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Abstract

We describe our system, a forecasting method enabling decentralized decision taking via predictions on particular proposals, and resolutions via the results of proposals decisions, based on resulting value of particular assets.

Preliminaries and forecast ratings. Let B_i be the balance of the ith account, and $B = \sum B_i$ be the total number of tokens that exist at the moment (might be not constant, due to inflation). We assume that some account (referred to as the *proponent*) submitted a proposal, and a poll about a proposal is being held during some pre-established time period. Let X be the minimal amount of funds that the proponent deems as minimally necessary for the proposal execution[1]. Let F_i be the forecast of the ith account on how much the proposal will collect; $F_i = 0$ means that the proposal is marked as "spam" by this account, and (just a notational convention) $F_i = -1$ means that the account did not participate at all in the poll. It is assumed that F_i's are only revealed in the end of the forecasting period, that is, the accounts cannot adjust their forecasts based on the information about the other accounts' forecasts.

Among the key variables in our model are the forecast ratings, which measure the account owner's ability to issue accurate predictions. There are, in fact, two forecast ratings: the *numerical* one (which is changed after each vote), and the *qualitative* one, which indicate to which *category* the account belongs. It is similar to e.g. internet forums, where a user can be "junior member", "member", "senior member" etc.; the accounts of higher categories have more "power" in the system. Specifically, let $r_i \in [0, R]$ be the current numerical forecast rating for account i (r_i is a real non-negative number, and R is some fixed maximum value for it), and g_i

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[1]as we comment below, the proponent will not need to specify the amount X if the community decides to remove the minimal amount required for proposal graduation; that rule is flexible and can be turned on or off

be the qualitative forecast rating: $g_i \in \{0, 1, 2, \ldots, G\}$ determined from r_i in the following way:

$$g_i = \begin{cases} 0, & \text{if } r_i < a_1, \\ 1, & \text{if } a_1 \leq r_i < a_2, \\ \ldots \\ G-1, & \text{if } a_{G-1} \leq r_i < a_G, \\ G, & \text{if } r_i \geq a_G, \end{cases} \tag{1}$$

where $0 < a_1 < a_2 < \ldots < a_G < R$ are parameters. As an example, we may set $G = 5$, $a_1 = 0.03R$, $a_2 = 0.1R$, $a_3 = 0.3R$, $a_4 = 0.6R$, $a_5 = 0.8R$, where $R = 1$ (adjusting the parameter R we can control how fast the accounts may grow their forecast rating; the smaller is R, the faster it will happen).

Marking a proposal as spam. Let

$$s = \frac{\sum\limits_{i:F_i=0} g_i}{\sum\limits_{i:F_i\geq 0} g_i} \tag{2}$$

be the weighted (by g_i's) proportion of voters that marked the proposal as spam. Let $s_0 > 0$ be some pre-established threshold for deciding that the proposal is marked as spam *by the whole system* (that is, the system decides that the proposal is spam whenever $s \geq s_0$). If the majority votes that that the proposal is spam, then the proposal's fee is divided between those that voted for spam, and no adjustment of ratings is made[2]. Note that it is not likely that a rational voter would mark a *good* proposal as spam, since this would give him no gains in case others do vote favorably, and the profit from supporting a good proposal is likely to be much better.

Value of the poll. This is a characteristics of a poll which measure how "important" it is for the system. If the system decides that the proposal is not spam, we calculate the *value of the poll* in the following way:

$$v = \ell^2 q, \tag{3}$$

where ℓ is the proportion of the tokens belonging to the accounts that took part in the poll, i.e., $\ell = B^{-1} \sum_{i:F_i\geq 0} B_i$, and $q = \frac{Q_3-Q_1}{Q_3+Q_1} \in [0,1]$ is the so-called quartile coefficient of dispersion [1] of the data set $\{F_i : i \text{ is such that } F_i \geq 0\}$ weighted

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[2]otherwise people would make spam proposals only to increase their forecast rating

by g_i's[3]. The choice of q as a measure of the relative variation is justified by the fact that it is a robust statistics, so manipulating this quantity is very difficult. The value of the poll is supposed to measure how "good and genuine" the poll is. Observe that, if one drops q from (3), this could open possibilities for manipulations of the following sort: one creates a "junk" proposal and asks people to predict that it collects exactly x funds; then, the proposal's creator himself invests x in it, thus ensuring that all predictions are exact, so that the forecast rating of all the participants increases. The present form of (3) makes this sort of manipulation difficult: no individual player would be willing to make a prediction different from x (which is necessary for increasing q), because this would decrease his individual profit.

