CS136 Final Project

Lana Gorlinski, Nathan Ondracek and Nikhil Suri

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1 Abstract

With the advent of blockchain technologies and the ability to create decentralized applications on top of networks which power smart contracts, such as Ethereum, multiple platforms for decentralized prediction markets have been created and are currently in use. One of the most successful of these platforms (and one of the most successful dApps to come out of the Ethereum network) is Augur. In this paper we present an in depth case study of Augur and explore areas of potential improvements. Ultimately, our goal is to analyze whether the new platform which we present in our paper would theoretically work if deployed as a decentralized application on Ethereum, or some other blockchain network, and what user behavior on such a platform would look like.

2 Introduction

Prediction markets elicit information about the probability of future events from a pool of users; they serve a dual goal of garnering information about the likelihood of outcome based on contract prices and giving users the opportunity to earn money. There have been a few longstanding, centralized prediction markets, such as Predict It and the Iowa Electronic Market. Yet Predict both have very limited scope–most open bets are on election results–and place relatively low ceilings on users' financial exposure to escape regulation. This has spurred the demand for decentralized prediction markets. Since anyone can participate, these decentralized platforms offer a broader range markets and more accurate bets, as well as lower fees and a lack of censorship (for better or for worst).

The first decentralized prediction market platform to launch for mainstream use is Augur, which is built on the Ethereum blockchain. Launched in July 2018 with the help of the Forecast Foundation, Augur allows users to create prediction markets and place bets in a continuous double auction style. Market outcomes are determined by user votes using REP, a cryptocurrency created for use on the platform that also has some functionality of a reputation system. While Augur has seen some success, it still has its fair share of problems. The process for determining outcomes of bets is convoluted and relies on the REP currency; if users dispute an outcome, the dispute can take weeks to resolve. The fact that the reporting currency REP can be bought also creates potential for wealthy users to sway outcomes, and since users can stake theoretically uncapped amounts of REP, they can profit greatly from correctly predicting the reported outcome, creating a parallel betting market on the reports. Augur also suffers from high bid-ask spreads due to low liquidity and saw a significant number of death pools within days of its nascence. Finally, Augur offers no means for creating bets on outcomes that cannot be publicly observed, providing no support for private betting. In the sections that follow, we'll explore how to build a better decentralized prediction market platform that mitigates these issues, focusing on the liquidity of the auction, outcome determination, the reputation system, and the potential for private betting.

3 Market Model

Seeing as our project is fairly similar to an existing decentralized trading platform, Augur, we want to give a brief overview of the current implementation, point out some issues, and propose some changes in a new model.

3.1 Augur

As mentioned above, Augur is a decentralized trading platform, meaning any user can create a market using Ethereum as the underlying currency. The creator of the market pays a small fee and sets a percentage of the winning they will take (which is publicly displayed to all users). Then, using a continuous double auction, shares of the outcome are bought and sold by any user on the platform when there is an ask-bid matching as per the auction rules of a CDA. At the end of the auction, winning agents get paid out, but have to give a creation fee to the creator of the market and a reporting fee to the people who participated in the reporting of the outcome.

The most complex part of Augur occurs during the reporting of outcomes. Only agents who participated in the market can report on the outcome of that market. After a market closes, either a designated reporter or the first person to report sets the outcome. Then, all other agents use a secondary currency, REP, to either buy participation tokens in favor of the outcome, or put REP tokens into a "dispute bond." If enough currency is put into a dispute bond, the outcome changes to that of the dispute and all agents who put money into the dispute bond are given 1.5x the REP they put into the bond. Now, agents again have the option to purchase participation tokens or buy into a dispute bond. Each dispute opens a new phase that can last up to 7 days. However, if a final outcome cannot be reached, the entire Augur universe forks (one universe for each possible outcome) with each user on the entire platform choosing which forked universe to be a part of.

The reporting system of Augur is constructed so that it is very thorough, going as far as forking the entire universe to avoid misreports. But, there are plenty of downfalls. Their system is long and confusing, incorporating multiple tokens and currencies through rounds that could take weeks to conclude. Further, only participants in the market itself can report, leaving the possibility for large skewed answers based on the majority of the bet rather than the truthful outcome. Finally, because reporting uses a currency, REP, that users can buy, one person can influence an outcome by singularly spending enough money to fill a dispute bond.

