MIRROR PROTOCOL V2

STANFORD LIU, IRENE LEE

Abstract. The Mirror Protocol has seen significant increases in adoption due to the various benefits described in the first version of the whitepaper. This paper will aim to give an brief overview of the existing protocol, describe various improvements to the mechanisms utilized by Mirror, and lastly outline open problems that will be addressed in future versions of the protocol.

1. Introduction

The Mirror Protocol is a protocol that allows for the minting of synthetic asset tokens [4]. To mint a mirrored asset (hereby called "mAsset"), a user must submit a form of collateral to the protocol. In essence, this process is equivalent to the mechanics of ab over-collateralized debt position that is commonly seen in Maker [2]. As a supplement to the protocol, liquidity providers to the trading pairs in the form of mAsset/UST are incentivized through inflationary rewards in MIR tokens. The whitepaper for Mirror V1 that outlines the basic motivations and protocol structure is attached in Appendix C.

While the Mirror Protocol has taken a big step in allowing users to gain price exposure from synthetic assets that have prices tied to a real world exchange-traded security in a decentralized manner, it was a skeleton proof of concept designed to show that real assets could be traded on the blockchain. In Mirror V2, we aim to introduce several features that will introduce new asset types, incentivize active governance, diversify protocol risks, and sufficiently incentivize all user cohorts on the protocol.

2. New Features

2.1. **Pre-IPO Assets.** In this past year, we have seen one of the biggest cryptocurrency IPOs in the market. Coinbase shares opened at a price of $389 and reached a first-day high of $429.54 per share. However, the majority of trading done pre-listing occurs during pre-IPO placement, which is a private sale of large blocks of shares before the initial listing. Buyers tend to be private equity firms, hedge funds, and other large institutions willing to buy significant stakes in the firm. As a result, the individual investor is not able to gain access to these types of transactions.

Various places have made large strides in allowing the typical retail investor to make a pre-IPO investment. FTX, a cryptocurrency derivative exchange, saw volumes of over $2.2 million in the span of several hours after its initial release for its pre-IPO Coinbase derivative product [5]. The ability for users to conveniently trade derivative products that would correspond to a pre-IPO asset was a step in the direction of finance moving into the cryptocurrency industry. Mirror V2 brings an innovative mechanism that will allow users to bet on both sides of the trade for pre-IPO assets in a *decentralized* manner.

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During the period between in which a company announces an IPO and the filling of the final prospectus, several price range estimations are published. Any individual is able to start a governance vote to whitelist the pre-IPO asset with a fixed minting price rationally decided externally by the community. Once passed, any user is able to mint, trade, and provide liquidity for the asset. Unlike regular mAssets, pre-IPO assets have a fixed price feeder that provides the governance-voted price. In order to allow for natural price discovery, the minting of pre-IPO assets will be limited to a specific time window, after which the asset may no longer be minted. Once the underlying asset is listed on the exchange, the mPre-IPO asset goes through the standard migration process utilized in Mirror V1. Any person holding an mPre-IPO asset can burn it against any corresponding CDP at the first trading price (in the underlying market) to receive the position's collateral.

2.2. **Governance Voting Incentivization.** There were two major problems with governance in the first version of the protocol, (1) lack of incentivization to actively vote and (2) 'dynamic' quorums.

In Mirror V1, all users who staked MIR into the governance contract were given a pro-rata share of rewards generated by the CDP closure fees. In addition, these MIR staked in governance could also be used as voting power in on-going polls with the downside that the MIR would be non-withdrawable until the poll was over. Users who simply wanted a place to receive MIR rewards without experiencing potential impermanent loss placed their MIR in governance staking without actively voting. As a result, quorums were harder to meet due to low voter participation, and active participants in the Mirror governance system were insufficiently rewarded. Mirror V2 introduces a system where users are rewarded for their participation in on-going polls. If there are m number of MIR to be distributed to governance stakers, $(1-\alpha)m$ will be allocated to all MIR stakers in governance where $\alpha \in [0,1]$. The remaining αm will be distributed evenly across the n number of current on-going polls where $n \in \mathbb{Z}_+^*$. Thus each poll will be allocated $\frac{\alpha m}{n}$ MIR. A passive voter will receive at most