Note also that ℓ enters the formula squared; this is because 1 poll where everybody takes part should probably be considered more "important" than 100 polls where only 1% of people take part, and also to prevent spamming.

Listing of the proposal. This is an optional step: as explained below, we may opt for listing *all* the proposals that were not marked as spam. Let

$$\alpha = \frac{\displaystyle\sum_{i:F_i \geq X} g_i}{\displaystyle\sum_{i:F_i > 0} g_i} \tag{4}$$

be the (weighted) proportion of voters (among those who did not vote spam) who predict that the proposal will achieve X. Let $\alpha_0 \in (0,1)$ (it may be fixed, say, $\alpha_0 = 0.3$, or defined by the proposal's author) be some pre-defined *approval threshold*. In case $\alpha < \alpha_0$ the proposal is rejected, and the fee of the proponent is divided between all voters i with $F_i > 0$. Also, note that those who voted still benefit since they are less likely to have their forecast rating penalized for inactivity. Note that we can also set $\alpha_0 = 0$, which means that *all* proposals not marked as spam get listed in the system (and the value of X need not be specified); this basically allows us to disable the minimal requirement.

To reduce spamming possibilities, one may consider the following improvement: calculate proposal listing fee according to the account's forecast rating, i.e., the higher the account forecast rating, the lower the listing fee will be, and vice versa.

Calculating the new forecast rating of voters. In the following, we describe how the account's numerical forecast rating is affected by the outcome of the

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[3]just repeat ith prediction g_i times for all i (effectively discarding those with $g_i = 0$) and use the usual definition of quartiles

poll. The idea is, of course, that "accurate" predictions increase the rating, while "inaccurate" ones decrease it. We need, however, to define the rules carefully, to give enough incentive to forecast and to avoid abuses.

Assume that $\alpha \geq \alpha_0$, so that the weighted proportion of voters who predict that the proposal will achieve its goal is enough to pass the approval threshold. Let us describe what happens next. Assume that, in fact, the proposal collected Y funds. Let $b_i = B_i/B$ be the *relative* balance of the ith account. Let m be the median of the data set $\{F_i : i$ is such that $F_i > 0\}$ (note the strict inequality; that is, this data set does not include the votes for spam) weighted by g_i's. Denote also for $x > 0$

$$\Psi_Y(x) = \begin{cases} \left(1 - \frac{(x-Y)^2}{\gamma_1^2(|m-Y|+\theta_1 q)^2}\right), & \text{if } x \leq Y, \\ \left(1 - \frac{(x-Y)^2}{\gamma_2^2(|m-Y|+\theta_2 q)^2}\right), & \text{if } x > Y, \end{cases} \tag{5}$$

where $\gamma_{1,2}, \theta_{1,2} > 0$ are parameters to be chosen; recall also that v is the value of the poll defined in (3). Then, we set[4]

$$\Delta_i = vh(b_i)\Psi_Y(F_i), \tag{6}$$

where[5]

$$h(y) = \begin{cases} \left[\log_2(Kb_i)\right], & \text{if } Kb_i > 2, \\ Kb_i/2, & \text{otherwise}, \end{cases} \tag{7}$$

where K a (large) constant and $[\,\cdot\,]$ is the integer part[6]. To explain (5)–(6), notice that it gives a positive reward to the forecast rating only in the case $|F_i - Y| \leq \gamma(|m - Y| + \theta q)$, see Figure 1. For example, in the case when $\gamma_1 = \gamma_2 = 1$ and $\theta_1 = \theta_2 = 0$, and all the forecasts happened to be on one side of Y (so that $|m-Y|$ is large), then approximately a half of forecasters will have their rating increased. In practice, one may want to take $\gamma_{1,2}$ to be slightly larger than 1 and $\theta_{1,2}$ to be slightly larger than 0, in order not to excessively penalize the forecasters in case $|m-Y|$ is small[7] (i.e., the wisdom of the crowd turned out to be really wise). Then,

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[4]Note that in the previous versions of this paper we have the relative balance itself in (6); such an idea could work if a maximal ratio between account's wealth were not very large (e.g. 50 or so), but, from our experience in crypto-world we know that, in practice, that maximal ratio could easily go to thousands or even millions. This means that there will be no acceptable value of the parameter R (recall (1)), the wealthiest accounts would go from highest to the lowest level (and back) in one step, and the majority of accounts will delay too much to achieve a reasonable FR, even if their forecasts' quality were quite good.

