BERH

An all-in-one cross-chain DeFi protocol with high leverage

Rev. 1.3 | J2024
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Abstract

This paper introduces an all-in-one substrate-based DeFi protocol on Polkadot that unites a high leverage money market and an order book decentralized exchange (DEX) with margin trading. Berhoffers on-chain price discovery and system-wide insurance by enabling participants to separate and transfer volatility risk and price event risk from borrowers to so-called bailsmen. The money market integrated with DEX will run on Berh's parachain.

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Berh*(noun)*: A state in which opposing forces are balanced
(Oxford English Dictionary)

1. Why Berhmatters

Decentralized Finance (DeFi) has demonstrated impressive growth in the past two years becoming the most dynamically evolving segment of the crypto market. The total value locked in DeFi (TVL) peaked at a solid $253B in December 2021 [1]. Nearly 42% of these funds (roughly $106B) are locked as collateral to back leveraged positions in lending and derivative instruments that DeFi offers.

Capital efficiency in the given instruments may seem questionable though as the effective leverage that users get on their funds is often quite low. What are the fundamental reasons behind the mentioned inefficiency? How to solve them without sharpening the response to shocks originated in the crypto market?

This chapter considers four main challenges for DeFi, which Berhis working to overcome with its innovations while building a system resilient to adverse market conditions.

1.1. An inefficient approach to liquidations

Major DeFi platforms implement a suboptimal auction model for liquidating debt. Selling collateral at a discount can fail badly when the market starts to crash. It may turn out there are simply no market players willing to buy a rapidly depreciating asset, no matter the discount.

It is important to keep in mind that the risk of an undercollateralized loan remains in the system as long as its collateral hasn't been liquidated. This can result in losses for risk-averse users who hold collateral in the same pool, and can even lead to a system shutdown. The problem is further exacerbated by rising transaction fees on the blockchain when the network becomes congested. In order to transact quickly, you have to pay exorbitant fees.

These issues create a serious system risk since at least 80% of assets locked in lending protocols on Ethereum are subject to potential auctioning. You can imagine what can happen if this overwhelming amount of liquidity floods the market when it crashes sharply and a bunch of borrowers default simultaneously. An example is remembered the problem that MakerDAO experienced in March 2020 when over $7M was extracted from the protocol [2].

Fortunately, we can avoid rash actions in chaotic situations by setting liquidity pools for bailouts upfront. Berhis solving this inefficiency by using third-party agents (called "bailsmen") who provide liquidity in advance and earn fees by lending out assets and securing loans.

1.2. Excessive over-collateralization

Existing decentralized lending protocols require heavy over-collateralization for provided loans so users need to pledge somewhat $200 to borrow $100. However, it's a necessary measure as extra collateral is required if a margin call happens when collateralization drops below a pre-agreed threshold.

As we described above, the current design of most lending protocols keeps liquidated collateral in the system until it's bought out by third parties. During this period, there should be a guarantee that its value is sufficient to cover an initial loan and potential losses. Exactly this cushion absorbs fluctuations in collateral value during market downturns while it's being auctioned.

As such, excessive collateral is required to cover the maximum potential slippage within at least 24 hours (statistic-wise it's 20% for the majority of crypto assets) plus the interest of third parties participating in liquidations. Here we come to the number of 125% for the minimum collateralization. If we look at the most popular protocols, we can see even higher requirements (133% in Compound, 150% in MakerDAO).

Liquidations in Berhwork differently. In the case of margin calls, there are no delays and debt obligations are transferred from borrowers to bailsmen instantly. Bailsmen can cover them whenever they prefer (but before they can withdraw funds from the bailout pool). Loans become sufficiently secured again and we can afford to decrease the minimum collateralization level to 105% (the lowest in the space).

1.3. Fragmentation of DeFi liquidity

Liquidity in existing systems is isolated and limited by the boundaries of underlying blockchain networks. Ethereum currently holds a leading position in the field, with various money market, trading, and asset exchange protocols in its ecosystem. The obvious drawback here is that non-ETH-based assets cannot be used effectively inside those protocols. Thus, a big part of the ecosystem remains underutilized while the value of the assets locked in DeFi is dwarfed by comparison to the market cap of the overall crypto space.

Cross-chain communication has thus emerged as a major challenge of decentralized finance: interoperability will bring additional liquidity and asset variety into the DeFi space — consider the recent explosive growth of the WBTC token on Ethereum. It will also open up possibilities for building the DeFi infrastructure like multi-currency lending protocols, cross-chain DEX with margin trading, derivative contracts, and liquidity pools.

Interoperability also offers huge potential for further scalability, since the initial system on Berh's parachain is designed to handle all the core logic of the application. The task of connecting a new blockchain comes down to bridging it with the Dotsama ecosystem and rolling out an escrow smart contract in the network being connected.

1.4. Complicated user experience

Major stablecoins (USDT, USDC, and DAI) are the most demanded assets for borrowing in the most popular money markets, AAVE and Compound (over 85% of all loans). Most loans in stablecoins are taken to obtain liquidity (or working capital) for new investment opportunities instead of selling underlying assets.

But users cannot utilize newly borrowed working capital directly in lending protocols. They are forced to transfer them to external platforms like Uniswap, Sushi Swap, or use centralized exchanges. Beyond that, users are forced to monitor their positions across multiple protocols. In the aggregate, this scope of maintenance is overwhelming and inefficient.

Fortunately, emerging DeFi dashboards like Zerion, InstaDApp, Argent, and others simplify the user experience by aggregating access to various dApps in a single interface. But this does not solve the problem of siloed platforms, since most of these interfaces are only compatible with the Ethereum network and its clones. The economic models attached to these dApps still exist in parallel, but they could complement each other if they were integrated.

Berhunites a money market and an orderbook-based decentralized exchange under one umbrella. Both products are sharing the same liquidity pools complementing each other. This combination allows users to access DeFi instruments that they previously used via distinct protocols all in one single place.

2. Core system components

2.1. Risk Framework

Berh's proposed risk framework, which is further divided into a risk model and a pricing model , revolves around the notion of credit risk. Credit risk is the risk of a loss resulting from the fact that a borrower or counterparty fails to fulfill its obligations under the agreed terms. In other words, the borrower either cannot pay or does not want to pay. In traditional finance, credit risk is related to almost all types of financial instruments.