$$\Pi_{passive} = \frac{u}{U}(1-\alpha)m$$

where u and U represent the individual and total number of MIR staked in the governance contract. As an active voter, the total reward is a function of both the passive voter rewards as well as the rewards accrued to each on-going poll.

$$\begin{aligned}\Pi_{total} &= \Pi_{passive} + \Pi_{active} \\ &= \frac{u}{U}(1-\alpha)m + \sum_{i=1}^{n} \frac{v_i}{V_i}\frac{\alpha m}{n}\end{aligned}$$

where v_i and V_i represent the number of individual and total MIR utilized for the ith poll. Note that if all stakers in the governance contract are active voters and utilize all their MIR in each vote, then

$$\begin{aligned}\Pi &= \frac{u}{U}(1-\alpha)m + \sum_{i=1}^{n} \frac{v_i}{V_i}\frac{\alpha m}{n} \\ &= \frac{u}{U}\Big[(1-\alpha)m + \alpha m\Big] \\ &= \frac{u}{U}m\end{aligned}$$

which shows that rewards are split pro-rata based on the amount of MIR staked as expected.

The second problem arose due to the calculation of the quorum. Quorum is calculated as the number of MIR used in a vote as a fraction of the total MIR staked. However, this has the side effect that as users withdraw and deposit MIR from governance, the denominator changes. This can result a poll being over quorum but drop to under quorum if a significant amount of MIR is staked in the governance contract. To resolve this seesaw problem, the total amount of staked MIR will be snapshotted within a time window occurring near the end of the poll. This value of MIR staked will be fixed for the quorum calculation of the corresponding poll.

2.3. **Mint Collateral Diversification.** One of the main advantages of the Mirror Protocol is that all mAssets are backed by stable collateral (UST) that allows for relatively lower levels of collateralization. However, we would not want to preclude users from utilizing other forms of collateral. Instead, Mirror V2 will allow users to utilize LUNA, MIR, ANC, bLUNA, and aUST as collateral for minting mAssets (in addition to the current UST and mAsset collaterals currently allowed). To retrieve accurate prices for all collaterals, a collateral price feeder will be added to retrieve prices. In addition, pricing for bLuna, aUST, and other future 'derivative' collaterals will draw their prices directly from Terraswap and/or prices provided by the requisite smart contracts. For stability, bLuna prices pulled directly from Terraswap are adjusted by the Luna on-chain to Terraswap price ratio. That is to say,

$$p_{\text{bLuna}} = \frac{p_{\text{bLuna, terraswap}}}{p_{\text{Luna, terraswap}}} p_{\text{Luna, on-chain}}.$$

With the introduction of new collaterals, a new parameter modifying the 'UST value' of the collateral will be added. Consider a collateral with price $p_{collateral}$ and mintable asset (mAsset) with oracle price p_{mAsset} and minimum collateral ratio r. Then following the existing calculations, a mint position with c units of collateral is able to mint m units of mAsset. m is given by,

$$m = \frac{c}{r} \frac{p_{collateral}}{p_{mAsset}}.$$

Given that non-stable collaterals are much more volatile (as seen in the recent cryptocurrency market crash that wiped out over $1 trillion dollars [3]), we introduce an additional 'collateral effectiveness' parameter, ζ, which will dampen risks of undercollateralization. Applying this to the equation above, we have

$$m = \zeta \frac{c}{r} \frac{p_{collateral}}{p_{mAsset}}.$$

where $\zeta \in \mathbb{R}_+$. In general, ζ will fall between 0 and 1. For example, UST and aUST will have the parameter set as 1. If MIR has $\zeta = 0.5$, it implies that for every dollar supplied in MIR, the corresponding amount attributed to the position as collateral is $0.50.

