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zkLend Whitepaper v1.2

zkLend

Inspired by tradition and innovation to build the next generation of finance

First published on 7 April 2022
Last updated on 9 May 2023

ABSTRACT

zkLend is an L2 money-market protocol built on Starknet which combines zk-rollup scalability with Ethereum's security, enabling participants to efficiently earn interest on deposits and seamlessly borrow digital assets. The protocol offers a dual solution: a permissioned and compliance-focused solution for institutional clients, and a permissionless service for DeFi users - all without sacrificing decentralisation.

CONTENTS

Purpose

The purpose of this document is to outline the technical and financial components of zkLend, a money-market protocol built on Starknet, using StarkWare's validity roll-up and zero-knowledge proof technology. The implementation of zkLend will be made available to the public in various phases, hence this document is not intended to define exhaustively the scope of the protocol at launch, where this document will be updated from time to time during different developmental phases.

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1 Introduction

1.1 Ethereum's Security

Fundamentally two observations have been made since 2021's 'DeFi Summer' and 'NFT Mania'. DeFi summer saw the explosion of various L1 and L2 chains in response to the Ethereum scalability question. Declining Ethereum dominance can be observed as DeFi total value locked from 97% at the start of 2021 to 63% in Jan 2022 and 58% in Jan 2023. The introduction of alternative L1 and L2 chains which filled a growing demand for blockchain infrastructure capable of delivering cost and speed Ethereum could not achieve, which prove to be fundamental barriers to optimise usability to reach mass adoption.

However, these alternative chains lack modularity and fundamentally sacrifice decentralisation and security for speed and scalability.

Chain	Average Cost / Txn ($) [1]	Average Blocktime (s)	Nodes / Validators	Validator Requirements	Public Sale Allocation (%)
Ethereum	**3.264**	**13.34**	**5,398**	**4CORE / 16RAM / 500 GB**	**80.00**
Avalanche	0.000025	2.02	1,196	8CORE / 16RAM / 200 GB / 2000AVAX	9.97
Polygon	0.00000096	2.22	66	8CORE / 16RAM / 1.5 TB / Whitelist	19.00
FTM	0.00000034	0.89	65	4CORE / 8RAM / 2TB / 500,000 FTM	1.57
BSC	0.0000054	3.05	21	16CORE / 64RAM/ 2TB / 10,000BNB	50.00

Fig1. Comparison of various metrics for various chains. Figures based on public data available.

Below is a quick comparison between Ethereum and other alternative networks, where Ethereum excels in decentralisation, security and transparency.

- *Average Cost:*
  The average cost of gas for each transaction, converted from gwei to native currency token and converted to USD. Ethereum is more expensive than its peers.

[1]Using monthly average transaction data from 1-29 December 2021, and prices as of 29 December 2021.
Sources: Etherscan, Snowtrace, PolygonScan, FTMScan.

- *Average Blocktime:*
  The average time to complete a block. Ethereum is slower than its peers.

- *Nodes / Validators:*
  The number of nodes and validators for each chain. Higher number implies a higher level of *fault security* and a lower likelihood that all nodes will fail at the same time. Higher numbers also imply greater *attack security*: it is more costly for malicious attackers to attack the nodes. Ethereum has more nodes than its peers.

- *Validator Requirements:*
  The hardware and staking requirements to participate in the consensus of the blockchain. Therefore, it indicates the barrier of entry to validating in the consensus mechanism. In theory, lower validator requirements imply a higher level of *collusion security.* This means that it is harder for insiders to act in selfish ways against the greater good of the system to benefit themselves as it is easier to become a validator in the system. Ethereum has the lowest validator requirements.

- *Public Sale Allocation:*
  The allocation of initial token sale reserved for public sale. In proof of stake blockchains, native tokens are staked to secure consensus, even used for blockchain governance. Higher public token sale indicates lower concentration of power for the underlying blockchain, implying a higher collusion security as initially it would be hard to coordinate malicious actions from a bigger number of actors. Ethereum has the highest public sale allocation.

1.2 The Next Institutional DeFi Frontier

Secondly, it is clear that although 2021 was a landmark year for DeFi adoption - DeFi market cap is still a drop compared to the market cap and legacy infrastructure of TradFi. For example, total DeFi market cap amounts to only $145B, compared to total global equities market cap of over $100T. If only as little as 1% of assets under management from the world's 100 biggest banks were invested within DeFi, it would amount to $1T of capital into the industry.

There is huge potential as TradFi players are starting to enter the DeFi arena. Already, Chainanalysis reports that 60% of DeFi transactions are made by 'large institutions', defined as transactions greater than $10M. Beside fast transaction speed and transaction certainty at lower transaction costs, DeFi has the ability to offer competitive solutions in terms of enhanced market accesses, efficient payment rails, diversified liquidity provisions and attractive yields.

Meanwhile institutional literacy in DeFi is increasing: this year it was reported that around 30% of all crypto hedge funds use DEXes (Uniswap being the preferred choice), and Societe Generale took out a $20M in DAI using a tokenised bond as collateral.

There are two fundamental thesis:

1. Ethereum is unrivalled in terms of security and decentralisation.
2. There is a huge opportunity in institutional DeFi.

2 zkLend Protocol

zkLend is a money-market protocol built on Starknet,[2] combining zk-rollup scalability, superior transaction speed, and cost-savings with Ethereum's security. At its core, zkLend offers a dual suite of permissionless service for DeFi users ("**Artemis**") and a permissioned compliance focused solutions for institutional clients ("**Apollo**").

At a high level, Artemis enables users to deposit assets to earn a yield, with the option to utilise these assets as collateral to borrow other digital assets. Apollo functions similarly but borrowing and lending activities are only accessible to permissioned users who have gone through the KYC/KYB process by the protocol. As a result, the two products will function independently with separate capital pools and governance.

