Cap: Crypto-Synthetic Trading

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Abstract

Cap is a crypto-synthetic trading protocol that uses a price feed and a liquidity pool to make markets. An automated market maker modeled by Gaussian functions quotes prices to traders. Users can trade with leverage using a fair system that shares margin across positions to minimize liquidation risk. Anyone can participate in the liquidity pool by buying CAP tokens, which track each user's share in the pool. Some components of the protocol that rely on speed and low cost are managed off-chain.

1 Introduction

Modern financial services rely on multinational institutions ("Big Finance") to serve as trusted middlemen to create currency, process payments, offer loans, settle trades, and provide insurance. While the system appears to work well, it has structural weaknesses due to its highly centralized, opaque, and state-affiliated nature.

The system's lack of transparency makes it hard to regulate effectively, a feature eagerly exploited by ill-intentioned actors — including some banks — to the tune of trillions of dollars per year [1]. Its lack of openness makes targeted censorship easy and prevents large segments of the public from participating [2]. Centralization allows a small group of people to dictate monetary policy and revalue the public's purchasing power at will [3]. A practice known as "moral hazard" is repeatedly used by states to rescue financial institutions, making it easy for risk-taking banks to get paid off with public funds when their investments run into trouble [4]. The values of Big Finance underpin most of the important socio-political decisions of our time.

In response, a non-state Open Finance movement has emerged, pioneered by Bitcoin in 2009. Its vision is for an alternative financial system based less on power and more on contract governed by fair and open rules. By using blockchain as a base layer, open access and transparency are built into the system by design. New financial instruments have already been developed with this ethos in mind: non-state money [5], fiat-linked digital currencies [6], smart contract-managed lending [7], decentralized token exchanges [8], and crypto-synthetics.

Crypto-synthetics are cryptocurrency backed instruments that track the value of an underlying asset (e.g. a stock). They allow investors to gain exposure to an asset without needing to own the asset itself or to interact with the traditional financial system, saving time and money.

In this paper we describe Cap, a crypto-synthetic trading protocol enabling the liquid trading of any asset using cryptocurrency. Stocks, ETFs, cryptos, bonds, commodities, foreign exchange, and more can be traded. Cap is built on the Ethereum blockchain, with some components living off-chain on fast, secure, and distributed conventional infrastructure. Off-chain components could move on-chain as blockchain technology improves with regards to speed and cost.

2 Architecture

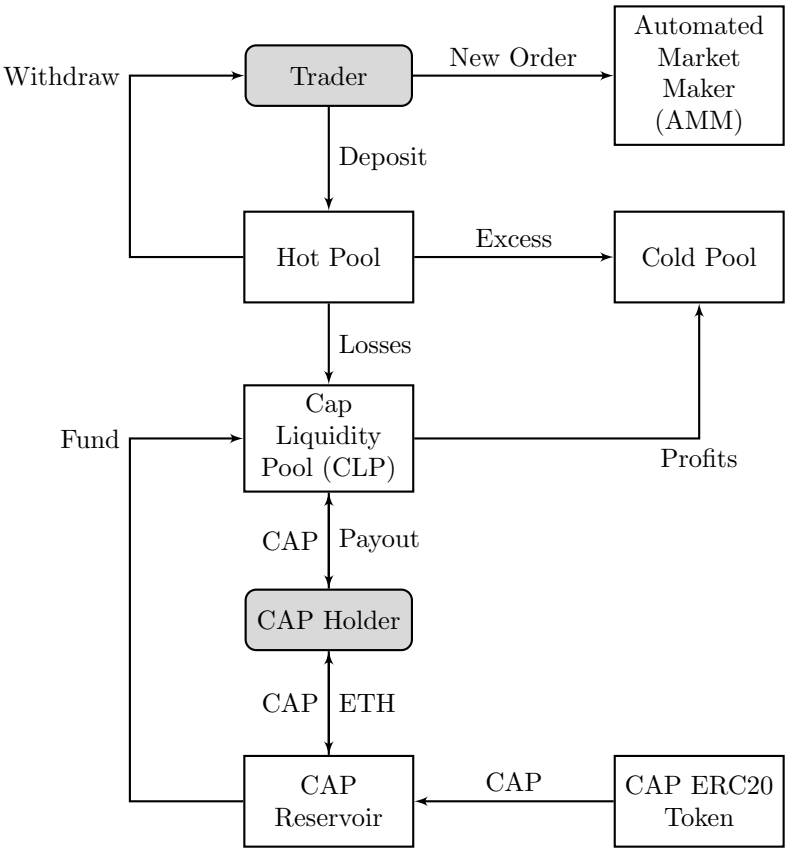

Figure 1: Cap Architecture

Cap's goal is to provide a trading service that is at least as good as traditional alternatives from a user experience perspective and orders of magnitude better

from a transparency perspective. Cap has two stakeholders: Traders, who place trades, and CAP Holders, who provide liquidity.