The optionality of a diverse set of collaterals as well as multi-collateral positions[1] allows users to utilize interest bearing aUST to mint assets that the mAsset accrues interest. More sophisticated participants can modify their mint positions so that the total exposure (minted asset and collateral) is variable. For example, if the collateral

[1]Coming soon.

and minted asset are perfectly negatively correlated, then a delta hedged position can be constructed by adding both the volatile collateral and UST in appropriate ratios.

2.4. **Short Minting.** During the early stages of the protocol, the relatively high levels of APR for mAsset liquidity provision rewards resulted in a large premium in the mAsset Terraswap price relative to its underlying oracle price. Moreover, there were relatively little incentives for a user to mint an asset and provide liquidity compared to outright purchasing the mAsset despite the high premiums. Given that liquidity pools consist of pairs of mAsset and UST, any person seeking to earn MIR had to inadvertently take on a long position.

To simultaneously solve the above problems, Mirror V2 will be introducing a new minting and inflationary reward distribution structure. Note that this new minting (let us call it 'short minting'[2]) procedure will co-exist with the existing minting procedure. When opening a short mint position, an amount of collateral is provided in order to mint the mAsset. During this process, an additional *un-tradable* token is minted. This 'short LP token', sLP, can be staked to receive a portion of the MIR that is allocated to the given mAsset-UST LP pool.

As soon as the mAsset is minted, the asset is automatically sold (with a user-defined slippage tolerance) to Terraswap, the mAsset AMM DEX. The UST received from this automatic sell-off is locked for a governance-voted period before being claimable by the user. By immediately selling the minted mAsset, the mAsset supply is increased relatively to the UST in the pool pair. Thus some of the upward pressure on the mAsset prices due to MIR staking demand is alleviated. In addition, the user ultimately receives their UST after the lock-up period which allows for greater capital efficiency. The lock-up period is advantageous to the overall Terra ecosystem for three reasons: (1) the average total value locked in both Terra and Mirror is increased, (2) prevents the minter from immediately buying back the sold mAsset, and (3) decreases the velocity of Terra stablecoins and increasing average seigniorage.

The percentage of rewards going to sLP stakers versus the total allocated MIR is adjusted as a function of the premium. The premium is defined to be the percent difference between the AMM DEX price and the oracle price.
Note that this is applied to each mAsset separately and capped at 40% (cf. Appendix A and B).

3. Open Problems

Mirror V2 brings about many changes to the underlying mechanisms, but there still exist a multitude of problems to be solved for future versions. We outline some of the remaining major tasks to be accomplished below.

While the new changes for governance should incentivize active votership turnout, the fact those with an extensive amount of MIR have a linear relationship with voting power, causing the ecosystem to be potentially more centralized than anticpated. Proposals of similar nature (such as new listings of similar classes of assets) could be potentially first grouped together to employ a quadratic voting procedure. Ideally, votes would be equally distributed to each unique protocol participant, but the largest obstacle would be expected exploitation voting procedure by utilizing multiple addresses. However, there is the classical 'skin in the game' counter-argument that could be made as well.

[2]Taking name suggestions.

Table 1. Premium & Short Reward Ratio

Premium	Short Reward Ratio
0.00	0.0091001
0.25	0.0160237
0.50	0.0267229
0.75	0.0422599
1.00	0.0634621
1.25	0.0906509
1.50	0.1234150
1.75	0.1605175
2.00	0.2000000
2.25	0.2394825
2.50	0.2765850
2.75	0.3093491
3.00	0.3365379

Premium	Short Reward Ratio
3.25	0.3577401
3.50	0.3732771
3.75	0.3839763
4.00	0.3909000
4.25	0.3951102
4.50	0.3975161
4.75	0.3988081
5.00	0.3994600
5.25	0.3997692
5.50	0.3999070
5.75	0.3999646
6.00	0.3999873
6.25	0.3999957

