obtain a more correct value for r_1's score subtracting the "wrong" value previously added (first addendum in Formula (6) and Formula (7)), and adding the new "correct" value (Formulae (6) and (8)):

$$\begin{aligned} s_{r_1}(t_2) \quad = \quad & s_{r_1}(t_1) - \\ & \rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_1)^{H_G} + \\ & \rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_2)^{H_G}\,. \end{aligned} \qquad (9)$$

Let's remark that: (i) steadiness values σ_r and σ_p might have changed too (as we will see in the next subsection), leading to have $\rho(t_0) \neq \rho(t_1)$ (see (5)), but this does not influence the goodness, that is the only "wrong" value to be corrected; and (ii) in general, it is not correct simply to start from $s_{r_1}(t_0)$, since this would lead to lose any eventual change to r_1's score happened between t_1 and t_2)

Going on with our example, when, at time t_2, $j_{r_3,p}(t_2)$ is expressed, it modifies, besides p's score as usual ($s_p(t_3)$), r_2's score in a way analogous to (9):

$$\begin{aligned} s_{r_2}(t_3) \quad = \quad & s_{r_2}(t_2) - \\ & \rho(t_1)^{H_R} \cdot g_{j_{r_2,p}(t_1)}(t_2)^{H_G} + \\ & \rho(t_1)^{H_R} \cdot g_{j_{r_2,p}(t_1)}(t_3)^{H_G}\,. \end{aligned}$$

But $j_{r_3,p}(t_2)$ has to modify also r_1's score, in the following way:

$$\begin{aligned} s_{r_1}(t_3) \quad = \quad & s_{r_1}(t_2) - \\ & \rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_2)^{H_G} + \\ & \rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_3)^{H_G}\,. \end{aligned}$$

This formula is correct because:

- $\rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_2)^{H_G}$ is what was added because $j_{r_2,p}(t_1))$ changed the score of paper p from $s_p(t_1)$ to $s_p(t_2)$ (see 9);
- $\rho(t_0)^{H_R} \cdot g_{j_{r_1,p}(t_0)}(t_3)^{H_G}$ is the more precise value that should have been added instead, given the new paper score $s_p(t_3)$.

Let's now state the formula for the general case. When a judgment $j_{r,p}(t)$ on a paper p is expressed by a reader r at time t, the scores of all the readers $r_i \neq r$ that read the

paper p at time $t_i < t$, respectively, and expressed a judgment $j_{r_i,p}(t_i)$ have to be updated as follows:

$$\begin{aligned} s_{r_i}(t+1) &= s_{r_i}(t) - \\ &\quad \rho(t_i)^{H_R} \cdot g_{j_{r_i,p}(t_i)}(t_k)^{H_G} + \\ &\quad \rho(t_i)^{H_R} \cdot g_{j_{r_i,p}(t_i)}(t+1)^{H_G}, \end{aligned}$$

where t_k is the time of the last goodness calculation (*i.e.*, $k = i+1$ the first time this formula is used, at the first goodness calculation, other values later).

One could also go on and remark that the new values of the previous readers should be used to re-estimate the weight of the judgments previously expressed by them. For instance, when r_2 expresses $j_{r_2,p}(t_1)$ and causes r_1's score to change from $s_{r_1}(t_1)$ to $s_{r_1}(t_2)$, the score of the paper p should be re-estimated, since it depends on the score of the reader and this has just changed. But this seems to lead to a quite complicate situation, and perhaps to a never-ending loop, thus we stop here; the approximation obtained seems anyway a good one.

