Lendland:

The Money Market Protocol

Abstract

In this paper we introduce a decentralized protocol which establishes money markets with algorithmically set interest rates based on supply and demand, allowing users to frictionlessly exchange the time value of GeneChain assets.

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1 Introduction

The market for cryptocurrencies and digital blockchain assets has developed into a vibrant ecosystem of investors, speculators, and traders, exchanging thousands of blockchain assets. Unfortunately, the

sophistication of financial markets hasn't followed: participants have little capability of trading the time value of assets.

Interest rates fill the gap between people with surplus assets they can't use, and people without assets (that have a productive or investment use); trading the time value of assets benefits both parties, and creates non-zero-sum wealth. For blockchain assets, two major flaws exist today:

- Borrowing mechanisms are extremely limited, which contributes to mispriced assets (e.g."scamcoins" with unfathomable valuations, because there's no way to short them).
- Blockchain assets have negative yield, resulting from significant storage costs and risks (both on-exchange and off-exchange), without natural interest rates to offset those costs. This contributes to volatility, as holding is disincentivized.

Centralized exchanges allow customers to trade blockchain assets on margin, with "borrowing markets" built into the exchange. These are trust-based systems (you have to trust that the exchange won't get hacked, abscond with your assets, or incorrectly close out your position), are limited to certain customer groups, and limited to a small number of (the most mainstream) assets. Finally, balances and positions are virtual; you can't move a position on-chain, for example to use borrowed RNA or tokens in a smart contract or ICO, making these facilities inaccessible to dApps.

Peer to peer protocols facilitate collateralized and uncollateralized loans between market participants directly. Unfortunately, decentralization forces significant costs and frictions onto users; in every protocol reviewed, lenders are required to post, manage, and (in the event of collateralized loans) supervise loan offers and active loans, and loan fulfillment is often slow & asynchronous (loans have to be funded, which takes time)

In this paper, we introduce a decentralized system for the frictionless borrowing of GeneChain tokens without the flaws of existing approaches, enabling proper money markets to function, and creating a safe positive-yield approach to storing assets.

2 The Lendland Protocol

Lendland is a protocol on the GeneChain blockchain that establishes money markets, which are pools of assets with algorithmically derived interest rates, based on the supply and demand for the asset. Suppliers (and borrowers) of an asset interact directly with the protocol, earning (and paying) a floating interest rate, without having to negotiate terms such as maturity, interest rate, or collateral with a peer or counterparty.

Each money market is unique to an GeneChain asset (such as RNA, an ERC-20 stablecoin such as USDT), and contains a transparent and publicly-inspectable ledger, with a record of all transactions and historical interest rates.

2.1 Supplying Assets

Unlike an exchange or peer-to-peer platform, where a user's assets are matched and lent to another user, the Lendland protocol aggregates the supply of each user; when a user supplies an asset, it becomes a fungible resource. This approach offers significantly more liquidity than direct lending;

Unless every asset in a market is borrowed (see below: the protocol incentivizes liquidity), users can withdraw their assets at any time, without waiting for a specific loan to mature.

Assets supplied to a market are represented by an ERC-20 token balance ("eToken"), which entitles the owner to an increasing quantity of the underlying asset. As the money market accrues interest, which is a function of borrowing demand, eTokens become convertible into an increasing amount of the underlying asset. In this way, earning interest is as simple as holding a ERC-20 eToken.

2.1.1 Primary Use Cases

Individuals with long-term investments in RNA and tokens ("HODLers") can use a Lendland money market as a source of additional returns on their investment. For example, a user that owns RNA can supply their tokens to the Lendland protocol, and earn interest (denominated in RNA) without having to manage their asset, fulfill loan requests or take speculative risks.

dApps, machines, and exchanges with token balances can use the Lendland protocol as a source of monetization and incremental returns by "sweeping" balances; this has the potential to unlock entirely new business models for the GeneChain ecosystem.

2.2 Borrowing Assets

Lendland allows users to frictionlessly borrow from the protocol, using eTokens as collateral, for use anywhere in the GeneChain ecosystem. Unlike peer-to-peer protocols, borrowing from Lendland simply requires a user to specify a desired asset; there are no terms to negotiate, maturity dates, or funding periods; borrowing is instant and predictable. Similar to supplying an asset, each money market has a floating interest rate, set by market forces, which determines the borrowing cost for each asset.