3.2 Market

In our platform, we create markets the same way: anyone is allowed to create their own market. However, we want to address the problem of low liquidity and high bid-ask spreads that occurs in Augur so, our markets will be automated market makers. In this way, a user will always be able to buy a contract, regardless of any ask prices. An AMM puts the market creator at a little higher risk as they can have some loss in the market, but we will dynamically scale the creator fee percentage to cover for the current bounded loss of the market. Prospective participants can see the current creator fee percentage and the current price of a contract (but not how many contracts have been bought/sold).

3.3 Reporting

Unlike in Augur, our platform will allow anyone to report the outcome of a market, not just the agents who participated in the market. We still want to give incentives for outside reporters to report truthfully, so all reporters will have to pay a fee in order to report. A reporter will then lose reputation (outlined below) if they report an outcome that does not end up winning. On the other hand, they will gain reputation, get refunded the fee they paid to report, and be allocated a portion of the reporting fee paid by market winners if they report the realized outcome.

To minimize a person's ability to pay enough money to unfairly influence the outcome of reporting, our platform will choose the outcome based on the number of people voting for each outcome crossed with their reputation. In this way, while we don't have a simple majority rule, one person only has as much influence as they have reputation, which will be capped. This reporting method also is much quicker and more simple for users to follow, so after a market closes, the window for reporting can be as short or as long as necessary, instead of taking weeks using a convoluted dispute bond system.

3.4 Reputation

As mentioned above, one of the major changes that our platform will have from Augur will be an incorporated reputation system. A users reputation will be between 0 and 1 based on their previous reports. This reputation system can be used to inform entry into a market by seeing the average reporting reputation of agents participating in a market or the reputation of the creator of a market. The reputation system can also be used when creating a market to give a necessary threshold for entry or reporting. However, most importantly the reputation is used in place of a currency so that users can only influence a market based on their reputation but only so much. This way a reporter cannot decide to spend more money to sway a market, but, instead, their vote on outcome is only as good as their reputation.

Our reputation system lends itself to be susceptible to white-washing as a user could build their reputation, try to use their increased influence to report an incorrect outcome, then just start a new account. But, to combat this, all users will start with low reputation (meaning they have to report correctly in markets before they start building influence. This way new users have less influence in markets they report in, discouraging white washing. Finally, we will tie all accounts to "identity" in a similar way as some crypto wallets. We will require some sort of identification and keep all ID's on file without linking an ID to a specific account. With that we keep the platform decentralized and anonymous while also ensuring the same person does not make multiple accounts.

3.5 Censoring

Lastly, Augur dropped in popularity after death pools became abundant on the platform. To discourage any immoral markets, we will implement a censoring system. A user can report quality of other markets, but if a user has traded in the market, they cannot report on the quality. If enough people report the market as "bad," then the market closes, creator's reputation goes down, and all trades are reversed. If a person votes to censor a market, but it doesn't get enough votes, then their reputation decreases. The threshold of votes to be censored is a weighted number (like reporting) of censor votes and those users' reputations. This threshold will be 10% of total average daily users.

3.6 Model Extensions

As an extension, we want to add private markets. In this situation, the creator chooses which other user(s) to wager with with a maximum of 5. In this scenario, the market is not a AMM as described above, but instead it will be a simple wager on outcomes where the winner takes the pot. Users in the bet will agree to a price and put that money into the "market." After a set time, the users can

However, the reporting on private bets is a trickier as it requires losers of the bets to report truthfully because the platform doesn't know the actual outcome. To handle this, we are giving incentive for losers of bets to report truthfully even if it causes them to lose. If all participants agree on the outcome, then the winner(s) gets 95% of the winnings and the loser(s) gets 5%. But, if the participants do not agree, then all parties lose their money and don't get paid out. With this system, losers of a bet will still want to report truthfully as they will get paid out 5% instead of 0%, and winners will want to report truthfully as they will get 95% instead of 0%.