MIR inflationary rewards given to Ethereum side users will also be undergoing re-evaluation given the relatively low trading volume compared to the Terra-side pools. Based on various community-decided KPIs, effective strategic partnerships with other Ethereum-based AMMs to incentivize liquidity should be considered. For example, trading volume, total market share, and potential for other protocol benefits is as possible non-exhaustive list. Active liquidity and fee diversification on Uniswap, combined rewards on Sushiswap (MIR+SUSHI), impermanent loss protection on Bancor, cross-chain liquidity pools on Thorchain, multi-asset pools on Balancer, proactive market makers on DODO, etc are competitive advantages that should be considered.

Lastly, new classes of derivative products built ontop of existing mirrored assets and contractual agreements between minters and third parties for collateralization will be extensively considered for Mirror V3.

Appendix A. Short Mechanism Derivation

We apply techniques commonly used by the data acquisition systems in particle accelerators. Suppose there is an estimator, x, that represents the current premium of a given asset. However, given the large amount of trades that can happen in a single moment as well as uncertainty of the exact time of the queued trades, we have a signal that is not perfect. Let us denote the perfect signal as y. In addition, suppose that the short staking incentives should rapidly increase at some trigger premium θ_x. That is to say that when $x > \theta_x$, the short rewards should be increased, and very small (almost 0) if not.

Let us consider the set of data (x, y) for each possible random event. In this case, both x and y represent the premium at a given point in time. Consider a histogram, $I(x, y)$, of x and y for many events. Note that since x and y describe the same quantity, they are correlated and the data will form a ‘band’ in this 2-dimensional space. The data has spectrums of

$$I(x) = \int_{-\infty}^{\infty} I(x,y)dy \quad \text{and} \quad I(y) = \int_{-\infty}^{\infty} I(x,y)dx \tag{A.1}$$

for x and y. Given that we know that the short rewards should start to change as a function of x, we want to look at the efficiency of this as a function of the real signal, y. We can define the efficiency as $\varepsilon(y)$. To find such a curve in y, we can utilize the following process:

(1) Normalize the histogram $I(x,y)$ such that $I(x) = 1$ for $x \geq \theta_x$. Note that this can by done by dividing each bin (x,y) in the histogram by $I(x)$. Denote this as $I_x(x,y)$. After normalization, $I_x(x)$ is equivalent to the efficiency curve in x.

(2) We have that $I_x(y) = \int_{-\infty}^{\infty} I_x(x,y)dx$. For values of y, where all possible values of x are above the trigger threshold, a constant plateau arises. For values y where some of the possible x values are below this threshold, the spectrum is diminished by that fraction of x values which lies below the threshold.

(3) The height of the plateau is determined by a fit with a straight line.

(4) Finally, $I_x(y)$ is divided by the plateau height. The resulting curve, is an estimate of the efficiency turn-on function.

The crucial feature necessary for this method to work is the constant plateau in $I_x(y)$. In other words, (1) forces the spectrum $I_x(y)$ to be uniform. A constant plateau arises when $I_x(y)$ does not depend on x or y until the trigger threshold is introduced. That is, $\hat{I}_x(y) = c$ where the hat indicates the absence of the trigger, and c is a constant plateau height. Any value in the actual $I_x(y)$ histogram not equal to c then indicates that the influence of the trigger and the difference $c - I_x(y)$ is proportional to the number of events missing at y due to the trigger efficiency.