2.2.1 Collateral Value

Assets held by the protocol (represented by ownership of a eToken) are used as collateral to borrow from the protocol. Each market has a collateral factor, ranging from 0 to 1, that represents the portion of the underlying asset value that can be borrowed. Illiquid, small-cap assets have low collateral factors; they do not make good collateral, while liquid, high-cap assets have high collateral factors. The sum of the value of an accounts underlying token balances, multiplied by the collateral factors, equals a user's **borrowing capacity**.

Users are able to borrow up to, but not exceeding, their borrowing capacity, and an account can take no action (e.g. borrow, transfer eToken collateral, or redeem eToken collateral) that would raise the total value of borrowed assets above their borrowing capacity; this protects the protocol from default risk.

2.2.2 Risk & Liquidation

If the value of an account's borrowing outstanding exceeds their borrowing capacity, a portion of the outstanding borrowing may be repaid in exchange for the user's eToken collateral, at the current market price minus a **liquidation discount** ; this incentives an ecosystem of arbitrageurs to quickly step in to reduce the borrower's exposure, and eliminate the protocol's risk.

The proportion eligible to be closed, a **close factor** , is the portion of the borrowed asset that can be repaid, and ranges from 0 to 1, such as 25%. The liquidation process may continue to be called until the user's borrowing is less than their borrowing capacity.

Any GeneChain address that possesses the borrowed asset may invoke the liquidation function, exchanging their asset for the borrower's eToken collateral. As both users, both assets, and prices are all contained within the Lendland protocol, liquidation is frictionless and does not rely on any outside systems or order-books.

2.2.3 Liquidation Pool

In order to reduce the Lendland protocol's default risk, Lendland introduces a liquidation pool to ensure that the risk exposure in the system can be cleared in a timely manner when liquidity risks occur. Users can deposit their assets in the designated liquidation pool to earn liquidation income. Once liquidation occurs, the income generated by **liquidation discount** will be shared with users of the entire liquidation pool.

2.2.4 Primary Use Cases

The ability to seamlessly hold new assets (without selling or rearranging a portfolio) gives new superpowers to dApp consumers, traders and developers:

- Without having to wait for an order to fill, or requiring off-chain behavior, dApps can borrow tokens to use in the GeneChain ecosystem
- Traders can finance new ICO investments by borrowing RNA, using their existing portfolio as collateral
- Traders looking to short a token can borrow it, send it to an exchange and sell the token, profiting from declines in overvalued tokens

2.3 Interest Rate Model

Rather than individual suppliers or borrowers having to negotiate over terms and rates, the Lendland protocol utilizes an interest rate model that achieves an interest rate equilibrium, in each money market, based on supply and demand. Following economic theory, interest rates (the "price" of money) should increase as a function of demand; when demand is low, interest rates should be low, and vise versa when demand is high. The utilization ratio U for each market a unifies supply and demand into a single variable:

$$Ua = Borrows_a/(Cash_a + Borrows_a)$$

The demand curve is codified through governance and is expressed as a function of utilization. As an example, borrowing interest rates may resemble the following:

$$BorrowingInterestRate_a = 2.5\% + U_a * 20\%$$

The interest rate earned by suppliers is implicit , and is equal to the borrowing interest rate, multiplied by the utilization rate.

2.3.1 Liquidity Incentive Structure

The protocol does not guarantee liquidity; instead, it relies on the interest rate model to incentivize it. In periods of extreme demand for an asset, the liquidity of the protocol (the tokens available to withdraw or borrow) will decline; when this occur, interest rates rise, incentivizing supply, and disincentivizing borrowing.

3 Implementation & Architecture

At its core, a Lendland money market is a ledger that allows GeneChain accounts to supply or borrow assets, while computing interest, a function of time. The protocol's smart contracts will be publicly accessible and completely free to use for machines, dApps and humans.

3.1 eToken Contracts

Each money market is structured as a smart contract that implements the ERC-20 token specification. User's balances are represented as eToken balances; users can `mint(uint amountUnderlying)` eTokens by supplying assets to the market, or `redeem(uint amount)` eTokens for the underlying asset. The price (exchange rate) between eTokens and the underlying asset increases over time, as interest is accrued by borrowers of the asset, and is equal to:

$$exchangeRate = \quad (underlyingBalance + totalBorrowBalance_a - reserves_a)/eTokenSupply_a$$

As the market's total borrowing balance increases (as a function of borrower interest accruing), the exchange rate between eTokens and the underlying asset increases.

Function ABI	Description
`mint(uint amountUnderlying)`	Transfers an underlying asset into the market, updates msg.sender's eToken balance.
`borrow(uint amount)`	Transfers an underlying asset out of the market, updates msg.sender's eToken balance.