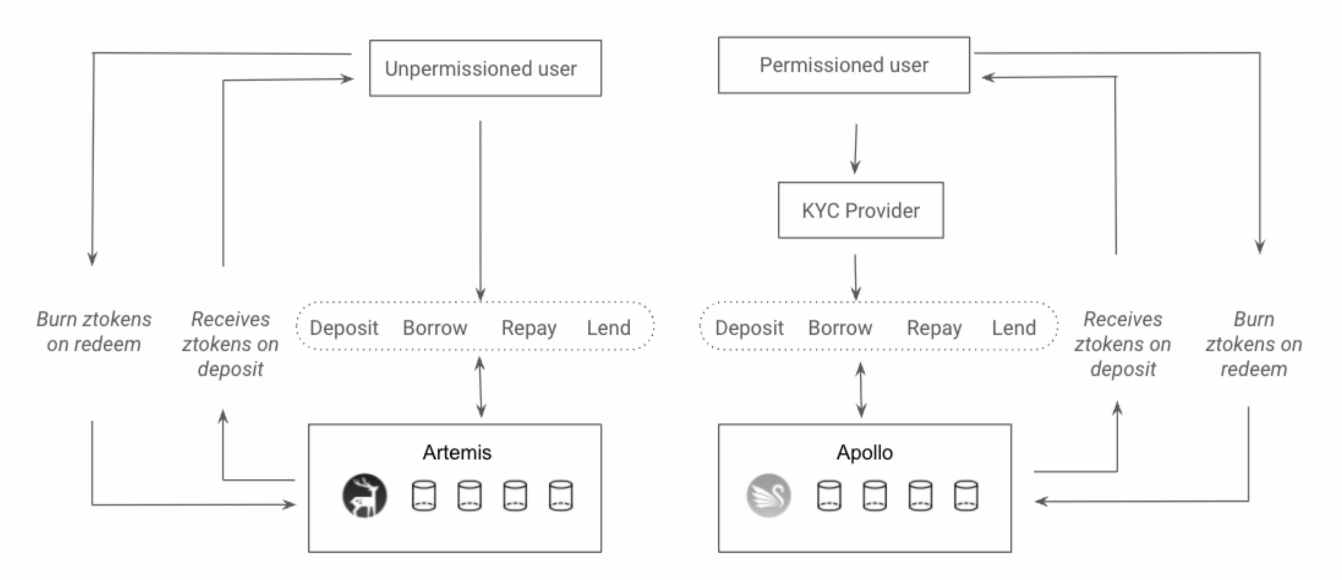


Fig2. High level overview of zkLend.

2.1 Artemis

2.1.1 Lend

Users will be able to deposit their assets into an asset pool, thereby providing capital to each liquidity pool. In return, users will receive zTokens which represent the respective deposited share of the pool. Overtime, zToken's exchange rate will adjust to account for interest accrued during the deposit period. The total assets in the pool will increase due to the financing costs received from borrowing. Users can deposit any amount into the pools with no lock-up period on withdrawal.

[2] For more information, please refer to https://starkware.co/starknet/.

2.1.2 Borrow

Users will be able to borrow assets in the various liquidity pools using their deposited assets as collateral. The borrowers' financing cost for each asset depends on the asset-specific interest rate model (more details in Section 3.2), which is a function of market supply and liquidity pool utilisation. The maximum borrowing amount is determined by the users' borrowing capacity. If the users exceed their borrowing capacity, their positions may be liquidated to ensure sufficient funds for repayment.

2.1.3 Tokenised Debt

zkLend tokenises debt on the protocol with ERC20-compliant zTokens. Upon deposit of assets, the depositors receive corresponding amounts of zTokens into their wallets. Each deposited asset will be represented by its own zToken (i.e. zUSDC, zUSDT, zETH, zwBTC, etc.) and each of them will have a value that maps the prevailing exchange rate relative to the underlying asset that reflects both the principal and interest accrued over the deposit period.

In future iterations of the protocol, zTokens can be used in derivative product construction, such as debt obligations, total return swaps and credit swaps; there could also be further composability between zkLend and other protocols for these zTokens in the future.

2.1.4 Flash Loans

Flash loans are types of borrowings that allow developers to borrow any available assets without putting up collateral upfront, as long as the borrowed assets are returned to the protocol within one block transaction. They are often used in DeFi for executing complex and time-sensitive financial transactions, such as trading on DEX or arbitraging between different DeFi protocols.

However, because of the short period of availability, there is a high level of risk involved. To execute a flash loan, users need to build a contract that requests the loan and then execute the steps and repay the loan plus interest and/or fees within the same transaction. Flash loan fees for Artemis are currently set at 0.09% of the borrowed amount. This feature will also be made available to institutional users through the Apollo protocol (where applicable).

2.1.5 Market Pools

zkLend will organise assets into respective designated market pools, such that higher-risk assets will be placed together in an 'Isolated Markets' pool for active monitoring and risk containment of these assets in case of rapid price volatility and/or market downturns.

Assets with similar risk characteristics and high price movement correlation will have comparable collateralisation ratios and interest rate curve models. Assets that have high volatility may be restricted from being used as collateral, but only available for lending and borrowing. The protocol will also introduce 'Core Markets' and 'Isolated Markets' pools to separate interaction and risks between stable assets (i.e. USDC, ETH) and variable assets (i.e. Starknet ecosystem project tokens). The protocol will review the assets periodically to determine whether they can move to become collateral.

zkLend internally classifies assets into three tiers, details of which have been shown in the below table:

	Category A	**Category B**	**Category C**
Price Volatility	Low	Medium / High	High
Lending	Yes	Yes	Yes
Borrowing	Yes	Yes	Yes
Pledged as Collaterals	Yes	Yes **in isolated markets*	No
Interaction with zkLend	Assets can be borrowed, lent and pledged as collateral.	Assets can be borrowed, lent, and pledged as collateral in isolated markets.	Assets only available for lending and borrowing in core markets, but not available to be pledged as collateral.
Examples	USDC, ETH	STRK	smaller cap ecosystem project tokens

Fig3. Asset tiering and attributes.