Now let us assume that y follows a Gaussian distribution for any given x. Note that the shape parameters of a Gaussian distribution are functions of x, and the data has spectrum $N(x)$[3]. Then this means that

$$I(x,y) = \begin{cases} N(x)\dfrac{1}{\sqrt{2\pi}\sigma(x)}e^{-(y-\mu(x))^2/(2\sigma(x)^2)} & x \geq \theta_x, \\ 0 & x < \theta_x. \end{cases}$$

Division by $N(x)$ gives $I_x(x,y)$ which by construction is already normalized so that $I_x(x) = 1$. In order to obtain $I_x(y)$, shape parameters must be assumed *a priori*. In the simplest case, we take $\sigma(x) = \sigma$ and $\mu(x) = ax$. Thus we have that

$$I(x,y) = \begin{cases} \dfrac{1}{\sqrt{2\pi}\sigma}e^{-(y-ax)^2/(2\sigma^2)} & x \geq \theta_x, \\ 0 & x < \theta_x. \end{cases}$$

We also note that

$$\begin{aligned} \hat{I}_x(y) &= \int \frac{1}{\sqrt{2\pi}\sigma(x)}e^{-(y-ax)^2/(2\sigma^2)}dx \\ &= \frac{1}{a} \end{aligned}$$

[3]The spectrum is explicitly chosen to be $N(x)$, and by integration, we have that $I(x) = \int I(x,y)dy = N(x)$.

The spectrum in y is a constant if no trigger condition is applied. This implies that the critical condition for the method to work is met, i.e. that for values of y well above the trigger region, $I_x(y)$ forms a constant plateau.

The analytic shape of the turn-on curve can be obtained by including the trigger condition in the integral. That is,

$$\begin{aligned}\hat{I}_x(y) &= \int \frac{1}{\sqrt{2\pi}\sigma(x)} e^{-(y-ax)^2/(2\sigma^2)} H(x-\theta_x)dx \\ &= \frac{1}{2a}\left[\operatorname{erf}\left(\frac{y-a\theta_x}{\sqrt{2}\sigma}\right)+1\right]\end{aligned}$$

This integral is simply the convolution of a Gaussian with a step function, and describes the fraction of events that pass the trigger for each value of y relative to some plateau height of $\frac{1}{a}$ that is reached for $y \gg a\theta_x$.

Appendix B. Error Function Approximation

Given that integral and exponential expressions are not easy to compute on the blockchain, a polynomial approximation is necessary for the error function calculations in the short mechanism. The polynomial approximation utilized is defined by

$$\operatorname{erf}(x) \approx 1 - \frac{1}{(1+a_1x+a_2x+\cdots+a_6x^6)^{16}},\ x \geq 0$$

where $a_1 = 0.0705230784$, $a_2 = 0.0422820123$, $a_3 = 0.0092705272$, $a_4 = 0.0001520143$, $a_5 = 0.0002765672$, and $a_6 = 0.0000430638$. This gives a maximum error of 3×10^{-7} [1]. Note that the Terra blockchain holds up to only six decimal digits, so any potential error resulting from the approximation will not affect actual on-chain requirements. As such, all x values causing the short reward to be less than 0.000001 or greater than 0.400000 are additionally rounded to 0.000000 and 0.400000 respectively.

Appendix C. Mirror Protocol V1 Whitepaper

Abstract. Traditional asset classes have yet to enter the transparent, censorship resistant and globally accessible universe of public blockchains. Geographical barriers, high transaction costs and liquidity constraints make it hard for the average person to invest a small amount in assets like stocks and real estate. Asset tokenization has the potential to break down many of those barriers via blockchain reflections of traditional assets that are globally accessible, infinitely divisible and cheap to transact in. We present Mirror, a protocol that allows anyone to issue and trade synthetic assets that track the price of arbitrary real world assets without physical backing. Mirror enables two markets with well-balanced incentives: a market for minters to safely issue overcollateralized synthetic assets, and a market for traders to gain exposure to them. Mirror has the potential to democratize finance by making assets of all shapes and forms accessible to anyone, anywhere in the world.