[5]On the other hand, it is still a good idea that richer accounts gain FR more rapidly, to decrease the danger of a Sybil attack. This would incentivize people to keep their tokens on a single account, and avoid that very small accounts get high FR rapidly.

[6]it is very easy to calculate the integer part of the binary logarithm

[7]they should not be penalized because they were close to the right answer, but (5) without the term θq may lead to this unfortunate event
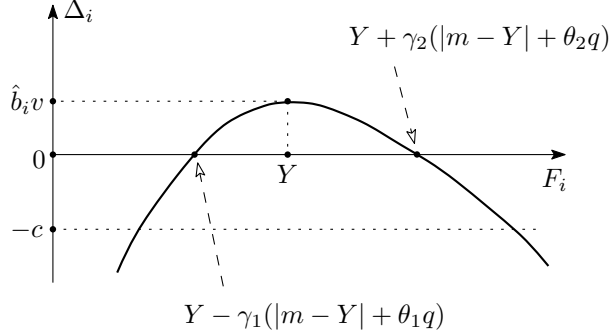
Figure 1: On the definition of Δ_i (as a funcion of the forecast value F_i)

the *new* numerical forecast rating of ith account is calculated in the following way:

$$r_i^{\text{new}} = \begin{cases} 0, & \text{if } r_i + \Delta_i \leq 0, \\ R, & \text{if } r_i + \Delta_i \geq R, \\ r_i + \Delta_i, & \text{otherwise.} \end{cases} \quad (8)$$

Now, observe that the reward Δ_i is positive if and only if

$$F_i \in \big(Y - \gamma_1(|m - y| + \theta_1 q), Y + \gamma_2(|m - y| + \theta_2 q)\big),$$

that is, the forecast was "close enough" to the outcome Y. One can also consider some modifications of (5), e.g., use $\Psi_Y'(x) = \max(\Psi_Y(x), -c)$ for some parameter $c > 0$, to limit the negative increments in the forecast rating (cf. Figure 1).

As an initial guess for the parameter set of the model, one can propose e.g. $\gamma_1 = 1.1$, $\gamma_2 = 1.5$, $\theta_1 = 0.2$, $\theta_2 = 0.3$, $c = 0.7$. Testnet experiments will be performed to adjust the values.

As will be discussed later, we allow the forecast ratings of the rich accounts to vary more rapidly; this is a necessary measure to avoid Sybil attacks. This can indeed create an impression of "unfairness" towards the users that are not so rich; observe, however, that this problem can be mitigated by the delegate system of the liquid democracy: good predictors will become popular delegates and will be able to increase their forecast rating more rapidly even if they are not so rich.

Forecast rating of the proponent. We may also choose to influence the proponents' forecast ratings using the "quality" of their proposals.

First of all, if the proposal was marked as spam, the proponent's forecast rating can be severely penalized (say, even zeroed, or set to a_1, recall (1)). On the other hand, it seems to reasonable to reward the proposals not marked as spam according

to (5)–(8) with $F_i = Y$ (i.e., receive the "maximal reward"), thus leading to the reward

$$\Delta_i = vh(b_i). \tag{9}$$

That is, if the proposal not marked as a spam, the higher is its resulting quality (many forecasters participating with disperse forecasts), the higher is the reward for the proponent's forecast rating.

Penalizing accounts for inactivity. It is desirable that the accounts' forecast rating decrease in case the account remains inactive for some time: this will incentivize the users to actively participate in forecasting. Let us discuss how this penalizing should work. A reasonable way to do this is to consider the values of all the polls during a given time period, and compare it to the values of all polls where a given account took part. If the ratio of the latter to the former is less than some threshold, then there is a penalty on the forecast rating. Just as the reward, this penalty should be proportional to the (truncated) relative balance and the polls' values, compare to (5). Also, probably, the votes for "spam" should not receive the "full credit" for participating in the poll (maybe, only some partial one).