2.2 Apollo

Apollo serves as the institutional lending protocol, targeting established operators such as venture capital funds, hedge funds, market markers, and DAOs as borrowers while tapping into both retail and institutional capital as lenders.

2.2.1 Whitelisting Layer and Whitelisters

The whitelisting layer ensures that only permissioned participants will be able to borrow (and in some cases deposit) from pools. Each permissioned borrower can create their own borrowing pool(s) and set forth requirements on loan terms and criteria for lenders to provide funding into the said borrowing pool(s). On borrowers side, the whitelisting process typically includes compliance checks (KYC, AML, CFT, sanctioned parties checks, etc.), legal due diligence (holding structure, UBOs, use of proceeds, etc.), administrative onboarding procedures (understanding terms and conditions, fiat-to-crypto on ramping) and technical procedures (providing permissions for the selected Ethereum and Starknet wallet addresses).

The due diligence process will be managed by one or more third-party operator(s) while the decision to whitelist borrowers will be determined by zkLend management team initially and then subsequently through DAO approvals. Prospective borrowers will be responsible for completing the requested compliance checks, providing relevant records and deploying criteria for permissioned users' to participate in the borrowing pools.

The zkLend DAO will decide on the regulator-approved and/or licensed whitelisters in the implementation of Apollo markets. However there are several factors to consider in determining whitelister suitability, such as (but not limited to):

- Whether they employ KYC and compliance standards in accordance, or to the same degree as FATF / local jurisdiction guidelines to identify and accept their users;
- Robustness of their AML / CFT programs (if any); and
- Reputation (licensed or otherwise) in their selected jurisdiction; and
- On-chain and off-chain credit history

*** Details of responsibilities and duties of participants and the zkLend protocol will be built out as Apollo is developed to ensure further risk control, adequate compliance standards, and oversight to be implemented. zkLend will work closely with financial and legal advisors.*

2.2.2 Institutional Onboarding

The institutional onboarding process comprises both on-chain and off-chain reviews. The off-chain component consists of working with industry recognised service providers for background and reference checks. The on-chain component includes collaborating with service providers on blockchain to wallet addresses approvals, on-chain risk assessment, ongoing credit checks/monitoring, and custodian services.

Apollo will offer a ‘high touch’ and high client engagement approach. Dedicated institutions and compliance team will engage with institutions to understand their product needs and compliance requirements prior to onboarding, provide onboarding guidance and liaise with various KYC service providers, custodians and white-listers to streamline the process.

2.2.3 Deposit / Lend

Depending on the criteria of each borrowing pool, whitelisted institutions (and retail participants who meet those criteria) will be able to deposit their assets into the respective liquidity pools, thereby adding capital available for drawing to the borrowers. In return, participants will receive corresponding zTokens representing their deposited share of the pool for their principal and accrued interest. Depending on the pools and lenders’ specifications, there may be specific terms applicable for deposits and withdrawals. The interest earned will vary between borrowing pools and will depend on factors such as the interest rate model of the borrowed assets, the premium on the borrower's profile and other loan specifications.

The scope of assets supported will be more limited than Artemis with an emphasis on short-tailed assets, most likely only supporting USDC, USDT, DAI, ETH and wBTC. For private borrowing instances between borrower(s) and lender(s), we are flexible to explore other assets on the basis the lenders understand and accept the potential market and liquidity risks involved.

2.2.4 Borrow

Institutional participants will be able to borrow from whitelisted institutional clients and retail users. Borrowing rates as well as borrow capacity will vary by pool and are determined based on factors such as the borrower's profile, borrowing asset type, loan amount and collateralisation ratio.

If the participants' total borrowings exceed their borrowing capacity, their position may be liquidated as a risk control management procedure to protect the protocol against systemic risk.

2.3 Artemis and Apollo Comparison

	Artemis	**Apollo**
Description	Permissionless money market protocol	Permissioned money market protocol
Target Users	DeFi users Anyone with an internet connection	Borrowers: Institutions, SMEs, Family Offices, Hedge Funds, Web3 protocols. Lenders: Retail and institutional users
Asset Types	More, featuring native ecosystem tokens in isolated markets	Fewer, Basic
KYC / Whitelisting Layer	N	Y, for borrowers and in some cases lenders
Interest Rate Model	Dynamic	Dynamic & fixed
Ouroboros Model[3]	Y	N
Flash Loans	Y	-
Variable Liquidation Fees	Y	Y
Under-collateralised Loans	N	Y

Fig4. Comparison of Artemis and Apollo by product feature.