C.1. **Introduction.** Blockchain technology has been adopted in a wide variety of industries thanks to its core properties of accessibility, transparency and immutability. Public blockchains, meaning those accessible by virtually anyone with an internet connection, have enabled unprecedented access to capital and to non-sovereign assets such as Bitcoin. Despite those developments, the financial industry remains closed and inaccessible, only experimenting with private blockchains which restrict access to specific parties. Indeed, access to financial assets such as stocks, bonds and derivatives remains a challenge for most of the world outside of America and Europe. We believe that a necessary requirement for an open financial system is open, unfettered access to financial assets.

In this paper we discuss how asset tokenization can be an avenue for democratization of financial assets and propose an implementation via synthetic tokens - tokens that track the prices of real-world assets without physical backing. We present Mirror, a protocol that allows anyone to issue synthetic assets that track arbitrary real-world assets using public blockchain technology. In the latter half of the paper we discuss the core mechanisms that enable Mirror and argue that the protocol will play a crucial role in expanding the audience of traditional finance.

C.2. **Asset Tokenization.**

C.2.1. *Motivization.* Let us first consider a simple problem where an individual wants to invest in a piece of real estate but only has a portion of the total required capital necessary to make the purchase. It may be in the investor's best interest to invest a portion of the total amount every month (known as dollar cost averaging) and slowly build up the investment capital. However, this would be an unusual concept in the real estate industry as it does not make sense to buy, say $10m^2$ of a piece of property. In a similar vein, the reverse scenario where an individual would like to procure $50,000 worth of liquidity but only has a piece of real estate worth $100,000 must necessarily sell the whole piece of real estate. It would be absurd to only sell half the house. However, we can view this as capital inefficiency as the individual would be left with an excess of $50,000 if they were to sell the entire house.

C.2.2. *Tokenization on a Public Ledger.* An elegant solution to the above problem would be to introduce asset tokenization. To put it simply, we would convert the ownership rights, an asset, into a digital token. We can arbitrarily say that our $100,000 property converts to 100,000 “tokens", each corresponding to an equal share of ownership. If an individual seeks to control 50% of property ownership, it would be necessary and sufficient to purchase 50,000 of those tokens. A requirement for this solution to work is agreement among all parties on a point of reference for assessing the current state of ownership division. The introduction of blockchain to this framework provides a public ledger where ownership is verifiable by all parties and cannot be forged nor revoked. Users can transfer rights through explicit contractual agreements that are publicly verifiable and are free of counterparty risk. Blockchains are by design a natural fit for asset tokenization.

C.2.3. *Tokenizable Assets.* While almost anything is “tokenizable” in theory, we expect the main tokenization demand drivers to be the following categories of assets:

- **Physical Assets** - This would include types of goods such as real estate, commodities, precious metals, famous paintings and a long tail of illiquid assets.
- **Abstract Assets** - This would include the majority of investment asset classes such as stocks, bonds, investment funds, derivatives etc.

We review the advantages of tokenizing those types of assets in the following section.

C.2.4. *Advantages of Asset Tokenization.*

(1) **Reduced Geographical Barriers** - As all the relevant information and records of previous transactions are stored on a permissionless blockchain, individuals can transact from anywhere in the world.
(2) **Reduced Reliance on Middlemen** - The traditional need of a middleman trusted by involved parties to validate and facilitate transactions is eliminated thanks to the blockchain's immutability and transparency.
(3) **Enhanced Accessibility through Fractional Ownership** - Tokenization allows assets to be divided into as many units (tokens) as desired, thereby enabling wider investment participation for high-value assets such as real estate and expensive stocks. While fractional ownership for stocks is becoming increasingly popular in brokerages, it comes with operational overhead that does not exist with tokenized stocks.
(4) **Improved Asset Liquidity** - Assets that are hard to transfer/trade tend to suffer in terms of liquidity. The use of blockchain to track and transfer ownership substantially reduces friction and therefore permits higher liquidity.
(5) **Increased Transaction Efficiency** - Blockchain transactions can dramatically improve efficiency of traditional settlements by reducing time and cost. Complex transactions can be automated via smart contracts, thereby reducing legal and operational costs and minimizing the risk of disputes.
(6) **Expanded Investor Base** - Flexible fractional ownership improves access to investment opportunities by allowing investors to partake in transactions that were previously inaccessible to them due to capital or liquidity constraints.