- **Traders** start by depositing a supported digital currency.[1]
- Orders submitted by traders are executed by the **Automated Market Maker** ("AMM").[2]
- Deposits are made to a **Hot Pool** that serves to process withdrawals and make payouts to the **Cap Liquidity Pool** ("CLP").
- The CLP backs trader positions. Trader profits are paid *from* the CLP and trader losses are paid *to* the CLP at the daily settlement.
- Excess funds are sent from the Hot Pool to the **Cold Pool** which is offline and secured with multi-signature encryption.
- Ownership stake in the CLP is tracked with **CAP**, a token that adheres to the ERC20 standard. Anyone can purchase CAP by sending ETH to the **CAP Reservoir** contract, available weekly.[3]
- **CAP Holders** can redeem their tokens by sending CAP to the CLP. They receive a payout equal to their share in the CLP plus profits or losses.

3 Market Making

To set up a crypto-synthetic market for a given asset, we need:

- **A price feed**. Programmatic access to an asset's last trade price.
- **Liquidity**. Provided by a market maker who quotes prices at which traders can buy and sell.

Price feeds are readily available.[4] Market making, on the other hand, is a more complex problem. Market makers face a classic trade-off: provide too much liquidity and risk holding excess inventory (inventory risk) or provide too little liquidity and risk executing too few trades (non-execution risk) [9]. Market makers also face the asymmetric information risk arising from informed traders [10]. An effective market maker must adapt their quotes dynamically to mitigate these risks.

Cap runs a zero-intelligence Automated Market Maker ("AMM") to provide liquidity for traders across a broad range of assets. It is conflict-free, transparent, and aims to outperform underlying spot liquidity in most market conditions. Below we provide a brief description of how Cap's AMM works. For the technical details, please refer to our Crypto-Synthetics Market Making paper [11].

[1] This can be ETH, stablecoins, or other ERC20 tokens.
[2] See Section 3 for details.
[3] See Section 5 for details.
[4] Using centralized sources, usually the spot exchange on which the underlying asset trades. On-chain access to price feeds through "oracle networks" is an active area of research.

3.1 Overview

Several order management systems exist to make markets, each with their own pros and cons:

- **Limit Order Book**. Limit orders are matched with incoming market orders on a public order book. Order books are transparent but inefficient (80% of queries are cancellations).
- **Dealer Quoting**. Dealers provide traders with a quote at which they are willing to buy or sell. This can result in lower costs but execution policies are often not transparent and a conflict of interest may arise.
- **N-Sided AMMs**. Used in some decentralized exchanges, multi-sided AMMs require depositing several assets and price is set based on the asset pool ratio. Trades can incur high slippage and fees.

Cap's AMM combines several elements from the systems described above. An asset's last price is determined using its price feed. Liquidity is then distributed on each side of that price along a **liquidity curve**, which is a Gaussian function whose properties — amplitude, center, and standard deviation — are automatically adjusted based on price volatility and the AMM's inventory. A basic liquidity curve is defined by:

$$G(x, \sigma, \mu) = \frac{L_{max}}{\sigma\sqrt{2\pi}} \exp\left(-\frac{1}{2}(\frac{x-\mu}{\sigma})^2\right)$$

where:

- L_{max} is the maximum amount of liquidity to be offered at a single price
- $\sigma = \gamma_d \times \sigma_v$, where σ_v is the market's short-term volatility and γ_d is a manually-set dispersion factor. A higher γ_d yields a flatter curve.
- $\mu = \gamma_r \times \sigma_v$ where γ_r is a manually-set risk aversion factor. A higher γ_r yields a curve that's centered further away from the asset's last price.