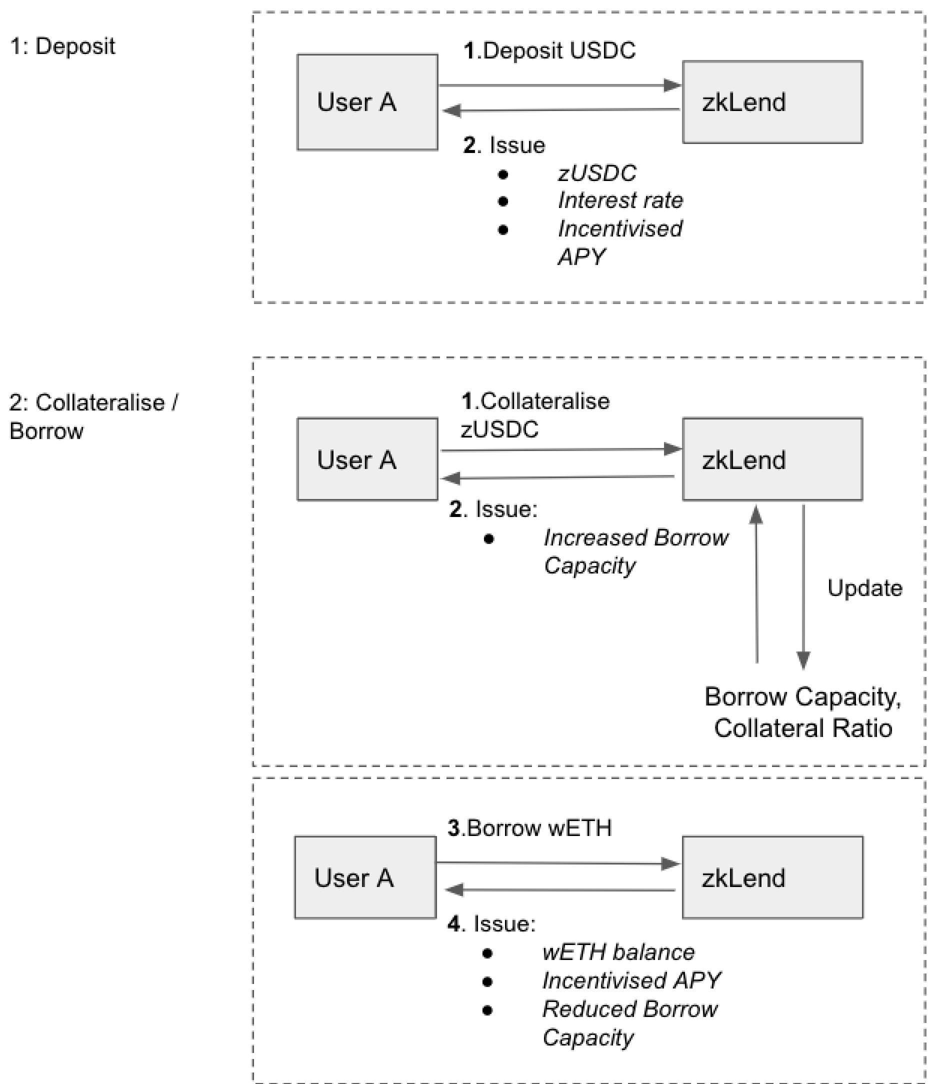
[3] Ouroboros model focuses on rewarding borrowing activities in the market pools with the highest fee generated, where a portion of the revenue generated will be used towards funding rewards for token holders to create a circular incentive of fees generated to fund further borrowing pools with the next highest revenue generation capability.

3 Architecture & Implementation

The below architecture and implementation is specific to Artemis. Details on Apollo will be provided at a later date.

3.1 zToken

zTokens are minted when users deposit assets to any market. Each deposited asset is represented by its own zToken (i.e. zDAI, zETH, zwBTC), which will have pro-rata ownership to the underlying liquidity pool. Each minted zToken will have a value that maps the prevailing exchange rate relative to the underlying asset that reflect both the principal and interest accrued over the deposit period. zToken is redeemed and burned when the user would like to withdraw their deposited funds from the pool.



