DECENTRALIZED MARKETS DESIGN AND SYMBOLIC AI METHODS

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Abstract

This research points to the significance of fundamental market design expressed using the theoretical foundation, and corresponding tools, based on formal logic. This approach enables both, to formalize and to formally reason about the core system's properties. In addition, it complements artificial intelligence methods based on data, which come into play when we consider not only the game, but agents and strategies as well. Based on the experience of applying symbolic artificial intelligence in the domain of centralized markets design, we propose applying similar approach on decentralized markets. We touch on several current projects in the domain of decentralized exchanges, and provide parameters to illustrate the commercial potential.

Key words: financial exchange, decentralized exchange, defi, uniswap, market design, logical frameworks, automated reasoning, formal logic, symbolic ai

1 Introduction

We propose to employ the methods of fundamental computer science, namely logical frameworks, which is a type of symbolic AI, combined with experience in centralized market design, in the domain that recently demonstrated a remarkable commercial potential, namely in the design of decentralized electronic markets.

These methods can be considered qualitative, and it is reasonable to expect that they naturally complement quantitative methods, primarily machine learning. The former are used for certified market design (properties are intrinsic in the system by design), whereas the later can enable to control how the game is played, in the sense of recognising and preventing the misuse of the game, e.g., the disruptive trading practices, or foreseeing the critical states such as exchange flash crashes.

2 Symbolic AI and centralized markets

Financial exchanges are a cornerstone system in finance and economics in general, and they facilitate the automated matching of buy and sell orders. Computational core of exchange is the order matching engine, where the market interaction between buy and sell sides is handled. In order to guarantee trading fairness, exchanges must meet the requirements of regulatory bodies, in addition to any internal requirements of the trading institution. However, both specifications and requirements are presented in natural language which leaves space for ambiguity and interpretation errors. As a result, it is difficult to guarantee regulatory compliance [1]. For example, the main US regulator, the Securities and Exchanges Commission (SEC), has fined several companies, including Deutsche Bank (37M in 2016), Barclay's Capital (70M in 2016), Credit Suisse (84M in 2016), UBS (19.5M in 2015) and many others [2] for non-compliance.

Experience has shown that (possibly unintentional) violations often originate from unforeseen interactions between order types [3]. Formalization and formal reasoning can play a big role in mitigating these problems. They provide methods to verify properties of complex and infinite state space systems with certainty, and have already been applied in fields ranging from microprocessor design, flight sefety and financial derivative contracts [4, 5], trading systems being a prime candidate as well [6].

In the aforementioned article [6], we first formalize the sequential order matching core, followed by proving properties such as: the trade always takes place at either bid or ask; the market is never in a locked or crossed state; and order priority is never violated. Everything is based in being able to declaratively represent an archetypal sequential (in matching one-by-one fashion) trading system, with pure symbols and symbol manipulation, which provides a setting for verification, i.e., some form of semi-automated reasoning.

3 The methodology and towards the decentralized model

Formalization in a logical framework assumes defining the object system by specifying the state transitions at the right level of abstraction. Each rule defines the rewriting of the relevant facts from the previous state, to obtain the new state. Each rule consumes some of the facts and generates others, thus reaching a new state. Typically we have a handful of transition rules covering all possible scenarios for computation of (in this case) an infinite state space system. Declarative nature of system's formalization allows for inductive reasoning about the system. Initial state is assumed to be an empty market, where bid price is 0, and ask is the largest integer.

Considering decentralisation, any system based on the distributed ledger should be characterized by the following: organizational and technical decentralization, tamper-proof recording of events and their evidence, and guaranteed resource preservation. That is why defining the decentralized model of the exchanges' very core, representing the market logic, is rather important. Moreover, for the future regulation of digital economy this will be required.

Order matching in decentralized exchange differs slightly, and although the differences are subtle they are important. Decentralized order matching has a certain level of parallelism (incoming independent limit orders can be matched in parallel). We believe that the time should be discrete (in units), and that instead of using price/time priority we should use price priority. This is due to every exchange being effectively a market, which by definition should have a price discovery mechanism.

Market participants and market design domain experts today are aware of certain unwanted behaviors, as well as the design glitch responsible for that [7]. These market phenomena have first been brought to general public attention in a book Flash Boys, by Michael Lewis [8].