When modeling credit risk losses, one should take several important aspects into account:

- Defaults are relatively rare events by comparison to market losses. A lack of available data is an issue for both calibrating the models, as well as backtesting.
- Correlations between failures have a material impact on the final result and shouldn't be underestimated. This is especially true for the crypto space, where different assets display high correlations to dominant market assets like BTC.
- Portfolio concentration risk should be taken into account.
- Loss distribution has fat tails and is not symmetric.

Credit risk models can be subdivided into two broad categories:

Structural models: These models assume that a default can be explained by a specific trigger point. For example, it can be caused by a decrease in asset value below some threshold (like the value of the debt). The value of assets itself is modeled as a stochastic process.

Reduced-form models: These models assume that defaults are driven by default intensity. No specific trigger event is assumed, but the default intensity (or default rate) might depend on changes in external factors. The relationships are estimated using historical data and econometric models.

The entire system design of Berh's collateralized and decentralized store of value dictates that we should use the structural approach. It more closely reflects the current system architecture and does not rely on heavy backtesting or historical data, which the emergent DeFi space naturally lacks.

Borrower portfolios will maintain stable value if borrowers have either excess collateral or if the bailsman pool is sufficiently capitalized. Therefore, our smart contract models the capitalization of the bailsman pool with critical importance. Berhutilizes a methodology similar to the SEC's Theoretical Intermarket Margining System (TIMS) [3], used for portfolio margin calculations by accredited US investors. This technology is underpinned by the idea that the margin should be set to the maximum loss the portfolio would incur under adverse market scenarios.

Initially, the stress model will involve parametric calculations of collateral and debt pools under different market conditions as follows:

Step	Explanation
Calculate the value of the collateral pool	Sum of dollar values of all tokens held as collateral. C = sum(Q(i)*P(i)), where Q(i) is the total balance of i-th currency in the collateral pool and P(i) is the price of i-th currency.
Calculate the value of the debt pool	Sum of dollar values of all tokens held as a debt (negative balances). D = sum(Q(i)*P(i)), where Q(i) is the total negative balance of i-th currency and P(i) is the price of i-th currency.
Calculate the value of the bailout pool	B = sum(Q(i)*P(i)) - total bailsman debt where Q(i) is the total balance of i-th currency in the bailout pool and P(i) is the price of i-th currency.
Calculate the value of the collateral pool in stressed market conditions (downside risk).	$C_{stressed}$ = C * (1 - VaR(C)), where VaR(C) is a Value at Risk measure at 5 sigma by default.
Calculate the value of the debt pool in stressed market conditions (upside risk)	$D_{stressed}$ = D * (1 + VaR(D)), where VaR(D) is a Value at Risk measure at 5 sigma by default.
Calculate the value of the bailout pool in stressed market conditions	$B_{stressed}$ = B * (1 - VaR(B)), where VaR(B) is a Value at Risk measure at 10 sigma by default.

Calculate insufficient collateral	Cins = max(0, $D_{stressed}$ - $C_{stresse}$d)
Calculate scale factor	Sf = max(min(Cins / $B_{stressed}$)^rho, upperLimit), lowerLimit) - bounded in [lowerLimit, upperLimit] range scale factor .rho is a sensitivity parameter.

When performing statistical tests such as Value at Risk, the following complications naturally arise: given the sample distribution of returns available to us, what is the best distribution fit of the left tail, and how do we account for sample bias? A sample of discrete interval collateral returns is only one sample drawn from the actual law that governs collateral return, so how do we account for parameter uncertainty?

Berh's roadmap entails more complicated, non-parametric methods for portfolio stress-testing to answer these questions. One of the approaches we will consider is a decomposition of portfolio risk to model the dependence structure among the assets, and to see if the risk contributions of various portfolio components are significantly different. We will use the research outlined in endnote [4] for these purposes.

2.2. Baskets of collateral

Borrowers inside Berhmay hold multiple assets and liabilities on their account simultaneously (portfolio margining) and thus are subject to collateralization requirements (margin levels). At any point in time user account's *current margin* is calculated the following way:

$$current\ margin\ =\ \frac{total\ collateral\ value - margin\ used\ on\ active\ orders}{total\ debt\ value}$$ expressed in %

Margining applies both to borrowers and bailsmen and works both for the money market and the DEX. When trading on the DEX, active orders in the order book also affect margin levels. The following table presents currently used margin levels within the system.

Margin Level	**Value in %**	**Description**
Initial Margin	120%	If current margin < initial margin, borrowers can not borrow further.
Maintenance Margin	110%	If the current margin falls below the maintenance margin, a user has 24 hours to top up their accounts' current margin to the initial margin level or higher. Otherwise, the user will default and his portfolio will be liquidated.
Critical Margin	105%	If the current margin falls below the critical margin level, the system liquidates the user's portfolio and distributes his assets and debts to the bailsman pool. There is an implicit penalty of 5% for liquidation.

When users perform actions in the system (place orders, make transfers), the system checks their current margin and compares it against the above-mentioned margin levels.

2.3. Bailout mechanics for Liquidations

In the event of default or liquidation borrower losses are socialized across the entire bailsman pool, every bailsman is given his share of collateral and debt based on his relative share of the entire bailout pool.

Berhuses relative portfolio weights initially. For example, a bailsman with 10% of the entire bailout portfolio weight will receive a 10% share of user collateral and user debt respectively.

At later product stages, we will migrate to more robust measures like risk weighting or contribution to solvency approach, where the system may gauge how the robustness (ability to withstand market crashes) of the system changes when a single user escrows assets into a bailsman pool.

Furthermore, if the entire bailout pool becomes insolvent (the value of liabilities exceeds the value of assets), the stability fund (treasury which collects part of the interest fees borrowers pay) comes into play and processes unhandled liabilities from its holdings.