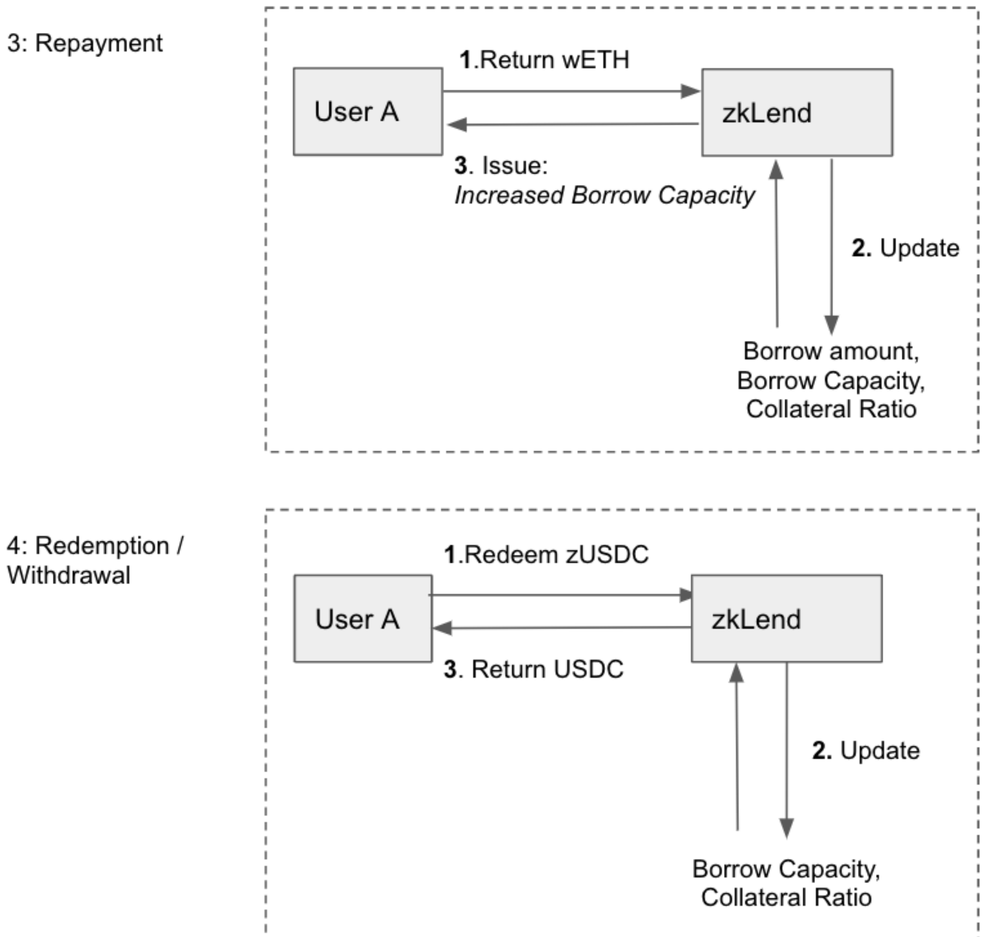


Fig5. Example of zToken lifecycle within the protocol, using zUSDC as collateral to borrow wETH.

1: Deposit

1. User deposits asset (USDC) into the zkLend protocol
    a. Deposit rate will vary based on the asset's interest rate model and will include any additional incentives for each pool
2. zToken is minted with the value of equivalent of asset (zUSDC)

2: Collateralise / Borrow (Artemis only)

1. User enables his/her zTokens (i.e. zUSDC) as collateral
2. zkLend increases the users' borrowing capacity
3. User borrows asset (i.e. wETH) from the zkLend protocol
    a. Borrow rate will vary depending on the interest rate model and any additional incentives for each pool
4. zkLend issues wETH for the user

a. Users' borrowing capacity will be updated (reduced) upon issuance

3: Repayment

1. User returns asset owed (wETH) on zkLend
2. zkLend updates:
    a. Record of asset borrowed, and
    b. Borrowing capacity (increased)

4: Redemption / Withdrawal

1. User will choose the withdraw feature and select any amount up to the maximum allowed in account (depending if the user has an outstanding borrowing position)
2. zkLend will calculate new borrowing capacity of user*
3. USDC corresponding to zUSDC will be released to lender

**When there is an outstanding loan position, the user will be able to withdraw up to the amount that keeps their portfolio Health Factor above 1. Should the user wish to withdraw all of their collateral, we recommend the user to first repay their loan balance.*

3.2 Interest Rate Model

The interest rate model determines the borrowing and lending interest rate for each asset market on the protocol. Artemis offers a dynamic interest rate model. Apollo may offer both a dynamic and fixed-rate interest rate model, subject to further development.

For the dynamic interest rate model, each asset market has a separate interest rate curve based on the market's utilisation rate. The utilisation rate is calculated as:

$$U_x(Utilisation\ rate\ of\ market\ x) = Borrowings_x \div (Cash_x + Borrowings_x)$$

The interest rate model will follow a simple two-sloped model where optimal utilisation will be assessed and readjusted periodically to best reflect actual market utilisation. The utilisation rate of each pool is a function of the current outstanding loan amount over the total capital supply in the specific liquidity pool; the utilisation ratio will be refreshed after each new supply and borrowing. Lender and borrower participation will help to provide data points in assessing the best representation of the elastic demand.

The utilisation rate of each asset pool will have a specific optimal utilisation rate (U_o). The interest rate model has two slopes: (i) below the U_o, the interest rate curve will follow the optimal slope (Slope 1 or 'S1'); & (ii) greater than or equal to the U_o, the interest rate curve will sharply increase (Slope 2 or 'S2').

$$Rt = Ro + S1 \cdot \frac{Ut}{Uo} \qquad \textit{(for Ut < Uo)}$$

$$Rt = Ro + S1 + S2 \cdot \frac{(Ut - Uo)}{(1 - Uo)} \qquad \textit{(for Ut >= Uo)}$$

where
$Rt = borrowing\ rate\ at\ Ut$
$Ro = base\ rate$
$S1 = slope\ for\ Ut < Uo$
$S2 = slope\ for\ Ut > Uo$
$Ut = current\ utilisation$
$Uo = optimal\ utilisation$

Example Interest Rate Curve Parameters

Asset	***Uo (%)***	***Ro (%)***	**S1**	**S2**
USDC	[90]%	[0]%	[4]%	[60]%
USDT	[90]%	[0]%	[4]%	[60]%
DAI	[80]%	[0]%	[4]%	[75]%
ETH	[65]%	[0]%	[8]%	[100]%
wBTC	[65]%	[0]%	[7]%	[100]%

Fig6. Example interest rate curves.[4]

Currently, the joint of the two slopes intersecting at U_o represents a discontinuity, or a 'kink'. In order to accurately incentivise supply and demand of liquidity, zkLend plans to move from the two-sloped interest rate to the following dynamic interest rate model in subsequent iterations once there is working data in relation to the functions on interest rates versus utilisation rates:

$$R_{Ut} = \alpha e^{Ut} + c$$

where
R_{Ut} *= Borrowing rate at utilisation ratio Ut*
α = Interest rate curve coefficient
c = minimum borrowing rate at zero utilisation ratio

A utilisation ratio above a prescribed market equilibrium would result in a higher financing and deposit rate. This is especially useful in managing long-tail asset liquidity pools, where the optimal utilisation ratio (and the respective curves' coefficients) would also take into account risk of increased borrowing against long-tailed assets as collaterals.

[4] Interest rate parameters to be adjusted and refined prior to launch of testnet and subsequently reviewed periodically.

To determine coefficients α and c, the protocol will leverage a regression model based on historical liquidity supply and demand data to determine the most representative model for each asset market. For example, the borrowing curve of short-tail assets would likely have a smaller concavity which should resemble closer to a linear curve. For long-tailed assets, the interest rate curves are expected to exhibit greater concavity due to the accelerating degree of risk at higher pool utilisation.