As shown in Figure 2, most liquidity is distributed around the curve's highest point, which is centered at μ ticks from the asset's last price. An incoming market buy order will consume a portion of the area under the curve starting on the left-hand side. The larger the order, the higher the slippage it will incur as the average execution price increases (or decreases in case of a sell order).

The area under the curve is the total cumulative liquidity that incoming orders can consume at any given time. This is equal to the integral of the liquidity curve, shown in Figure 3. We notice the resemblance of this curve with the depth charts of order book based trading venues. In practice, the curve is not continuous but discrete, with a sample size equal to the market's tick size, and the asset's BBO (best bid/offer) is used instead of its last price.

Cap's trading system supports market orders only. More complex order types such as stop and limit orders can be custom built on top of the protocol

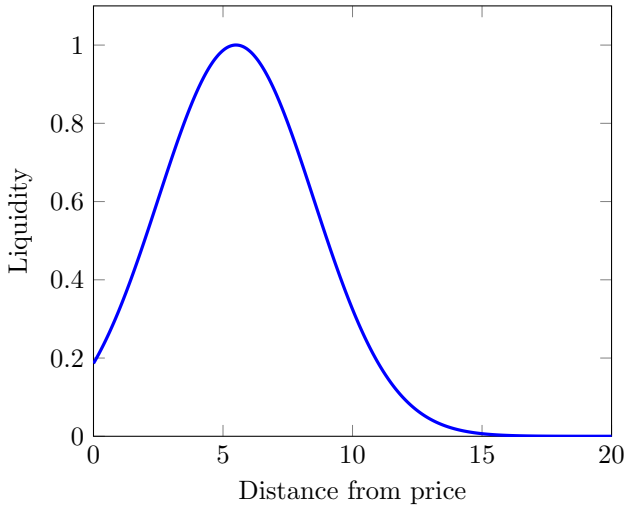

Figure 2: Base Liquidity Curve

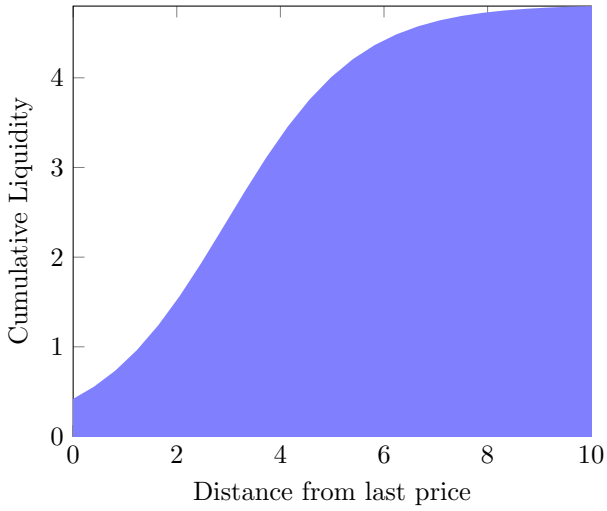

Figure 3: Integral of the Base Liquidity Curve

programmatically. Orders matched on the liquidity curve are backed by the Cap Liquidity Pool.[5]

[5]See Section 5 for details.

3.2 Benefits

Liquidity curves offer several important benefits to traders.

- **Shared liquidity**. Sharing liquidity across all markets enables the liquid trading of thousands of assets on day one.
- **Transparent**. Cap's AMM is open-source [11] and fully automated, eliminating conflict of interest.
- **Superior order execution**. Cap's AMM is incentivized to offer best-in-class execution quality to traders while minimizing risks for CAP Holders (liquidity providers). Liquidity curves are automatically tuned to match or provide better liquidity than underlying trading venues.
- **No fees**. Liquidity providers generate revenue through the effective bid-offer spread quoted by the AMM. Traders incur no other costs.[6]

4 Margin

Cap uses a fair margin trading system that automatically shares margin across open positions, minimizing liquidation risk. Traders can have up to one position per market representing their long or short exposure to the underlying asset. For traders looking to isolate margin per position or open long and short positions simultaneously, sub-accounts can be used.

Cap also offers the ability to open positions without margin.[7] This is equivalent to buying or shorting the underlying asset without leverage.