It is reasonable, however, to include a mechanism that permits for an account to remain inactive for some time without being penalized, because, for example, the account's owner is on vacations. Possible solutions to it include leasing the balance and/or the forecast rating to some active account for a fee, or even declaring the account to be "frozen" for some period of time. One must, however, require that the leased or frozen account maintains at least some fixed amount of tokens on it.

Tokens' transfers and forecast rating. One can imagine the following scenario: a (relatively rich) user achieves the maximal (qualitative) forecast rating[8], then transfers the tokens to another account and makes its rating high as well, and so on, thus accumulating many accounts with high rating. This opens possibilities for a Sybil attack. Indeed, observe that controlling many accounts with high aggregate forecast rating permits an attacker to influence the values of polls (recall (3)) through q, and also influence quantities defined in (2) and (4); therefore, allowing one entity to acumulate many accounts with high forecast rating is not a good idea[9].

So, we propose the following to handle this: if an account with current balance b (of tokens) and the (numerical) forecast rating r transfers x tokens to another account, its forecast rating is decreased proportionally, that is, the new numerical

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[8] with some luck, it can be done rather quickly when one is rich

[9] note that penalizing accounts for inactivity will not work for this purpose: a user is not obliged to leave an "almost empty" account completely inactive; he can continue making forecasts with it to avoid loosing the rating

forecast rating will be equal to $r(1 - \frac{x}{b})$. Notice that, if x is not so large (with respect to b), then the qualitative forecast rating (i.e., the one that really influences the poll's value and other important quantities, as observed before) may remain the same (since it is *discrete*).

The reward inflation model. As a further improvement (meant to motivate the participants to submit proposals), we are considering the idea to introduce some inflation (with respect to the total number of tokens) into the model.

The system will issue new project tokens at the end of the forecasting action, distributing them to:

- proposal creator;

- proposal forecasters (curators),

The proposal creator will be rewarded according to:

- how many forecasts were submitted (e.g. how many unique users have participated), taking into account the forecasters tokens amounts (to prevent Sybil attacks);

- how wide spread (dispersed) the forecasts were, the more opposite they are, the more controversial the proposal (hence of a higher quality) and the higher the reward.

The proposal forecasters will be rewarded according to:

- how close their forecasts were to the proposal resolution;

- the quality of the proposal they have forecasted on.

All these goals can be achieved, for example, with the following approach: if a proposal was accepted, and the resulting outcome was positive (measured by resulting token price for example, or another parameter provided by an Oracle or another immutable method), then both its author and the participating accounts receive some amount of newly issued tokens, proportionally to $vb_i\Psi_Y(F_i)$ (recall (5)) provided it is positive (for the forecasters)[10]. As an additional measure to discourage accounts' splitting, we may consider slightly superlinear rewards (e.g., proportional to $b_i \max\{\log_2(Kb_i), 1\}$). Also, we may normalize the rewards by the sum of values of all poll held during a given time period (this is to keep the rate of inflation roughly constant).

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[10]recall that the above quantity for the proponent is calculated according to (9) and is always positive, unless the proposal was marked as spam

Attack scenarios. One may suggest the following attack scenarios:

1. An account can try to manipulate its forecast rating by submitting many proposals.
   This will not work because: junk proposals will be marked as spam, and reduce the forecast rating; uninteresting proposals will not have a good value, so the gain will not be considerable; also, since we require a good spread, conspiracies of the form "hey guys, vote exactly Z for my proposal, I'll then invest exactly Z and everybody wins" are unlikely.

2. The attacker can create many Sybil identities and inflate their forecast rating, to gain more "decision power".
   This will not work because: as explained above, the attacker cannot transfer the funds to a new account without decreasing the forecast rating of the current account.

3. The attacker can try to grab most of the "new" (i.e., created because of the inflation) tokens.
   This will not work because: the proposal must have a high value for that, and the concept of value is designed in such a way that it is difficult to manipulate.

Acknowledgments

References

[1] https://en.wikipedia.org/wiki/Quartile_coefficient_of_dispersion