3.3 Deposit APY

Deposit APY is a function of the total interest earned by each pool's liquidity providers, represented by zTokens, excluding a share which will be reserved for the ecosystem. It is calculated the following way:

$$D_t = U_t (S B_t \bullet S_t + V B_t \bullet V_t) \bullet (1 - R_t)$$

where
D_t = *Deposit APY*
U_t = *Utilisation Rate*
$S B_t$ = *Weight in Stable Borrowing*[5]
S_t = *Stable Borrowing Rate*[5]
$V B_t$ = *Weight in Variable Borrowing*
V_t = *Variable Borrowing Rate*
R_t = *Asset-specific Reserve Ratio*

3.4 Borrowing Capacity

Specific borrowable amounts, the users' borrowing capacity, will vary according to the asset tiers of the users' deposits and the borrowing asset's collateral requirements (loan-to-value ratio). The collateral value represents how much can be borrowed against the deposited amount for each market. In general, more volatile, small cap assets will have lower collateral value as they will not be considered the best collateral - and vice versa for more stable, large cap assets. A users' borrowing capacity is calculated as:

Borrowing Capacity = Σ(Value of underlying Token Balance) × Collateral Factor

zkLend utilises two-way collateralisation approach to refine risk management: (1) collateral will be subject to "Collateral Factor" which governs the maximum loan-to-value users may be able to borrow against the particular pledged assets, and (2) the borrowing will also be subject to 'Borrow Factor' which dictates the maximum limit at which users may be able to borrow such target asset.

[5] Apollo intends to offer under-collateralise stable or fixed-rate borrowing to institutional users; Currently, there is no stable borrowing available in current version of the protocol.

The protocol also will build in a specific “Reserve Ratio”, such that a predetermined percentage of the revenue generated from the asset pool will go towards the safety module in the event of a liquidity shortfall.

Assets	**Can be used as collateral**	**Collateral Factor**	**Borrow Factor**	**Reserve Ratio**
USDC	Y	[80]%	[100]%	[15]%
USDT	Y	[70]%	[91]%	[15]%
DAI	Y	[70]%	[91]%	[15]%
ETH	Y	[80]%	[100]%	[15]%
WBTC	Y	[70]%	[91]%	[15]%

3.5 Liquidation

The liquidation process is triggered when a borrower's Health Factor[6] falls to 1 or lower, indicating that the value of their collateral may not be enough to cover their debt, posing risks to the lenders and zkLend protocol. The liquidation process incentivises external party(ies) to actively monitor zkLend's loan portfolios to seek out borrowings that have Health Factor below 1 and to actively repay these loans to ensure liquidity safety and health of the protocol.

A borrower whose outstanding loan exceeds his/her borrowing capacity will be liquidated at market rate. Instead of a static close factor, zkLend will implement a variable close factor where liquidators can only repay the portion of loan position that has exceeded the borrowing capacity. While the liquidation threshold for each borrower varies on his/her assets pledged as well as the borrowing asset, liquidations happen when the underlying collateral decreases in value relative to the borrowed asset and/or if the outstanding loan value (asset value + accrued interest) now exceeds the borrowing capacity. Examples may include large price increases in a borrowed asset, or dramatic price decrease in the underlying collateral.

Upon reaching liquidation threshold, any Starknet address (i.e. Liquidator) can initiate a liquidationCall() contract to repay the debt on behalf of the borrower and receive a Liquidation Bonus. Liquidation Bonus is an additional % applied on the collateral received after the repayment. Liquidators are only allowed to repay the amount that will bring the borrower’s Health Factor back to 1. This ensures that no excess collaterals are slashed in a forced liquidation situation, and only the amount of debt exceeding the value of Risk-adjusted Collateral would be repaid / liquidated. This provides a more transparent, decentralised and efficient way to handle liquidation risks.

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[6] Health Factor is a numerical representation of the safety of your deposited assets in relation to the borrowed assets. It is calculated by dividing users’ Risk-adjusted Collateral by the market value of their Liabilities.

Assets	Liquidation Bonus (%)
USDC	10%
USDT	10%
DAI	10%
ETH	10%
WBTC	15%

3.6 Price Oracle

The price oracle fetches off-chain data for the protocol such as token prices to enable the calculation of collateral ratios for each market and any necessary liquidations should positions fluctuate beyond a users' borrowing capacity.

The protocol will aim to integrate decentralised oracles providers like Pragma (already available on Starknet mainnet) and Chainlink (available on Starknet testnet, and expected mainnet integration by late-2023). zkLend will also set deviation thresholds against TWAP pricing from automated market makers on L1 (i.e. Uniswap) as sanity checks to compare with Starknet oracle(s) prices and screen for potential price manipulation attacks from natural market volatilities. As the Starknet ecosystem becomes more mature, zkLend may look to take in a wider variety of decentralised oracles to further pricing reliability.

3.7 ZEND Token

The native cryptographically-secured fungible protocol token of zkLend (ticker symbol **ZEND**) is a transferable representation of attributed governance and utility functions specified in the protocol/code of zkLend, and which is designed to be used solely as an interoperable utility token. ZEND will be an ERC-20 token, a standard interface for fungible (interchangeable) tokens on Ethereum.

ZEND tokens holders will be entitled to certain rewards and incentives by engaging with the protocol on the below forms of 'Active Participant Incentives':

1. A portion of the protocol's borrowing fees (revenue) would be allocated to users as rewards to encourage them to interact within the network, for example borrowing/lending activities, providing protocol liquidity, community events, or participation in marketing/airdrop campaigns.
2. A portion of the protocol's operating profit will be allocated to the governance treasury with the DAO deciding on use of proceeds.
3. Another [5]% will be directed to the safety module[7].