The bailout mechanics approach is perhaps one of the core innovations Berh introduces in DeFi: handling liquidations this way doesn't require auctioning liquidated collateral into distressed markets. Debt (Liabilities) are physically settled by bailsmen. Let's illustrate this on example:

Let's assume a borrower initially brought $100,000 of margin to borrow Bitcoin and his portfolio looks like this:

Asset	Price	Balance	Debt
USD	1.00	**100,000.00**	0.00

Let's further assume say the bailsman liquidity pool has two bailsmen and BTC and ETH in liquidity:

Bailsman Id	Asset	Price	Balance	Debt	Weight
1	ETH	2,500.00	**20.00**	0.00	25%
2	BTC	50,000.00	**3.00**	0.00	75%

If the user borrows 1 BTC at ~ 50,000.00 USD, ignoring all the fees and price changes, his portfolio will look like this:

Asset	Price	Balance	Debt
USD	1.00	100,000.00	0.00
BTC	50,000.00	0.00	**1.00**

There won't be any changes (any asset movement) to the bailsman pool, but there is now a 1 BTC debt in the system. So the overall system looks like this:

- Total borrower collateral = 100,000 USD
- Total borrower debt = 1 BTC
- Total Bailsman collateral = 3 BTC, 20 ETH
- Total Bailsman debt = 0
-

Now let's assume BTC price is rising and it rose to $100,000 USD, the level where borrowers get liquidated (borrower collateral of $100K = borrower debt $100K), ignoring all the penalties and critical margin levels for the sake of simplicity, when the borrower liquidates, his assets are transferred to the bailsman pool. So resulting bailsmen balances will look like this:

Bailsman Id	**Asset**	**Price**	**Balance**	**Debt**	**Weight**
1	ETH	2,500.00	20.00	0.00	
1	BTC	100,000.00	0.00	**0.25**	25%
1	USD	1.00	**25,000**	0.00	
2	BTC	100,000.00	**2.25**	0.00	75%
2	USD	1.00	**75,000**	0.00	

Notice how bailsman 1, who got ETH collateral, now has 0.25 BTC debt, while bailsman 2, who had BTC has his balance reduced by 0.75 BTC (since he got 75% of the entire liquidated collateral and debt). Now the total system aggregates will look like this:

- Total borrower collateral = 0 USD
- Total borrower debt = 0 BTC
- Total Bailsman collateral = 2.25 BTC, 20 ETH, 100,000 USD
- Total Bailsman debt = 0.25 BTC

Bottom line: Bailsmen bear the risk of liquidation and need an effective liquidity management tool (DEX) to get rid of their liabilities and liquidated assets in a timely manner so bailsmen don't become insolvent themselves. To give bailsmen some room when dealing with liquidity we have two mechanisms on the table:

Liquidation penalty (critical margin):

When the borrower liquidates he pays a 5% penalty on the amount of liquidated debt.

Assessment of liquidity risk:

One approach which captures liquidity risks of various collateral assets involves the introduction of a set of discounts for these assets. Generally speaking, price predictability and lower associated risks result in lower discounts (higher coefficients when calculating collateral value), as bailsmen have a high degree of certainty that the full amount of the loan can be covered if the collateral must be liquidated.

Initially, liquidity risk will be assessed off-chain on a per asset basis and will involve the calculation of realized values of collateral if it is sold on the open market (e.g. what is the magnitude of the slippage we expect to observe when realizing liquidated collateral?) These slippage values, averaged over some period of time, and across market regimes, will be then used as discounts.

Speaking of concrete values, initially, users may expect to see something similar to the following:

Asset type	Asset	Discount
Stablecoin	USDT	1
	USDC	1
	BUSD	1
	DAI	1
	EQD	1
	LPT curve	1
Native	BTC	0.95
	ETH	0.95
	DOT	0.95
	KSM	0.95
Blue Chip	BNB	0.85
	CRV	0.85
Speculative	EQ	0.5
	XDOT	0.5
	LPT yield	0.5

3. Cross-chain money market

Berhconsists of a substrate-based engine on the Polkadot network and smart contracts on bridged blockchains that act as non-custodial liquidity pools. The engine enables cross-chain interoperability for these pools and unites them into a decentralized lending platform with advanced price discovery and bailout mechanics.

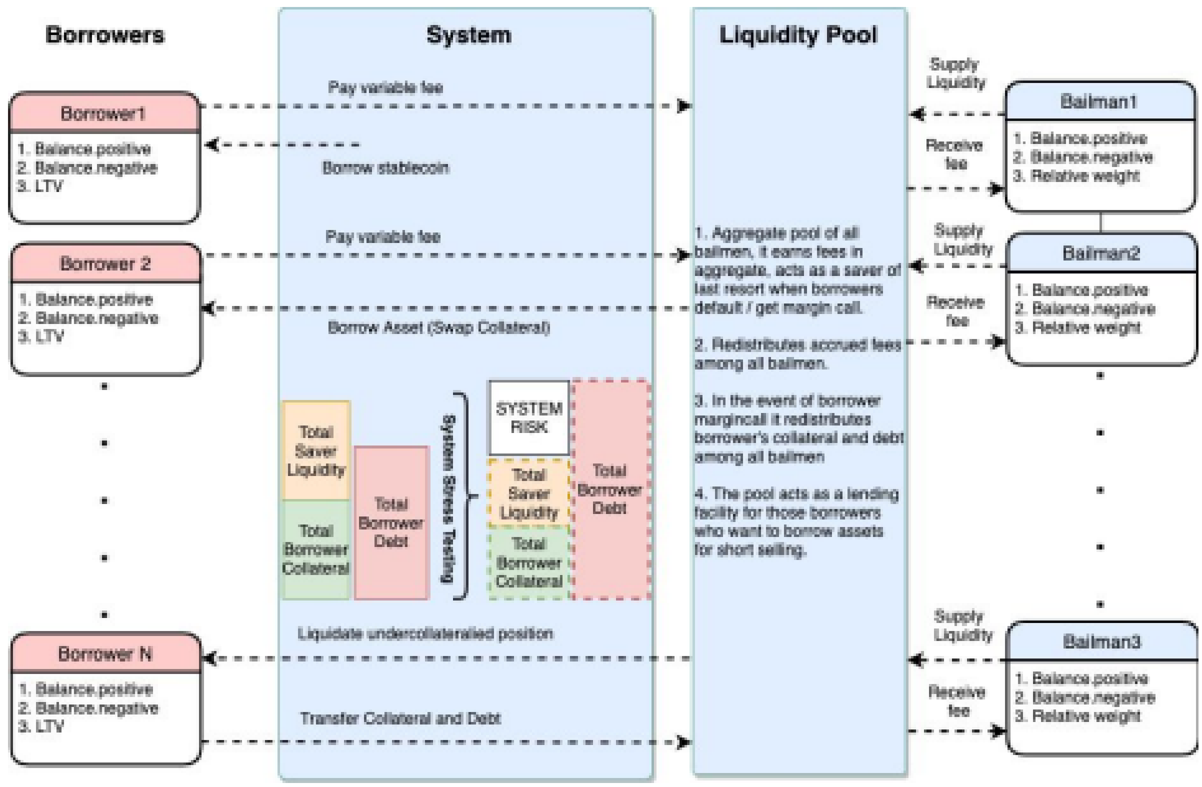
Berhis addressing the three main challenges of DeFi that we outlined in the first chapter. It is eliminating DeFi fragmentation by offering a money market with integrated DEX to meet the demands of various DeFi users. Thanks to the technology underpinning the platform, it delivers interoperability out of the box. Its liquidation mechanism provides for bailout liquidity to be settled in advance. It thus mitigates the risk of a lack of auction participants to buy liquidated collateral after market turmoil.