4.1 Definitions

- **Balance**. Your account balance.

$$\text{Balance} = \text{Deposits} - \text{Withdrawals} + \text{Profits or Losses}$$

- **Margin Requirement**. This is the amount of margin (real balance) that is locked when you submit a new trade. For example, if the margin requirement on a given market is 5%, to open a $10,000 position you need:

$$\$10,000 \times 5\% = \$500$$

- **Unrealized P/L**. The profit and loss incurred by open positions.
- **Equity**. The current value of all the cash and positions in your account. Equity is the balance you'd have if you close your open positions.

$$\text{Equity} = \text{Balance} + \text{Unrealized P/L}$$

[6] Interest rate applies for margin trading.
[7] See Section 6 for details.

- **Locked Margin**. The margin currently locked in open positions.
- **Free Margin**. The margin currently available to open new positions.

$$\text{Free Margin} = \text{Equity} - \text{Locked Margin}$$

- **Margin Level**. Equity vs Locked Margin, expressed as a percentage.

$$\text{Margin Level} = (\text{Equity} \div \text{Locked Margin}) \times 100\%$$

Margin Level keeps track of how close your account is to being liquidated. On Cap, when

$$\text{Margin Level} \leq 100\%$$

you can no longer open new positions. And when

$$\text{Margin Level} \leq 20\%$$

liquidation occurs.

4.2 Liquidation

Cap uses a zero-impact liquidation process. When Margin Level $\leq 20\%$, all open positions are closed at the prevailing market price,[8] realizing losses.

The loss incurred may exceed the account balance, particularly in fast-moving markets. In this case a Liquidation Rebate is applied to the account to readjust the balance back to 0. On the flip side, the liquidation could end up using less than the account balance. In this case, a Liquidation Charge is applied to the account to adjust the balance to 0. Liquidation Charges offset Liquidation Rebates.

To avoid liquidation, keep an eye on your Margin Level. If it gets too close to 20%, you can close positions to free up margin or deposit additional funds to increase your Equity.

4.3 Interest Rate

Interest is charged at 00:00 UTC daily on the total amount of borrowed funds locked in open positions and collected from your account balance. The interest rate is set to 5% per year and can be updated by the Cap Common Council.[9]

$$\text{Daily Interest Rate} = \text{Yearly Interest Rate} \div 360$$

Assume that you have a $10,000 position open on a market with a 10% Margin Requirement. The amount of borrowed funds is:

$$\$10,000 \times (100 - 10)\% = \$9,000$$

Given a 5% yearly interest rate, the daily interest charged is:

$$\$9000 \times 5\% \div 360 \ = \$1.25$$

[8] For markets that are closed during liquidation, the last available price is used.
[9] See Section 7 for details.

4.4 Examples

4.4.1 Funding

Let's assume you want to fund your account with $10,000. You select USD as your account's Base Currency. You deposit $10,000 worth of ETH, DAI, or any other supported cryptocurrency. Funds are converted at the USD conversion rate at deposit time and credited to your account.

Your account is:

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,000	$0	$10,000	$0	$10,000	∞

You are now ready to trade. Open long positions to profit from the price going up or short positions to profit from the price to go down.

4.4.2 New Position

AAPL, a crypto-synthetic with a 10% Margin Requirement, is currently priced at $300. You think AAPL's price will rise, so you open a $5,000 long position. The amount of margin that is locked to open this position is:

$$\$5,000 \times 10\% = \$500$$

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,000	$0	$10,000	$500	$9,500	2,000%

4.4.3 Unrealized Profit: Price Rises

AAPL's price rises and its quoted bid price is now $306. You now have an unrealized profit equal to:

$$\$5,000 \times \frac{306 - 300}{300} = \$100$$

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,000	$100	$10,100	$500	$9,500	2,020%

4.4.4 Unrealized Loss: Price Falls

In this scenario, AAPL's price falls and its quoted bid price is now $294. You now have an unrealized loss equal to:

$$\$5,000 \times \frac{294 - 300}{300} = -\$100$$

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,000	-$100	$9,900	$500	$9,500	1,980%

4.4.5 Opening Additional Positions

You decide to add money to your existing AAPL long position. You submit a market buy order for $2,000 that gets filled at $306. You still have one AAPL position on your account, but the margin tied to that position has increased by:

$$\$2,000 \times 10\% = \$200$$

The position's entry price is the average entry price of all its orders, weighted by their size:

$$\frac{300 \times 5000 + 306 \times 2000}{5000 + 2000} = \$301.71$$

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,000	$100	$10,100	$700	$9,400	1,442%

You now decide to open a short position on Gold, a market that has a Margin Requirement of 5%. You submit a market sell order for $20,000, locking up $1,000 in margin. You now have two separate open positions: an AAPL long position and a Gold short position.