Function ABI	Description
`repayBorrow(uint amount)` `repayBorrowBehalf(address account, uint amount)`	Transfers the underlying asset into the market, updates the borrower's borrow balance.
`liquidate(address borrower, address collateralAsset, uintcloseAmount)`	Transfers the underlying asset into the market, updates the borrower's borrow balance, then transfers eToken collateral from the borrower to msg.sender

3.2 Interest Rate Mechanics

Lendland money markets are defined by an interest rate, applied to all borrowers uniformly, which adjust over time as the relationship between supply and demand changes. The history of each interest rate, for each money market, is captured by an Interest Rate Index , which is calculated each time an interest rate changes, resulting from a user minting, redeeming, borrowing, repaying or liquidating the asset.

3.2.1 Market Dynamics

Each time a transaction occurs, the Interest Rate Index for the asset is updated to Lendland the interest since the prior index, using the interest for the period, denominated by r * t, calculated using a per-block interest rate:

$$Index_{a,n} = Index_{a,(n-1)} * (1 + r * t)$$

The market's total borrowing outstanding is updated to include interest accrued since the last index:

$$totalBorrowBalance_{a,n} = totalBorrowBalance_{a,(n-1)} * (1 + r * t)$$

And a portion of the accrued interest is retained (set aside) as reserves, determined by a **reserveFactor** , ranging from 0 to 1:

$$reserves_a = reserves_{a,(n+1)} + totalBorrowBalance_{a,(n-1)} * (r * t * reserveFactory)$$

3.2.2 Borrower Dynamics

A borrower's balance, including accrued interest, is simply the ratio of the current index divided by the index when the user's balance was last checkpointed.

The balance for each borrower address in the eToken is stored as an account checkpoint . An account checkpoint is a Solidity tuple <uint256 balance, uint256 interestIndex> . This tuple describes the balance at the time interest was last applied to that account.

3.3 Borrowing

A user who wishes to borrow and who has sufficient balances stored in Lendland may call `borrow(uint amount)` on the relevant eToken contract. This function call checks the user's account value, and given sufficient collateral, will update the user's borrow balance, transfer the tokens to the user's GeneChain address, and update the money market's floating interest rate.

Borrows accrue interest in the exact same fashion as balance interest was calculated in section 3.2; a borrower has the right to repay an outstanding loan at any time, by calling `repayBorrow(uint amount)` which repays the outstanding balance.

3.4 Liquidation

If a user's borrowing balance exceeds their total collateral value (borrowing capacity) due to the value of collateral falling, or borrowed assets increasing in value, the public function `liquidate(address target, address collateralAsset, address borrowAsset, uint closeAmount)` can be called, which exchanges the invoking user's asset for the borrower's collateral, at a slightly better than market price

3.5 Price Feeds

A Price Oracle maintains the current exchange rate of each supported asset; the Lendland protocol delegates the ability to set the value of assets to a committee which pools prices from the top exchanges. These exchange rates are used to determine borrowing apacity and collateral requirements, and for all functions which require calculating the value equivalent of an account.

3.6 Comptroller

The Lendland protocol does not support specific tokens by default; instead, markets must be whitelisted. This is accomplished with an admin function, `supportMarket(address market, address interest rate model)` that allows users to begin interacting with the asset. In order to borrow an asset, there must be a valid price from the Price Oracle; in order to use an asset as collateral, there must be a valid price and a collateralFactor.

Each function call is validated through a policy layer, referred to as the Comptroller ; this contract validates collateral and liquidity, before allowing a user action to proceed.

3.7 Governance

Lendland will begin with centralized control of the protocol (such as choosing the interest rate model per asset), and over time, will transition to complete community and stakeholder control. The following rights in the protocol are controlled by the admin:

- The ability to list a new eToken market
- The ability to update the interest rate model per market
- The ability to withdraw the reserve of a eToken
- The ability to choose a new admin, such as a DAO controlled by the community; because this DAO can itself choose a new admin, the administration has the ability to evolve over time, based on the decisions of the stakeholders

4 Summary

- Lendland creates properly functioning money markets for GeneChain assets
- Each money market has interest rates that are determined by the supply and demand of the underlying asset; when demand to borrow an asset grows, or when supply is removed, interest rates increase, incentivizing additional liquidity
- Users can supply tokens to a money market to earn interest, without trusting a central party
- Users can borrow a token (to use, sell, or re-lend) by using their balances in the protocol as collateral