4 Analysis

Since we would like to use an AMM for our markets, the market creators face higher risk. We know that if we use the LMSR AMM, the loss of the AMM in a market with a binary outcome is bounded: if p_1 is the most recent report and p_k is the oldest report, then the loss of the AMM is

$$\ln(p_1) - \ln(p_k)$$

In Augur, market creators pay a small fee to create markets, and during the settlement phase (when trading is over and an outcome has been decided) participants in the market pay a small fee to the creator (also known as the "creator fee"). This fee is preset by the market creator. We propose to also let market creator set their own "creator fees" for the markets that they create. This can offset the loss that the market maker faces.

In a similar fashion, we would like to reward the agents who participate in reporting in our market. Augur implements a reporting fee for all markets that is dependent on the market capitalization of their own reporting token (REP) and the value of "open interest" in all of Augur's markets. "Open interest" in a market is measured as the total value of shares in every outcome of that market. Therefore, the reporting fee in Augur is a dynamic value. We would also like the reward that agents receive for reporting to be a consistent value across all markets (so that we avoid the situation where agents are only incentivized to participate in markets where there are high reporting payoffs). The value of this reporting fee can also be a dynamic value that is tied to the amount of money that is currently in all of our markets.

Another aspect that we must clarify and analyze is the nature of our reputation system. The way that we are proposing to decide outcomes in a market is by summing over the reputations of all agents for each outcome and choosing the outcome with the highest reputation. For example, if we have a market with 2 outcomes where outcome A is the true outcome and has n agents who bet on it all with reputation 1, while outcome B has m agents who bet on it all with reputation 0.5, then in order for outcome B to outweigh outcome A, we must have

$$0.5m > n, m > 2n$$

This is a result that we could experiment more with. For example, instead of just a linear sum of reputations for each side, we could implement a squared sum of reputations for each side. In this case, for outcome B to outweigh outcome A we would need to have

$$0.25m > n, m > 4n$$

A method such as this would place even more emphasis on the reputation of users. It is important to realize, however, that this method disincentivizes hedging. It is not unrealistic to expect that many agents may want to hedge outcomes. If we have k agents who hedge and have reputation r, then in order for outcome B to outweigh outcome A we must have

$$0.5m + rk > n + rk, 0.5m > n$$

After agents on the platform make reports on outcomes and an outcome for a market is realized, we would like to update the reputation for those agents that participated in the reporting phase. The agents that reported outcomes that were not the realized outcome should be penalized, while the agents that reported the realized outcome should be rewarded. Part of the reward that we propose to give agents that report the realized outcome (in addition to a higher reputation) is a share of the pooled reporting fee. Also, similarly to how Augur requires agents to stake REP when they make a report, we will require agents in our system to also pay a fee when they report. If they report the realized outcome, then this fee will be returned to them along with the reporting fee that is collected during the settlement phase from agents who participated in trading. We think that adjustments to agent reputations should be done by comparing how the agent reported to the rest of the population of reporters in the market. For example, if the agent reported the realized outcome and many other agents reported this outcome, then the reputation score for that agents should increase more than if the agent reported the realized outcome and few agents out of the population reported this outcome. Similarly for agents that report outcomes other than the realized outcome: if the population of agents who reported other outcomes is very small, then these agents should be penalized more than if this population is fairly large.

Finally, the last part that requires analysis is our introduction of private betting circles. When an outcome is realized, we would like to incentivize agreement so that the money pooled in the bet is paid out properly. One way that we could do this is by giving a 95% payoff to the winners and a 5% payoff to the losers under agreement, and giving 0% back to any of the agents under disagreement (we could redistribute the money the agents pooled into a random, public, betting pool). For a 2-player private betting game, we can consider the following normal-form representation (where there is a binary outcome and outcome A is the true outcome, which player X placed her bet on):

		Player Y: A	Player Y: B
Player X	A	$(95, 5)$	$(0, 0)$
	B	$(0, 0)$	$(5, 95)$

At first, we see that there are two pure strategy Nash equilibria for this game, which could be problematic because one of the equilibria results in a false outcome. However, there are also similarities between this game and the game of chicken. We can achieve a correlated equilibrium if we let the true outcome of the bet be our signal (from example 2.7 in the textbook chapter 2). Then, we know that player X will play A will probability 1 and player Y will play B to get a positive payoff of 5 instead of 0. We know that this is a correlated equilibrium because the signal that is drawn (the outcome of the event) is the same for both players. We would not reveal the reports that the players make until after the deadline for reporting has passed and we reach the settlement phase. Therefore, there is no advantage for player Y to deviate and try to "scare" player X into changing her mind.