Gold's price drops and the unrealized profit on the Gold position is now $250 while the unrealized profit on the AAPL has remained at $100. Your account is now:

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,000	$350	$10,350	$1,700	$8,400	608%

4.4.6 Realizing Profit or Loss

You now have $350 in unrealized profit and would like to "realize", or take, some of that profit. To fully or partially close a position, you submit an order in the opposite direction.

Let's assume you would like to close half of your $20,000 Gold short position. You therefore submit a market buy order for $10,000. Half of your Gold position's margin ($500) is unlocked and half of its unrealized profit ($125) is added to your balance.

Balance	U. P/L	Equity	Locked Margin	Free Margin	Margin Level
$10,125	$225	$10,350	$1,200	$8,900	862%

4.4.7 Withdrawing

Realized profits for the day are available to withdraw after the daily settlement with the CLP at 00:00 UTC. You can withdraw funds to any Ethereum address in any of the supported digital currencies. Funds are converted from your account's Base Currency to your withdrawal currency at the prevailing conversion rate. Assuming you'd like to withdraw $4,000 in ETH, currently priced at $200, then 20 ETH are sent to your withdrawal address.

5 CAP Token

At any given time the AMM holds the inverse of the positions held by traders. A trader with a $5,000 *long* position on TSLA means the AMM holds a $5,000 *short* position on TSLA. The Cap Liquidity Pool ("CLP") backs the AMM's portfolio: trader profits are paid *from* the CLP while trader losses and interest are paid *to* the CLP. CAP tokens track ownership stake in the CLP.

CAP's total supply is 10 million. Initially, 1 million CAP are made available to the public, distributed over 36 months. CAP can be obtained by contributing to the liquidity pool through the weekly reservoir contract (80% of distribution) or by trading on Cap and receiving CAP as cash back based on trading volume (20% of distribution).

Every Sunday at 12:00 UTC, CAP tokens are put up for sale for anyone who wants to get an ownership stake in the CLP. The sale aims to adjust CAP's market cap to the **Target Supply Value** ("TSV"), equal to 10% of the average **Open Interest**[10] ("OI") over the past week.

$$\text{TSV} = 10\% \times \text{OI}$$

For this example, let's set CAP's price to $1. For an OI of $1M, the number of CAP tokens to put up for sale is:

$$\frac{\text{TSV}}{\$1} = \frac{10\% \times \$1,000,000}{\$1} = 100,000$$

Funds raised by the sale are transferred to the CLP. Unsold tokens are burned and the remaining supply of CAP represents a 10% stake in the AMM's portfolio of positions.

A daily settlement occurs at 00:00 UTC during which trader profits for the day are transferred from the CLP and trader losses for the day are transferred into the CLP. Let's assume total trader losses for the first day are -$5K. This represents a profit for the AMM portfolio of +$5K. 10% of that — $500 — is transferred to the CLP. The total amount in the CLP is now $100,500. So, after the first day, CAP tokens can be redeemed for:

$$\frac{\$100,500}{100,000} = \$1.005$$

[10] The total size of positions currently open across all traders on Cap.

By next Sunday's CAP token sale, the average OI has increased to \$1.5M. The new TSV is:

$$10\% \times \$1,500,000 = \$150,000$$

Let's assume the net profits on the AMM's portfolio for the prior week were \$50K. The total amount in the CLP is now:

$$\$100,000 + 10\% \times \$50,000 = \$105,000$$

So an additional:

$$\$150,000 - \$105,000 = \$45,000$$

worth of CAP tokens must be sold to reach the TSV. Given the amount in the CLP, CAP's current price is:

$$\frac{\$105,000}{100,000} = \$1.05$$

which means the number of CAP tokens to put up for sale this week is:

$$\frac{\$45,000}{\$1.05} = 42,850$$

Assuming all tokens are sold, \$45K is added to the CLP. The total amount in the CLP is now:

$$\$100,000 + \$5,000 + \$45,000 = \$150,000$$

And the total supply of CAP is:

$$100,000 + 42,850 = 142,850$$

CAP can be redeemed during the redemption window, which is 01:00 UTC till 02:00 UTC every day. Let's assume a CAP Holder who purchased 10,000 CAP for \$10,000 at the first sale now wants to redeem their tokens. CAP's price is currently \$1.05. By sending 10,000 CAP to the CLP contract, they get back:

$$10,000 \times \$1.05 = \$10,500$$

The 10,000 CAP sent are burned so the remaining supply of CAP is:

$$142,850 - 10,000 = 132,850$$

And the amount remaining in the CLP is:

$$\$150,000 - \$10,500 = \$139,500$$

Some notes:

- A new reservoir contract is issued every week and contains newly minted CAP tokens for sale, in the amount necessary to meet the TSV.