3.1. User roles

Berhhas three distinct user roles in the system — bailsmen, lenders, and borrowers (traders).

- **Bailsmen** escrow assets as insurance, earn premiums from borrowers, and take over and recapitalize undercollateralized loans.
- **Lenders** provide liquidity to borrowers and earn interest rewards.
- **Borrowers** (traders) borrow crypto assets and generate synthetic assets (stablecoins), maintain collateralization levels, and pay premiums to bailsmen to insure their collateral.

This is how the user interaction looks schematically:



3.1.1. Bailsmen

Bailsmen insure the system making sure it is overcollateralized at all times. Bailsmen receive interest fees that come from users who borrow assets. The Berhmoney market uses a pool-based approach that aggregates users' supplied assets into a single Bailsman pool where all users share profits, risks, and losses.

Bailsmen earn variable interest rates which depend on the system solvency, borrower portfolios leverage, and the amount of risk borrower portfolios pose. Interest rates may vary a lot and are the highest in periods of market turmoil and low liquidity.

When borrowers default on their obligations, the system redistributes their collateral and debt among bailsmen on a pro-rata basis given their relative liquidity in the pool. More sophisticated approaches to bailsmen liquidity and profit-sharing like weighting based on contributions to system solvency or risk-weighting are also possible.

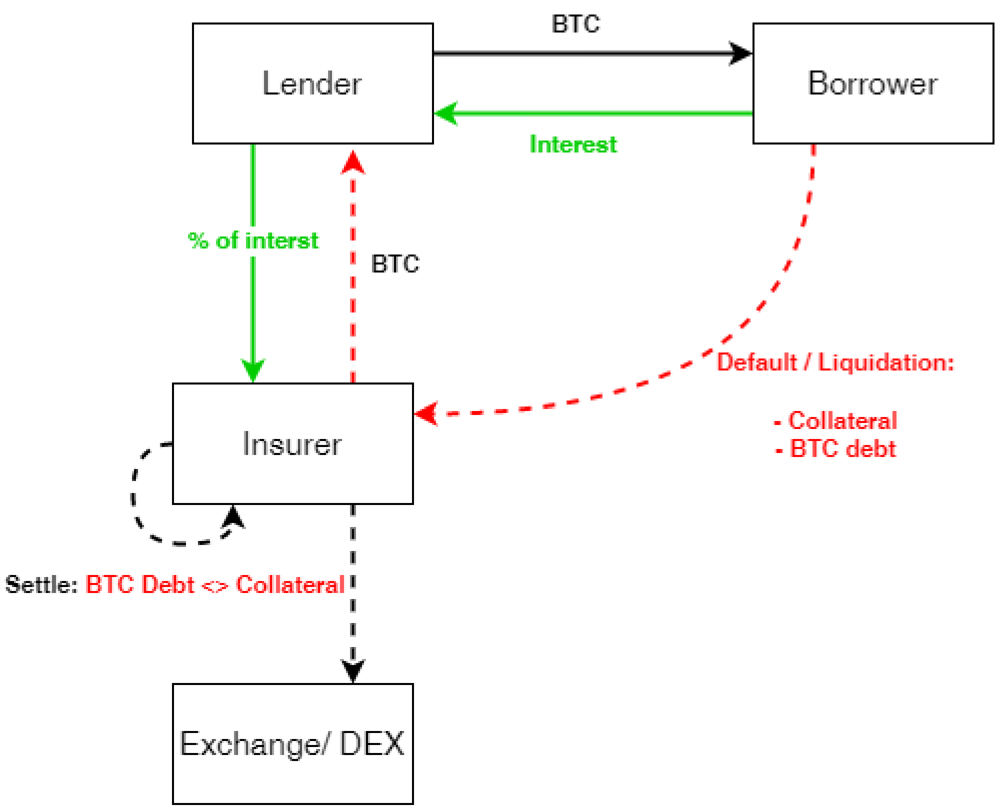
Bailsmen may only withdraw their funds from the bailsman pool only after paying down their fraction of the accumulated debt.

3.1.2. Lenders

Lenders provide liquidity for borrowers. Lenders do not bear the risk of liquidations and earn moderate interest compared to bailsmen.

It makes sense to introduce asset-specific lender pools, since, for example, if we have BTC and ETH available for lending in the system, and borrowers only take out BTC loans, ETH lenders shouldn't be entitled to any rewards/interest borrowers pay for borrowing BTC.

The interaction between borrowers, lenders, and insurers resembles the traditional CDS (Credit Default Swap) scheme:



- Borrowers deposit a portfolio of collateral and borrow assets from lenders.
- Borrowers pay interest fees to lenders.

- Lenders funnel most of the fee to Insurers because they take on liquidation risk (its possible to have a separable interest structure: borrowers pay: lender interest to lenders + insurance interest to insurance)
- In case of borrower default/liquidation borrower's collateral + penalty and borrower's debt is transferred to the Bailsman pool. Bailsman pool in return transfers liquidated amounts of BTC back to lenders so lenders are breakeven (lenders don't lose any of their assets).
- Bailsmen convert liquidated collateral and their own liquidity into accumulated debt to cover received liabilities. They can do it either internally, by swapping/ trading with other bailsmen in a form of auctions or they can go directly to the DEX to perform the exchange there.

3.1.3. Borrowers

Crypto assets carry volatility and price jump risks, so when borrowers use them as collateral, it requires additional collateral and a fee. We expect borrowers to supply various crypto assets as collateral via cross-chain wrapping, and will consider their overall collateral portfolios rather than treating each collateral token separately (this is a common shortfall in DeFI behemoths like MakerDAO, Aave, and Compound).

Each borrower will pay a floating rate fee based on their collateralization ratio, particular portfolio, and associated risks. To avoid using illiquid assets as collateral, we will introduce discounts on such assets. These discounts will be subject to periodical reassessment by the Berhgovernance.