3.6 Step 5: steadiness updating

The steadiness values (of the paper being judged, of the reader expressing the judgment, and of the author) have also to be updated after a judgment (step 5). The updatings take place in similar ways for readers, papers, and authors, by increasing the steadiness towards its upper bound Σ. The amount of the increase is calculated using three constants S_{σ_x}, where x stands for either p (paper), or a (author), or r (reader): if they were 0, no increment would happen; if they were 1, the new steadiness would be the upper limit Σ; if 0.5 the new steadiness is the mean between the old steadiness and 1. The formula is (see template (1)):

$$\sigma_x(t+1) = S_{\sigma_x} \cdot \Sigma + (1 - S_{\sigma_x}) \cdot \sigma_x(t).$$

The constants S_{σ_x} represent the speed of steadiness change for paper, reader, and author. The ideal value for S_{σ_x} has to be quite low, in order to have a slowly changing steadiness, *e.g.*, $S_{\sigma_p} = 0.01$, $S_{\sigma_a} = 0.005$, and $S_{\sigma_r} = 0.005$. Σ has probably to be < 1, for avoiding to have a paper, or a subscriber, with an almost constant score after some judgments. To choose a correct value some experimental activity is needed.

4 CONCLUSIONS AND FUTURE DEVELOPMENTS

Generally speaking, this proposal can be seen as an improvement of the dissemination of scholarly information through on line scholarly journals by improving the referee process and by making responsible the readers. More specifically, it can be seen as an improvement of the well known impact factor mechanism, of the democratic journal proposed in [9], and of collaborative information retrieval and filtering [6], since it allows distinguishing among "good" and "bad" collaborators. The mechanism presented in this paper can also be used as a complement, instead of a complete substitution, of the peer review. Two other proposals that are similar, but less formalized, are those by Stodolsky [11] and by Varian [12].

This proposal is not free from problems. In general, one may wonder if democracy is a good approach to knowledge dissemination. Of course, it is difficult to have an objective opinion on that: it could be appropriate, or appropriate in some fields only, or not appropriate at all. I believe that only by further studies and experiments we can find an objective answer. However, it has to be emphasized that the mechanism proposed here is different from democracy, since different readers will have different importance. A more specific problem are lazy readers: a reader can simply confirm the previously expressed judgments, giving to each read paper a score equal to its actual score. Two solutions seem suited here: give higher scores to fast readers (those that first read the papers), and do not show the paper score for a period after its publication (*e.g.*, until when its steadiness reaches a certain value). Another specific problem are the lobbies, *i.e.*, people that agree in mutually giving high scores. This might not be a problem at all, if the whole system can be modified to behave, by choosing appropriate formulae and constants, in a way that discourages the lobbies; if this is not the case, the solution would probably be to implement some software able to detect such situations. Of course there are technical difficulties too, *e.g.*, the identification of subscribers, or the huge amount of storage needed for recording the papers, the subscribers' data, and the history of expressed judgments. But these can be surely handled by database and cryptography technologies.

It is also easy to see some mandatory improvements, that seem not difficult: to deal with papers with more than one author; to have two different scores for a subscriber which is both an author and a reader, for separating the two skills; more generally, to have more scores, both for subscribers (authors and readers) and papers (comprehensibility, technical soundness, originality, experience as a reader, and so on); to have more than one journal, with different acceptance thresholds (a paper, or a researcher, must have a score larger than the threshold for being published, or, respectively, subscribing).

Finally, I sketch how I intend to proceed with this research. A software simulator of the electronic journal proposed here is currently under implementation. I also plan to use some mathematical models and techniques for formally studying the behavior of the whole system and for studying other similar approaches. These experimental and theoretical activities will allow to verify that the behavior of the system is correct and consistent and to choose in a more reliable way among the possible formulae and constants. After that, the software for the complete system will be implemented, tested, and evaluated. An ideal environment for these experiments is a repository of preprints, like ArXiv (http://xxx.lanl.gov). I plan to execute some laboratory experiments (with simulated papers, authors, and readers) and some real life experiments, involving real users.

These theoretical and experimental activities will also allow to determine the relations between the parameters's values and the real situation: indeed, it is likely that the values of H_P, K_P, H_A, H_R, K_R, H_G, S_{σ_p}, S_{σ_a}, S_{σ_r}, and Σ depend on figures like the number of subscribers, the rate of papers publishing, the rate of judgments expression, and so on. These dependencies must be singled out and, in case the above presented formulae turned out to be inadequate, new ones need to be proposed and evaluated. Again, ArXiv seems the ideal environment for this issue.

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