- If the TSV is less than (CAP's market cap + 5%), no sale occurs.
- The weekly sale runs for a maximum of 12 hours.
- CAP can be purchased with ETH directly from the weekly sale contract.
- The ETH collected from the weekly sale is automatically converted to supported stablecoins before being sent to the CLP.
- At daily settlement:
  - If the AMM's portfolio made a profit for the day, funds are sent from the Hot Pool to the CLP contract. If the profit amount exceeds what is in the Hot Pool, additional funds are sent from the Cold Pool manually by an administrator.
  - If the AMM's portfolio made a loss for the day, funds are sent from the CLP contract to the Cold Pool.
- CAP Holders have voting rights.[11]
- The total CAP token supply represents a 10% stake in the AMM's portfolio, a figure that is not set in stone. Our aim is to bring representation up to 100%, with the protocol receiving a share of the CLP's profits.
- Holding CAP is not risk-free. Although traders as a whole tend to underperform in the long run, there may be periods of heavy trader gains — and corresponding AMM losses — which could affect CAP's price negatively.

6 Asset Tokens

Cap offers the ability to trade with or without using margin. Long positions opened without margin (fully collateralized) are available to withdraw as Asset Tokens which can be stored in self-custody or used in other protocols. Asset Tokens are standard ERC20 tokens that can be redeemed for the value of the underlying asset on Cap at any time. Interest is not charged on positions opened without margin.

Assume you purchase, without using margin, $3,000 worth of AAPL at $300. 10 AAPL tokens are made available to you to withdraw to your Ethereum wallet.

Cap intends to offer self-custody and full decentralization for Asset Tokens that have robust oracle price feeds. Traders will be able to send funds directly from their wallet to a smart contract to buy or sell Asset Tokens. Prices to execute trades will be provided on-chain by an oracle network and trading profits will be backed directly by the CLP.

[11] See Section 7 for details.

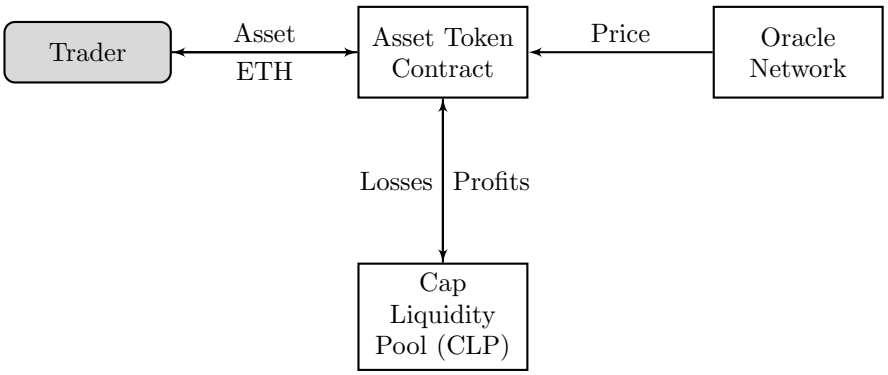

Figure 4: Permissionless Asset Token Architecture

7 Governance

Cap's aim is to minimize administrator intervention over time by gradually moving to a community-based governance system. In the early stages, administrators must intervene:

- to remedy vulnerabilities;
- to rebalance cold and hot pools;
- to apply rebates in case of erroneous price feeds;
- to prevent exploitation of erroneous price feeds;
- to protect the CLP by preventing abusive trading practices [12].

Anyone who owns more than 10 CAP is a member of the Cap Common Council (CCC) and is eligible to vote on protocol proposals including AMM settings such as risk aversion (γ), interest rate, crypto-synthetics to trade, and more. Votes are weighted by the amount of CAP held, which is fair because the more CAP you hold, the more exposure you have to the AMM's portfolio, and thus the more say you should have in the matter.