The above is undoubtedly only a subset of the vast advantages of asset tokenization.

C.2.5. *Implementations of Asset Tokenization.* We present the two primary implementations of asset tokenization and discuss the advantages of each:

(1) **Asset-backed tokens** are tokens which are backed one-to-one by the the physical or abstract good that they represent. For instance, an asset-backed gold token representing 1 ounce of gold would need to be backed by 1 ounce of physical gold stored in a vault.
(2) **Synthetic tokens** are tokens that provide "synthetic" exposure to the physical or abstract good that they represent without requiring one-to-one backing. For instance, a synthetic gold token representing 1 ounce of gold would be exchangeable for the price of 1 ounce of physical gold. Synthetic tokens can be issued either by a centralized party, e.g. a bank whose credit "backs" the token, or a decentralized network whose incentives guarantee that the synthetic token is always exchangeable for the price of the asset it represents.

The primary advantage of asset-backed tokens is **simplicity**: the design is easy for anyone to understand, and risk is limited to the custodian - if they are trustworthy then the token should be safe to hold. Synthetic tokens can be more complicated to implement. We see a number of important advantages of synthetic vs asset-backed tokens. First, the **accessibility** afforded by tokenization is typically wider for synthetic tokens: while anybody with an internet connection can access synthetic tokens on a public blockchain, asset-backed tokens may face restrictions imposed by the custodians backing them. Second, synthetic tokens tend to be more **affordable** to hold as they typically charge no holding fee. Custodians for asset-backed tokens will typically charge custody fees which can be high, particularly for physical assets such as gold or oil. Third, synthetic tokens provide complete **censorship resistance** which asset-backed tokens often cannot due to restrictions faced by custodians.

We see a market developing for both asset-backed tokens and synthetic tokens. Assetbacked tokens will certainly increase the transparency and liquidity of assets held by custodians, and we believe will become increasingly common. In the following section we introduce a protocol for synthetic asset tokenization, as we believe it has greater potential to democratize access to financial assets for a global audience.

C.3. **The Mirror Protocol.** Mirror unleashes the full power of asset tokenization to offer globally accessible, transparent and affordable access to financial assets.

C.3.1. *Basic Operations.* A synthetic asset issued on Mirror is said to be an mAsset. For instance, a synthetic version of real-world asset X would be called mX. The following are the main operations enabled by the Mirror Protocol:

- **Mint:** Anyone can mint an mAsset by locking up collateral, either in the form of a stablecoin or a different mAsset. The required collateral is at least a minimum multiple of the asset's value (150% for stablecoin collateral, 200% for mAsset collateral). For instance, if stock X is reported to be trading at $100, minting 1 mX would require at least $150 in stablecoin, or $200 in a different mAsset.
- **Burn:** To burn an mAsset, the issuer must burn the amount initially issued to receive the locked stablecoin collateral.
- **Trade:** mAssets are tradable on automated market makers (AMMs) on public blockchains like Terra and Ethereum, making it easy for issuers as well as investors to buy and sell them.

C.3.2. *Mirror Participants.* We expect Mirror to enable two types of markets involving different participants:

- **Minters:** Minters are those who mint mAssets and effectively take the opposite position of the asset's natural direction. For instance, an issuer of mXAU (gold) is effectively taking a short position on XAU. The minter's counterparty is the system itself.
- **Minters:** Minters are those who mint mAssets and effectively take the opposite position of the asset's natTraders: Traders are those who buy and sell mAssets on the decentralized exchanges supported by Mirror. Virtually anyone with an internet connection can gain exposure to mAssets via a Mirror-supported decentralized exchange.