[7] Structure and purpose of the safety module as explained in Section 4.

Please refer to "Appendix - Official Representations of ZEND Tokens" for more details.

3.8 Technical Architecture Summary

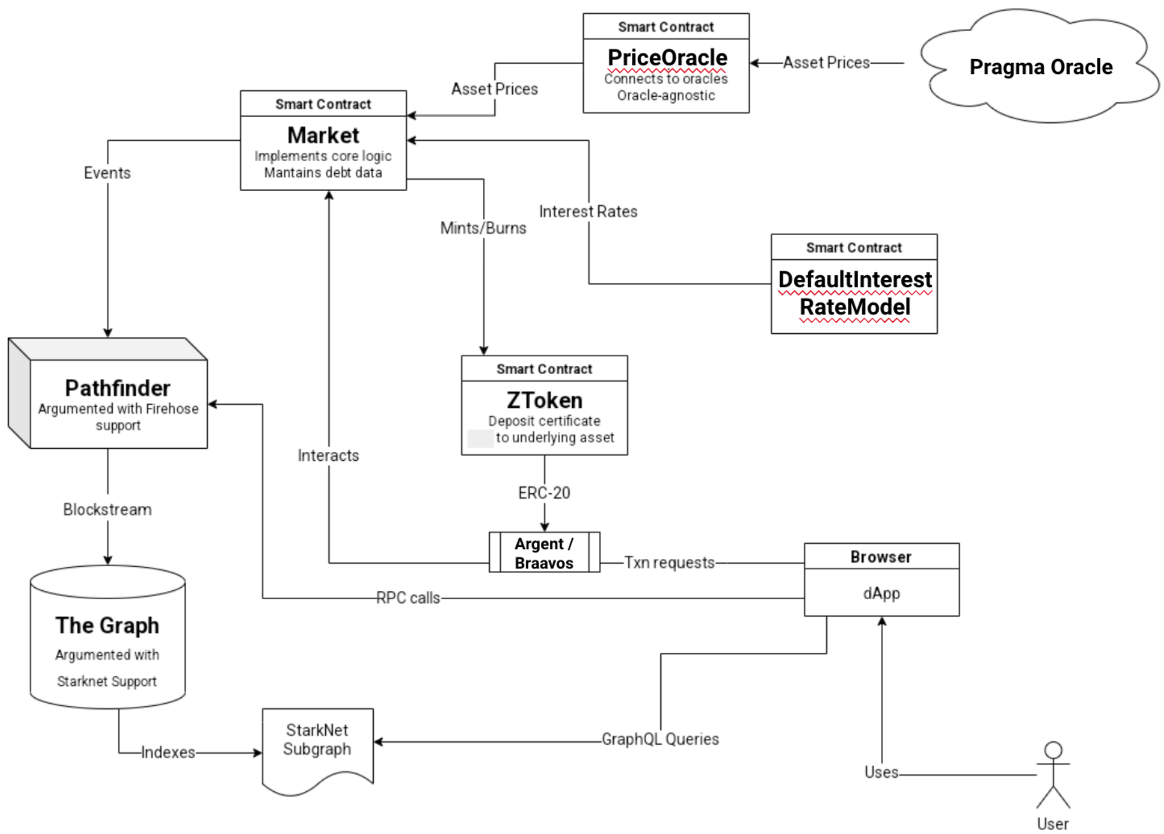

Fig8. zkLend architecture built on Starknet, and using Ethereum for settlement.

4 ZEND Token Utility

4.1 ZEND

Users can stake their ZEND tokens in exchange for stZEND. Upon the staking of ZEND, users will receive an equivalent amount of staked ZEND, which represents a claim to the underlying token, ZEND. Staking consists of depositing ZEND tokens into the protocol's safety module. The purpose of the safety module is to act as a risk management tool in the event of a liquidity shortfall, primarily as a result of extreme asset prices fluctuation, liquidity squeeze events, oracle inefficiency/failure and liquidation risks. The safety module may use up to [30]% of the stZEND to cover the shortfalls.

To incentivise users to actively participating to provide risk backing for the protocol, holders of stZEND may enjoy the following:

1. Revenue sharing
2. Emission rewards
3. Governance rights

The cooldown period for converting stZEND back to ZEND is [10] days upon trigger. Rewards for stZEND, however, will be claimable in the form of ZEND directly.

Additional use cases for the stZEND token may include membership perks, enabling holders of stZEND an additional boost on their borrowing and lending rewards on Artemis.

4.1.1 Protocol Governance

zkLend will only have one native token, ZEND with a single governance structure for Artemis and for Apollo. Holders of stZEND will be able to vote on matters pertaining to both protocols, with voting rights weighted proportionally to the number of ZEND tokens staked.

Examples of community proposals may include:

1. Listing new asset markets
2. Modifying Interest rate models
3. Incentives threshold
4. Deprecating old asset markets

The right to vote is restricted solely to voting on features of zkLend; it does not entitle ZEND holders to vote on the operation and management of the Company, its affiliates, or their assets or the disposition of such assets to token holders, or select the board of directors of these entities, or determine the development direction of these entities, nor does ZEND constitute any equity interest in any of these entities or any collective investment scheme; the arrangement is not intended to be any form of joint venture or partnership. After governance launch there will be no individual or corporate entity or other active promoter, sponsor, or group or affiliated party that maintains sole control over zkLend.

5 Use cases

5.1 Artemis

5.1.1 Liquidity Providing

Bob holds $150 worth of ETH, and he intends on holding it because he wants to take a long-term view. Bob can provide liquidity with his assets and earn passive income from the pools as a liquidity provider.