In addition to borrowing liquidity from the Lending pool, borrowers will be able to generate Berh's native stablecoin called EQD and pay interests for debt in EQD to the Bailsman pool.

3.2 Financial model

The pricing framework is an integral part of the cross-chain collateralized lending and borrowing system. The pricing problem confronts borrowers and lenders alike. There's great research on this by the team of Xia and Zhou (2007) [5]. They derived a closed-form pricing formula for an infinite-maturity stock loan by solving the related optimal stopping problem according to the Black-Scholes model.

The model takes the risk-free interest rate, the loan rate, collateral volatility, potential dividend payments, and the initial debt as its parameters. It is only relevant if the fee rate is higher than a risk-free interest rate. It leads to an elegant solution for the interest rate offered to borrowers based on the position collateralization ratio and collateral portfolio volatility.

As collateral price and volatility change over time, the borrowers' interest rate is adjusted using the pricing model — borrowers pay a floating premium rate. Premium adjustment is inversely proportional to collateralization levels and directly proportional to the level of collateral portfolio volatility.

The interest borrowers pay is constantly accumulated on a designated system account from which redistribution to bailsmen happens. Once we start accounting for the critical LTV level with continuous monitoring, then the structure changes and the Xia-Zhou model does not apply. In reality, the barrier monitoring is discrete (on-chain rate update intervals), and the collateral does not behave like a gaussian. It would be best to model the collateral price dynamics with a jump-diffusion process.

Adding margin calls and liquidation turns the American option into a down-and-out American barrier option. The penalty for not posting collateral when the price drops below the critical margin level would be included in our adaptation of the Ekstrom model [6].

3.3 How Money Market compares to other projects

Compared to the other top DeFi protocols, none can exceed the user value and system stability features offered by Berh:

Feature	Berh	Compound	MakerDAO	Synthetix
Min collateralization	105%*	133%**	150%	600%***
Cross-chain enabled	Yes (Polkadot native)	No	No	No
Fee token	Built-in decentralized stablecoin	cTokens, converted to underlying collateral	MKR	SNX
Collateral backed	Yes	Yes	Yes	Yes
Borrow stablecoins	Yes	No	Yes	Yes
Borrow assets	Yes	Yes	No	Synthetic assets
Unified liquidity pool	Yes	No, separate money markets for each token	No, separate vaults for different kinds of collateral	Yes
On-chain risk framework and stress testing	Yes	No	No	No
Liquidation mechanics	Redistribution of debt and collateral among the pool.	Auctions	Auctions	Redistribution of debt and collateral among the pool.

Interest rate pricing	Closed-form pricing formula for an infinite-maturity collateralized loan according to the Black-Scholes model	Arbitrary supply-demand formulas for each market.	Arbitrary stability fee set via MKR governance	N/A only system fees for trading, and exchanging synthetic assets.
Price discovery	As borrowers take out loans and prices fluctuate, the system could become riskier: interest rate pricing adjusts to drive the entire system to the predefined liquidity target set by system governance.	No	No	No

* could be set lower
** minimum across all available markets
*** the 600% figure comes from the fact that they use their utility token SNX as collateral

4. Decentralized exchange

Berh's asset module, as well as risk and pricing models, provide out-of-the-box Decentralized Exchange functionality. Berh's DEX is a fully on-chain order-book-based exchange built using a substrate framework. Thanks to its innovative design it has several advantages compared to existent DEX-es:

Cross-chain from the start

Berhhas the capability to go beyond the limits of current DEX's with the opportunity to add tokens from the Polkadot ecosystem as well as from other blockchains to the exchange. In doing so, the traded pairs on BerhDEX will not be limited to ERC20 tokens like other DEXs, but can be any blockchain that can be connected to the Polkadot ecosystem.

Highly efficient

A lot of limitations in the field of trading come from the high cost of transactions, making scalping or small lot trading ineffective in the blockchain environment. Scalability of the substrate and Polkadot technology allow Berhto overcome this issue, as there is no mining, and the consensus is reached much faster in Polkadot compared to, for example, Ethereum. Furthermore, designated off-chain workers and unsigned transactions make traders' life even easier, as they potentially allow for placing numerous orders without paying transaction fees, but at the risk of allowing the denial of service attack, so the exact approach has to be chosen carefully here.

Competitive leverage

Berh's approach to modeling collateralized loans allows for competitively low levels of collateralization and thus high leverage on its DEX. The design of our money market allows users to enjoy up to 20x leverage when trading on the DEX.

Berhwill further consider pricing with jump risk and build on the hyper-exponential jump-diffusion (HEM). We may also consider the double exponential jump-diffusion model (DEM) [7] and/or the jump-to-default extended constant elasticity variance model (JDCEV) [8]. Pricing models will consider infinite-horizon loans similar to the initial model.

4.1 On-chain orderbook

Berhhas developed a fully decentralized, on-chain order book that allows users to execute orders directly with a smart contract while still enabling flexibility with pricing and order sizes. Its Limit order book (LOB) and the matching engine provides both liquidity and price-time-priority-basis matching to users, enabling them to choose the price, size, and direction of their trades just as they would when interfacing with a traditional Exchange, but without all of the associated inefficiencies.

4.1.1 Order types

Apart from common Limit and Market orders available from the get-go, Going further, BerhDEX will support the following order types: Stop-loss limit, Stop-loss market, Trailing stop, Take profit, and Take Profit limit orders. These orders do not enter the orderbook until the market price reaches a trigger price, at which point they are sent as orders on the market.

Brief summary of the order types that will be available as the product matures:

- Stop-loss buy orders are sent when the market price exceeds their trigger price.
- Stop-loss sell orders are sent when the market price drops below its trigger price.

- Take profit buy orders are the opposite: buy orders are sent when the market price drops below their trigger price, and sell orders are sent when the market price exceeds their trigger price.
- Trailing stop orders are like stop-losses, but their trigger prices change as the market moves.
- IOC (immediate or cancel) orders will only take liquidity, while post-only orders will only provide liquidity to the LOB.

Note that having an advanced order does not guarantee a fill. In particular, having any type of limit, IOC, or post-only order might not get filled if the conditions are not met. If you send a (normal/stop/trailing stop/take profit) limit order, the market might have moved beyond your limit price by the time your order is executed. For example, If you send an IOC order, it will be canceled if it would not immediately trade; and if you send a post-only order, it will be canceled if it would immediately trade.