The Mirror protocol creates incentives for minters to mint assets and provide liquidity for traders. We discuss those incentives in the following section.

C.3.3. *Liquidity, Governance and the Mirror Token.* The Mirror protocol utilizes AMMs (automated market makers) to facilitate mAsset trading against stablecoins. For instance, trading against an mXAU/UST pool on Uniswap would be the easiest way for a trader to get access to XAU. Minting and liquidity provision are essential services without which Mirror would not be able to function. It would therefore be natural for traders to compensate liquidity providers. To incentivize minting and liquidity provision, the Mirror protocol rewards liquidity providers with:

- **Trading Fees:** All mAsset trades that go through the AMM pay a small commission to that mAsset's liquidity providers.

- **The native Mirror Token:** Mirror defines a native token with a deterministic inflation schedule that rewards mAsset liquidity providers

In addition to providing liquidity incentives, the Mirror Token has a core governance role for the Mirror protocol. Mirror Token holders stake their tokens to vote on key issues including:

- **Whitelisting Assets:** Enabling/disabling assets that can be minted.
- **Key Parameter Changes:** Changing key protocol parameters such as the minimum collateral ratio and trading fees.

The Mirror Token is therefore foundational for the Mirror protocol, acting as both an incentive for liquidity providers and the primary governance vehicle.

C.3.4. *Oracles, Liquidations and Peg Incentives.* A critical function of the Mirror protocol is the ingestion of asset price data external to the blockchain. This is necessary for determining the amount of collateral required for minting an mAsset, and for assessing whether or not sufficient collateral is locked for existing mAssets. The protocol achieves this via an on-chain oracle similar in design to Terra's: Mirror Token holders submit votes on each asset, which the protocol aggregates to compute a median weighted by each holder's Mirror Token stake. The Mirror oracle submits prices at a high frequency to accommodate real-time pricing of exchange-traded assets.

The Mirror oracle facilitates solvency of mAssets by triggering collateral liquidations whenever the collateral ratio of an mAsset (collateral value/asset value) drops below the governance-mandated minimum. For instance, if $150 worth of stablecoin have been locked by a minter to issue an mAsset worth $90, and the minimum collateral ratio is 150%, an increase in the asset's value to $101 would trigger a liquidation. When the collateral ratio drops below the minimum, the Mirror protocol needs a way to retrieve and burn the respective mAssets. It does so by seizing a portion of the collateral and initiating an auction at a discount for anyone willing to sell the mAsset in exchange. This process is performed recursively until the collateral ratio is above the minimum threshold. The liquidation procedure implemented by Mirror for mAssets is similar to the procedure Maker implements for CDPs.

In addition, the Mirror oracle facilitates a key property of mAssets: that their onchain price is pegged to the price of the real-world assets they represent, as supplied by the oracle. This is achieved by incentives naturally created by the Mirror protocol. In particular, if the price of an mAsset trades at a discount to the oracle price, minters are incentivized to purchase and burn it, thereby profiting by paying back their debt at a discount. Conversely, if the price of an mAsset trades at a premium to the oracle price, market participants are incentivized to mint and sell it at the premium price, thereby profiting from the difference. In both cases, a drift of the mAsset's price away from the price of the real-world asset creates arbitrage that market participants will exploit until the peg is restored.

C.4. **Conclusion.** Asset tokenization on public permissionless blockchains has the potential to break down the financial and geographic barriers that hold back traditional asset classes from global accessibility. Mirror is a protocol that allows anyone to issue and trade synthetic assets that track the price of arbitrary real world assets. Mirror's wellcalibrated system of incentives creates a market for minters to safely issue synthetic assets and for traders to gain exposure to them from anywhere in the world. Mirror unleashes the full power of asset tokenization to democratize access to financial assets of all shapes and forms.

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