5.1.1 Leveraging

Bob is bullish on ETH and is holding $150 worth of ETH. He can use his $150 in ETH as collateral and receive a $100 USDC loan for example. Bob can then use the borrowed $100 USDC to buy ETH. Bob now has a $250 levered position on ETH to capture potential increase value of ETH.

5.1.2 Shorting

Unlike Bob, Alice is bearish on ETH. She holds $150 USDC which she uses as collateral to receive $100 worth of ETH. Alice can now sell her $100 worth of ETH in the market and receive $100. Assuming Alice was right and ETH price dropped 20% she can now buy the same amount of ETH for $80. She can repay her ETH loan in full on zkLend and keep the profits, less the borrowing costs and transaction fees.

5.1.3 Efficient Liquidity Management

Alice holds a substantial amount of crypto. Selling it on CEXs or DEXs for a profit may incur large transaction fees. In order to avoid significant slippage, Alice decides to use her crypto as collateral and take a loan on stablecoins. These funds can now be used freely without having to monetise her crypto position and bearing significant transaction fees.

5.1.4 Arbitraging

Using flash loans, Callister can bundle all his trades into one transaction and save on transaction fees. The transactions for the arbitrage operation would be the following:

a) Use a flash loan to borrow USDC;
b) Use USDC to buy ETH on Uniswap (assuming lower ETH price);
c) Sell the recently bought ETH on Sushiswap (higher ETH price) for USDC;
d) Repay USDC loan plus the fees;

5.1.5 Collateral Swapping

Daphne has already taken out a loan with some crypto as collateral, she can replace the collateral with a different asset using flash loans. Let’s say she already took out a USDC loan using ETH as collateral.

Daphne can take a USDC flash loan to repay her debt and collect the collateral ETH, she can then swap that ETH to the asset of her choice and use it as collateral to get another USDC loan.

5.1.6 Self-Liquidation

Using flash loans, Callister can avoid having his positions getting liquidated when the price of his collaterals are falling. He can take out a USDC flash loan to partially repay his loans and unlock the respective collaterals, let's say ETH. Callister can now swap his ETH for USDC and repay the flash loan and keep the rest of his remaining position.

5.1.7 DeFi Protocol Funding (DAO-to-DAO)

zkLend will be able to offer under-collateralised lending to selected protocols - allowing protocols a revolving line of credit at a more efficient rate than current models of liquidity bootstrapping and liquidity-as-a-service.

5.2 Apollo

5.2.1 Cash management for institutions

Established institutions (corporates, funds, insurance companies, family offices, etc.) that have excess cash positions idle in the bank. By placing it in a checking account, institutions only earn 3-5% APY and are exposed to inflation risk. They could consider lending their cash in the form of USDC or other digital assets. Additionally, corporates can use their new borrowing power to borrow ETH and apply them to liquid staking which can earn 6-12% APY. This mechanism also allows them the flexibility to deposit into pools with different risk buckets and length to align with their risk appetite.

5.2.2 Liquidity Providing

Similar to retail users, institutional investors that are looking to take a long-term position on an asset (i.e. Ethereum) could look to provide liquidity with their assets, and at the same time support the protocol to earn rewards for their contributions.

5.2.3 Borrowing

Over-collateralised

Entities that hold a significant amount of crypto assets can deposit them as collateral to borrow. Like retail users, they could take out a loan on either a stablecoin to leverage up their positions or borrow other assets in order to sell them on the open market and take short positions. Utilising the best of DeFi, this trade will be compliant, automated and transparent, with rates set by parties involved.

Under-collateralised

Borrowers who opt to borrow under-collateralised will be able to do so with Apollo. At inception, the borrower will need to submit a loan request complete with loan term and principal amount while a borrowing rate will be determined by the borrower. Prospective lenders will then assess the due diligence material from the borrower to decide whether to proceed with the funding based on the borrower's credit, loan term, and interest rate offered.

6 References

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Appendix – Representation of ZEND Tokens

ZEND is the native utility/governance token which also provides the economic incentives which will be distributed to encourage users to exert efforts towards contribution and participation in the ecosystem on zkLend, thereby creating a mutually beneficial system where every participant is fairly compensated for its efforts. ZEND is an integral and indispensable part of zkLend, because without ZEND, there would be no incentive for users to expend resources to participate in activities or provide services for the benefit of the entire ecosystem on zkLend. Given that additional ZEND will be awarded to a user based only on its actual usage, activity and efforts made on zkLend and/or proportionate to the frequency and volume of transactions, users of zkLend and/or holders of ZEND which did not actively participate will not receive any ZEND incentives.

ZEND does not in any way represent any shareholding, participation, right, title, or interest in the Company, the Distributor, their respective affiliates, or any other company, enterprise or undertaking, nor will ZEND entitle token holders to any promise of fees, dividends, revenue, profits or investment returns, and are not intended to constitute securities in Panama, Singapore or any relevant jurisdiction. ZEND may only be utilised on zkLend, and ownership of ZEND carries no rights, express or implied, other than the right to use ZEND as a means to enable usage of and interaction within zkLend. The secondary market pricing of ZEND is not dependent on the effort of the zkLend team, and there is no token functionality or scheme designed to control or manipulate such secondary pricing.

ZEND functions as a loyalty membership point which embeds a licence granting active participants exclusive access to selected products or services, so users will be classified into different loyalty tiers based on the amount of ZEND staked, user activity, and/or volume of transactions. The premium membership tiers would allow users to get greater access to the ecosystem features and more preferential terms, for example (i) preferential borrowing rates, (ii) boosted borrowing capacity, and (iii) governance participation. For the avoidance of doubt, users will still need to engage with the ecosystem to access these rewards.