5 Discussion

We believe the biggest strengths of our new platform would be increased liquidity and a streamlined reporting process. The liquidity, and by extension responsiveness, offered by an automated market maker is fundamental to a prediction market's purpose of eliciting an accurate prediction of an outcome. We also know that in an automated market maker it is a dominant strategy to bid until the marginal price of a contract is equal to your true belief. We're operating under the assumption that this will have a positive effect, that the average user is risk neutral and will buy more contracts than in a CDA, in which the number of contracts one takes on is more of a function of the degree of exposure you want. If the price is close to but not equal to an agent's true belief, however, in a CDA an agent can still have a positive expected utility by buying or selling a number of contracts, whereas with an AMM an agent would only buy a fraction of a contract up to their true belief; similarly,the increased responsiveness of prices makes it less reasonable for agents to buy a large number of contracts without significantly driving their own price up; we think for the time being this is a fair tradeoff, since the current prediction markets currently have rather low liquidity and would thus face similar price swings; it is also possible to lower the responsiveness of AMM prices with an affinine transformation of the scoring rule, and we could explore the potential of adjusting these values dynamically.

Our platform also makes significant improvements in the simplicity, and what we believe to be slight improvements in the fairness, of deciding outcomes. By eliminating the ability for users to dispute, setting a strict reporting deadline, and simplifying voting into a binary decision with no choice of the amount of REP to stake, we hope that outcomes of bets will be decided more quickly and truthfully. Though we believe our platform would make some marked improvements over Augur, there are still several potential issues with our implementation.

For instance, we assumed that users voting on the outcome of an event in which they did not participate would produce more truthful results: in a situation in which the less popular outcome comes true, for instance, betters may be incentivized to report the more likely outcome: since outcomes are decided via majority rule, if everyone votes for the outcome that would result in them receiving a payoff, the more-popular but untrue outcome would win. By introducing outside betters and obfuscating the contract prices and pool size once a market closes, we hope to make truthful reporting a dominant strategy; by capping the potential payout from a report, we also hope to mitigate the sense that one can develop in Augur that there's a separate and equally-high-stakes market on the reported outcome of a bet once it closes. Still, we're operating under the assumption that we would have sufficient users to report outcomes of bets in which they are not participants, to the extent that these votes would counterbalance those of a bet's participants. We also would need the incentive of a small reporting and reputation payout to be sufficient to encourage participation, and the loss of the reported fee and reputation to be strong enough disincentives for untruthful reporting; similarly, we're operating under the assumption that a high reputation earned from successfully reporting an outcome in which an agent is just a spectator extends to trustworthiness in bets in which he has a much higher degree of financial exposure.

By weighting votes by reputation, similarly, we run the risk of creating an aristocracy in which high reputation is concentrated among a few users that would have the major sway in decisions. By restricting reputation $[0, 1]$ and having sufficiently negative incentives for low reputation (for instance, being barred from participating in certain bets), agents should hopefully maintain sufficient reputation such that high reputation agents should never have too much power. Moreover, because betting is anonymized, agents won't know whether they have sufficient high-reputation agents on their side to sway the bet. This still opens up opportunities for collusion–especially if private betting is included, as agents can collude on several rounds of private bets to build each others' reputations–but this seems to an extent unavoidable, as even centralized betting systems face this issue.

Finally, it must be acknowledged that in the course of this project, we've attempted to improve prediction markets in relation to its users, and focused on creating a positive betting experience for them, rather than focusing on improving prediction markets in terms of their goals as information elicitation tools. There is still much work to be done in this regard; one factor of the efficacy of a prediction market, for instance, is diversity, and any platform that operates on cryptocurrency is still only attracting a small and tech-savvy subset of the population, and the risk of a misreported outcome that will always exist in decentralized markets may still incentivize agents to vote on what they believe the reported outcome will be rather than the realized. Yet many of the improvements to users proposed here will have the secondary effect of improving the information eliciting properties of these markets, such as incentivizing truthful reporting, increasing liquidity and responsiveness, and in general encouraging broader participation, as an in-depth understanding of blockchain and a convoluted reporting process doesn't necessarily correlate with an informed and accurate view of current events.

6 References

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