4.1.1 Pooled order placement

Polkadot blockchain works with transaction pools, and so does Berh's parachain, this is the special location where all pending transactions are stored before inclusion into the blockchain block. Traders may use this functionality to handle their orders inside the transaction pool before they are included in the block.

There will be a public API available for interactions with the transactions pool. Basically, this is a real-time order management system (place, modify, cancel orders) where orders are finalized (included in the block) once per block (~every 6 seconds).

4.2 Market making pools

Liquidity is a crucial part of any exchange that attracts active traders. Though, its depth and tiny spreads provided by market makers to an orderbook require quite a bit of inventory. We are solving this chicken or egg problem by incentivizing liquidity providers who got used to having DeFi-like incomes to put their funds into dedicated pools.

MM pools are designed for investors who want to enjoy passive income on their liquidity. Accredited market makers are acting in favor of liquidity providers by taking liquidity from MM pools and placing orders to the orderbook. The pools are receiving a share of trading profits and staking rewards from our liquidity farming program.

User benefits:

- Profit-sharing incentives: up to 50% of trading profits will be distributed back to liquidity providers.
- Farming rewards: people who stake liquidity into MM pools will have an opportunity to earn rewards in EQ tokens
- Trading contests and active trader rewards: users will be periodically rewarded for their active participation in the trading on BerhDEX.

Market maker benefits:

- Free blockchain transactions
- Zero maker-side fees.
- Profits from market-making activities.
- Volume rewards on active trading.

4.3 API integration

Berhoffers a Node.js service for interactions with its DEX. Professional traders and market makers may automate their trading routine using this API. Currently, the API supports the following actions:

- Get the list of trading pairs/assets - returns the list of currently supported assets/trading pairs
- Get orderbook - returns the list of active limit orders sitting in the order book on the blockchain.
- Get BBO - get the current best bid and best offer from the order book.
- Get historical trades - get past trades for a particular trading instrument.
- Get balance - get the balance of the trading account in a particular asset.
- Deposit - deposit funds to a trading account.
- Withdraw - withdraw funds from a trading account.
- Place Limit Order - place order into the order book
- Place Market Order - send market order (taker) to the exchange.
- Cancel Limit Order - cancel an order and remove it from the orderbook.

4.4 Layer 2 for acceleration

Currently the DEX world experiments with various layer 2 scalability solutions when it comes to order management and trade settlement. Projects like dY/dX and IDEX are among ETH-based pioneers to introduce this technology to their exchanges.

In short, if we take a layer 2 system, all it does is periodically publish proofs (maybe even zero-knowledge proofs) to the blockchain to prove that state transition within the Layer 2 sidechain is valid.

This approach has several advantages compared to fully on-chain solutions, like reduced transaction fees, faster settlement times, reduced minimum trade sizes (a consequence of lower fees), better user experience (matching that of centralized exchange), faster price oracles, and higher leverage as a result.

More generally, below is the table describing possible approaches to DEX construction with respective pros and cons.

Type	Examples	Pros	Cons
Fully on-chain	Etherdelta, AMMs	Decentralized	Order management (place, modify, cancel) includes trx fees. Matching (trades) will happen no faster than per block. Not scalable.
Off-chain orderbook market makers broadcast an order off-chain to be picked up by a counterparty who then passes the full order to a smart contract for fulfillment	0x	Faster matching. Semi-decentralized.	Front running Trade failures (transaction failures) Order cancels have to be validated on-chain
Off-chain order book and matching Transactions execute in real-time but settle minutes later at the speed of the network. User balances are stored on-chain in the smart-contract and are handled by a single authorized address	IDEX, dY/dX	Fast Best user experience	Centralized orderbook - operator that keeps control of it. All transactions, such as deposits and trades, must be authorized by end-users and their private key. But the central agent maintains ownership of broadcasting certain authorized transactions to the network. Processing each trade separately leads to excessive costs. Limited scalability as all trades are written into the blockchain.

Layer-2 solution: (Side-chain order book or layer-2 ledger). The core contract becomes responsible solely for escrowing funds, while the actual account and balance information is stored off-chain in a public, layer-2 ledger maintained by the operator and cryptographically guaranteed to be available to the public.	Injective, IDEX 2.0, dydx layer 2	Trades, and deposits/withdrawals are set in batches into the primary blockchain.	Basically a bridge from one ledger to another with a sophisticated validator, proof challenge, penalties, and rewards structure.

Berhis a fully on-chain limit orderbook-based exchange which can currently handle up to 1000 transactions per block thanks to the underlying substrate technology. This high enough throughput along with the introduction of pooled order placement, where traders can operate with temporal orders before they are placed in blocks, allows Berhto offer an exceptional trading experience comparable to that of centralized crypto exchanges.

Berh's R&D team experiments with various Layer 2 approaches: off-chain worker shared storage for running the order book, or introduction of another orderbook-specific parachain are among the possible solutions we consider when designing upcoming product features. We also monitor ecosystem solutions and ways to integrate with Layer 2 solution providers.

4.5 How BerhDEX compares to other projects

Following table shows how Berh's DEX compares to other top exchanges in DeFi space:

Feature	Berh	DyDx	Uniswap	Serum
Cross-chain enabled	Yes (Polkadot native)	No (StarkEx + Ethereum)	No (Multichain)	No (Solana)
Exchange Type	Order-book based	Order-book based	AMM	Order-book based
Throughput	1000 TPS (Substrate)	10,000 TPS (StarkEx layer 2)	10 TPS (Ethereum)	3,000 TPS (Solana)

Fully on-chain	Yes	Layer 2 is off-chain	Yes	Yes
Spot enabled	Yes	No (perps)	Yes	Yes
Derivatives	Yes	Yes	No	Yes
Fees	0.05% maker 0.1% taker	0.02% maker 0.05% taker	1% 0.3% 0.05%	0.00% maker 0.04% taker

5. Governance

The governance for Berhwill be driven by an on-chain process and will make use of the Democracy and Council pallets similar to how Kusama and the Polkadot chains are governed. The overall intent of these modules is to allow the majority of tokens on the network to determine the outcomes of key decisions around the network. These decisions come in the form of stake-weighted voting on proposed referenda and get enacted by an autonomous enactment system that ensures that users' decisions are binding.

Some of the main components of this governance model include:

- **Council** — A group of elected individuals who have special voting rights within the system. Council members are expected to propose referenda for voting and have the ability to veto publicly-sourced referenda. There are rolling elections for council members where EQ token holders will vote on new or existing council members.