4 Existing exchanges and the case of Uniswap

Uniswap is the most popular decentralized exchange. It was created in November 2018, but did not reach a critical mass of users until Uniswap V2 released in 2020 [9, 10]. Already in 2020, it was among the top competitors in total values locked (TVL), as shown in Fig. 1. Today Uniswap has the most TVL of any DeFi protocol, reaching \$ 7B in January 2022. (see Fig. 2).

Uniswap is a constant product market maker. A constant product market maker satisfies that if $R_\alpha * R_\beta = k$ then $(R_\alpha - \Delta_\alpha) * (R_\beta - \gamma\Delta_\beta) = k$, where R_α and R_β are reserves of each asset, Δ_α and Δ_β are quantities transacted, and γ is the transaction fee. Trading any amount of either asset must change the reserves in such a way that, when the fee is zero, the product remains equal to the constant k. People often use a simplified form, namely $x * y = k$, where x and y are the reserves of each asset. A constant product function forms a hyperbola, and has a desirable property of always having liquidity as prices approach infinity on both axes.

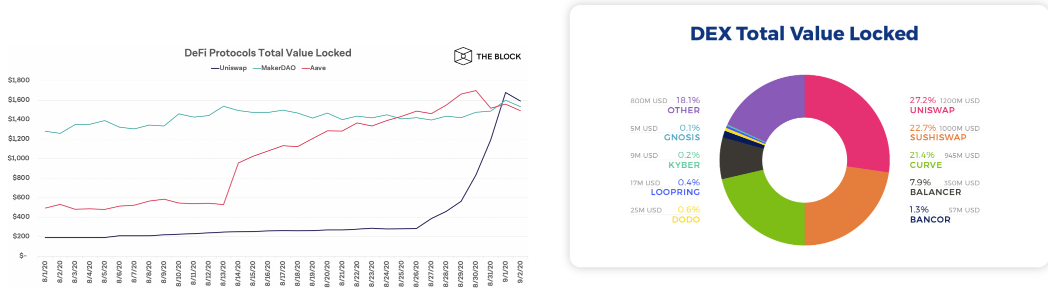

Figure 1: Comparision of Uniswap and competitors in TVL. Source: theblockcrypto.com and coingecko.com

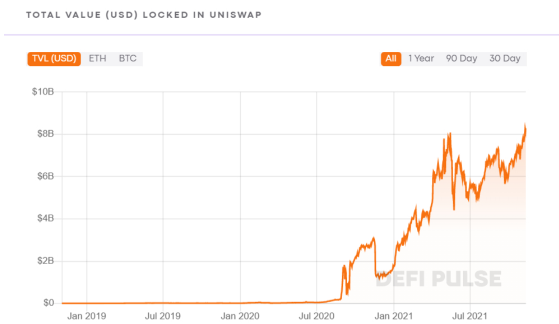

Figure 2: Uniswap TVL, end of January 2022. Source: defipulse.com

The unparalleled commercial success of Uniswap exchange is due to several factors, such as simplicity of market model, simplicity of use, properly defined incentives, innovative method of using the liquidity pool concept as a market making facility (together with incentivizing participants to contribute their currencies to the pool).

5 Conclusions

We point to the fact that although electronic exchanges, based on the centralized market design, date back several decades, financial companies are still struggling to achieve regulatory compliance. Methods relying on formal logic and automated reasoning, often regarded as symbolic AI, have recently emerged as the solution to this persisting finance industry problem. Moreover, companies running trading systems are facing challenges in ensuring that the market game is played in a fair way, and that flash crashes are prevented. We argue that if a formal model and its implementation are in a strict correspondence, these additional properties are naturally obtained by means of machine learning.

We have been able to formalize and reason about the centralized exchanges, as well as the new generation of centralized exchanges with parallel order matching. The desirable properties (of sequential systems) are preserved, whereas some additional significant properties are obtained. There are levels of parallelism (possible to define) in order matching, and the intuition is that the highest freedom in order matching, as well as certain parallelism, leads to a decentralized market model, as a conservative modification of centralized market models with some additional advantages. This would be the first step towards the regulatory compliant decentralized models by design.

Industry-wise, the decentralized exchanges being a recent phenomenon will face the same challenges in complying to regulations, and in preventing disruptive practices. These are rather challenging tasks, and having a strong grounding in theoretical models, which are then ensured to transfer to an actual implementation, coupled with understanding market design from the computer science perspective, provides us with a comparative advantage.

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