8 Transparency

All deposits, trades, withdrawals, profits, losses, account balances, hot and cold pool balances, and more are publicly accessible on Cap's Transparency website for anyone to audit and verify in real-time. The AMM's portfolio is publicly accessible in real-time, enabling CAP Holders (liquidity providers) to hedge positions as they see fit. Price feeds can be easily verified against the underlying asset's trading venue. Cap's order execution policy based on liquidity curves is open-source [11] and automated, eliminating conflict of interest. This kind of

transparency and auditing capability is only made possible by using cryptocurrencies on a public blockchain. This would not be possible to achieve with fiat due to the closed nature of the fiat banking system.

Regulation's goal is to protect consumers, businesses, and market integrity [13]. This is usually done through periodic market monitoring, auditing bank accounts and transactions, curbing dishonest marketing, and more. However, the financial system's opaque and heterogeneous nature makes it extremely hard to regulate efficiently. It's hard for anyone to know "what the hell is going on" and this enables bad actors to engage in illicit activities on a regular basis.

We believe that free markets are the most efficient means of creating wealth and distributing resources. But we also believe that markets are only effective where regulation has created an orderly environment. As Cap and other financial system components are progressively decentralized, the question becomes: how will these services be regulated? Traditional securities laws, which have been effective in preserving market integrity in important ways over the years, can no longer apply — not because blockchain developers intend to break laws, but because those laws make little sense in this new paradigm. Fully decentralized securities trading is already happening every day on several exchanges. As decentralized markets continue to grow, users will have to decide for themselves where and how they trade based on each protocol's policies. Public blockchains provide a level of transparency that no fiat-based venue can hope to achieve, giving everyone the ability to audit and verify in real-time.

9 Vision

Cap's goal is to be a trading service that is, in order of importance:

1. **Secure**. Traders expect their funds and data to be fully secured. Without this, everything else on this list is irrelevant.

2. **Cheap**. Traders care about their cost of trading because it impacts their bottom line. This includes fees, spreads, and slippage.

3. **Fast**. Traders care about speed. A trade executed a moment too late or too soon could mean the difference between a profit and a loss.

4. **Transparent**. Traders expect integrity and fairness from their counterparties. Order execution policies must be transparent.

5. **Fully decentralized**. A permission-less trading protocol is censorship-resistant and globally accessible.

Most traders would use a fully decentralized trading protocol, but not at the expense of speed, cost, and security. Present-day blockchains are still lagging behind in those respects. Many technical challenges remain, like enabling higher transaction throughput and fast access to off-chain data. Particularly, more research needs to be done around the Scalability Trilemma which postulates

that advances in decentralization, security, and scalability will be made at the expense of each other.

Cap utilizes what current blockchains do best where it makes the most sense: CAP token sales and issuance, settlement with the CLP contract, cryptocurrency deposits and withdrawals, and public auditing and verifiability tools. However, cost- and speed-sensitive features like order management and price feeds are mostly kept off-chain. These components could migrate on-chain if blockchain technology improves to make the trade-off — decentralization versus speed, cost, and security — worth it. A first foray into full self-custody and decentralization for the protocol was described in Section 6.

We believe blockchain technology is evolving rapidly. Initiatives like Ethereum 2.0, optimistic rollups, and developer-friendly blockchains like NEAR are a promising step forward. Within 10-20 years, we think a significant number of people will self-custody their funds and use user-friendly, open, and permissionless financial services that include borrowing, lending, trading, investing, payments, and insurance.

10 Conclusion

Cap's goal is to provide a trading service that is at least as good as traditional alternatives from a user experience perspective and orders of magnitude better from a transparency perspective. In this paper, we have described a crypto-synthetic trading system that is secure, cheap, fast, and transparent. We described an automated market maker that uses Gaussian functions to quote prices. We described a margin trading system designed to maximize a trader's free margin to reduce the likelihood of liquidation. When liquidation does occur, it happens off-book without market impact. The CAP token allows anyone to participate in the Cap Liquidity Pool, which backs part of Cap's market maker portfolio. Finally, Cap's Asset Tokens enable users to transfer assets to store or serve as a building block in other protocols. We hope this paper serves as a blueprint for further innovation in the largely untapped crypto-synthetic space and in Open Finance more broadly.

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