- **Referendum** — A proposal for a change to the Berhsystem including values for key parameters, code upgrades, or changes to the governance system itself.

- **Voting —** The referendum will be voted on by EQ token holders on a stake-weighted basis. Referendums which pass are subject to delayed enactment such that people that disagree with the direction of the decision have time to exit the network.

5.1. Governance roadmap

Initially, while developing, testing, and finalizing our core logic, Berhwill run on PoA consensus with a centralized sudo approach used for applying changes to the network.

After Berhdelivers a version of the product with the money market and DEX, we will introduce a governing council that will make Berh-related decisions and changes to be visible on-chain. Changes to the protocol will still be managed via a SUDO. Council members will be elected from nominees on a basis, similar to what Polkadot does, but with Berh-specific parameters.

After Berhbecomes a Polkadot parachain and delivers all of its product line, we will enable recurring council elections, public and council proposed referenda, tallying, and adaptive quorum biasing. We will publish the detailed list of system parameters the governance will be able to monitor and change.

6. EQ Token

The EQ token is the core utility asset of Berh, used within products built on top of it. EQ tokens grants access to many of these products' features and governance powers. The token is used for paying interest, paying fees, and governing the system.

In Berh's DeFi parachain, the EQ token will retain all of its utility and will also be used as described below:

6.1. Participation in bail liquidity and collateral provision

The system will be accepting EQ tokens in its bailout pool and as collateral. This will be the major use case for EQ.

In order for any willing party to start earning system fees, they will need to post some liquidity to the bailout pool to safeguard the system and they can lock EQ tokens as well. The requirement to participate in this pool will be set as a minimum deposit in USD.

Borrowers need to provide collateral to get a loan. Alongside major cryptocurrencies, the system will enable settling EQ tokens as collateral.

6.2. Transaction fees

Substrate resources like storage and computation are limited, and transaction fees prevent individual users from consuming too many resources. Berhuses Polkadot's weight-based fee model, where fees are charged prior to transaction execution. Once the fee is paid, nodes will execute the transaction.

Fees are paid in EQ tokens, and users may not go negative on their EQ balances for paying fees. If an account has an insufficient EQ balance, the system will trade part of the borrower's collateral into EQ tokens, and the treasury will cover the fees.

6.3. Governance

One other important function of EQ is that it grants access to the governance of the platform. Functions covered within governance include determining the amount and weights of fee distributions as well as upgrades and fixes to Berh's parachain.

Berhwill use Polkadot's native approach to system governance by proposing changes and voting on them. This comes with a voting timetable, tallying, adaptive quorum biasing, and voluntary locking mechanisms in place.

7. Technical implementation

Polkadot has developed a substrate technology to facilitate the easy creation of custom blockchains. This substrate comes with everything you need to create your own blockchain. The substrate's pallets make it easy to create custom blockchain-specific logic. Here are some of the benefits of using a substrate technology, which is also the reasons why Berhis building one of its own:

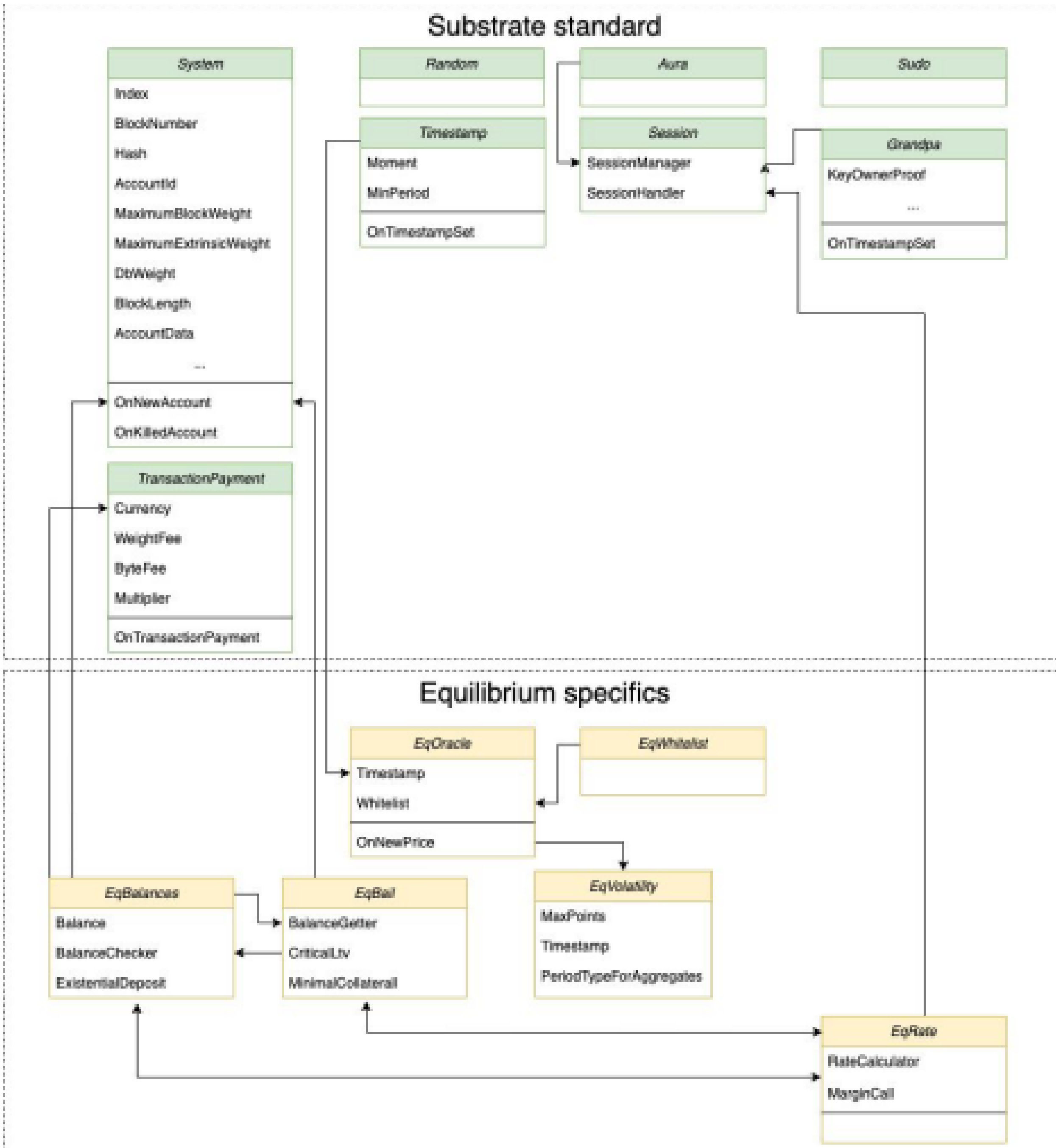
Forkless upgrades: out-of-the-box mechanisms perform easy upgrades of blockchain logic. The substrate comes with tools to help networks decide which upgrades to implement.

Consensus and finality: built-in consensus and finality mechanisms let blockchains come to a quick consensus to reach irreversibility or finality in a timely fashion.

Fast integration: Off-chain workers can integrate data, business logic, and complex computations into the blockchain with ease.

7.1. System architecture

Berhuses substrate pallets as different modules for handling system components. The following is a high-level overview of what the Berhsubstrate has under the hood:



Pallet	Description
System	The System module provides low-level access to core types and cross-cutting utilities. It acts as the base layer for other pallets to interact with substrate framework components.
Random	A simple randomizer that supports basic

	substrate functionality.
TimeStamp	Let validators set and validate timestamps on each block. Provides functionality to get and set on-chain time.
Aura	PoA consensus pallet
Grandpa	GRANDPA finality module for runtime. It manages the GRANDPA authority set ready for the native code. Will be used in conjunction with AURA.
Session	The Session module lets validators manage their session keys,it provides a function for changing the session length, and it handles session rotation. It's used to make validators perform extra work like margin call calculations.
SUDO	Adds root users to the substrate, enables the creation of settings and later manages them under root.
TransactionPayment	Handles transaction fees and fee logic. A detailed description of fees follows below.
EqOracle	Pallet for feeding prices on-chain. Handles several data sources and feeders, and calculates the median value of an asset price.
EqVolatility	Calculates per-token volatilities and asset correlation matrices with a given frequency (default time interval = 1 day)
EqWhitelist	Allows root to managing the whitelist of users and validators. Whitelisted actors are allowed to feed prices into the substrate.
EqBalances	Implements Currency Trait. This pallet handles the balance operations logic for borrowers. Borrowing increases the negative balance of the asset on the account.

EqBail	This pallet handles the balance operations for bailsmen. It also contains the logic for system fee redistribution, liquidated collateral redistribution, and debt redistribution among bailsmen.
EqRates	Handles the redistribution of user subsets among the validator set with help from the Sessions pallet. Performs the following calculations: Per-borrower system fees calculations. Stress-testing of the system's collateral and bailout pools. Per-borrower LTV ratio monitoring and liquidations (margin calls).

One important concept that runs throughout the system is that the fee each borrower should pay needs to be periodically recalculated and applied. Individual borrowers trigger these recalculations every time they deposit, withdraw, or transfer assets. Validators themselves trigger these calculations as well: each time a validator gets a random list of borrowers, they will be entitled to calculate fees for that list. Validators do not pay transaction fees, so it is natural to make them perform heavy calculations like determining fees per user on a block-by-block basis.

The system design also supports the auto-liquidation of undercollateralized borrowers. An off-chain worker feeds the lowest N LTV ratios by account id into the run-time. If it turns out that any of the LTV ratios breach the liquidation threshold, then the borrower's collateral and corresponding debt get redistributed among the bailout pool stakes.

7.2. Cross-chain communications

While cross-chain communications inside the DOTSAMA ecosystem will be supported out of the box with the introduction of the cross-chain messaging (XCM), bridging assets from other chains requires the use of separately-built bridges.

Bridges allow users to transfer tokens from one blockchain to another. The same token in different networks can be represented in completely different ways. Therefore, the Berh bridge operates with the asset identifiers.

The interaction between all the blockchains processed by the bridge is carried out by a special service called a *relay*. For reliable operation of the bridge, several relays should be operational simultaneously.

When a user wants to transfer tokens from one blockchain to another, he announces his intention by initiating the transfer in the source network. Initiating a transfer is reduced to calling the function of the bridge contract or a module. This contract or module then generates a *proposal* - a data structure containing all the information about the transfer. After that, the contract generates an event about a new proposal. Relays listen to this event and call the bridge function in the receiving network. This function receives proposals and finalizes the transfer through the bridge.

Berh's cross-chain communications protocol will operate initially on all EVM-compatible networks and will achieve interoperability between them via Polkadot's substrate technology. As ecosystem development and growth progress, Berhwill add other blockchains and use other bridges.

7.3. Price feeds

Any willing whitelisted party and system validators can feed prices into the system via an off-chain worker designated for this purpose. The price feeding logic consists of two main functional elements:

Medianizer:

The medianizer provides Berh's trusted reference prices for different assets. It maintains the whitelist of price feed accounts that are allowed to post price updates and a record of recent prices supplied by each address. Every time a new price update is received, the median of all feed prices is recalculated and the medianized value is updated if necessary.

Data Processor:

In order for Berh's framework to function smoothly, we need to pre-process and store asset prices, as well as calculate asset stats like log returns, volatilities, and correlations to be further used in our risk and pricing modules. Any asset within the system will be handled as a double map <assetId, frequency> → (prices, logReturns, correlations, volatility) where frequency denotes the time interval between data points stored inside the prices and logReturns arrays (e.g. 1 minute, 1 hour, 4 hours, e.t.c). Those arrays will be used to calculate correlations and volatility.

8. Summary

Berhhas already delivered one of the most complex and useful dAPPs built on the EOS blockchain to date. But the potential for serving the greater crypto community is still largely untapped: they need a broad pool of financial products like decentralized leverage, a stable unit of account, money market protocols, and synthetic assets.

Berhwill become the first DeFi one-stop shop by offering exceptional services to the users of major crypto assets like BTC, ETH, MATIC, SOL, and beyond. All this will become possible thanks to Polkadot's technology and its substrate framework for creating decentralized systems. Building such a system on the substrate will in turn help Polkadot differentiate its technology from other blockchain 3.0 projects like Kava, Cardano, Algorand, and others.

The opportunity to reshape the DeFi space here is immense. The times of fragmentation of users across various DeFI protocols and different blockchains is coming to an end. Berh will unite them all and has developed a solution that combines the capabilities of the top DeFi protocols by locked value (Maker DAO, Compound, and Curve).

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